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Aspects of Neogene Palaeoceanography in the Southern Tasman Sea (DSDP Site 593)

A thesis submitted in fulfilment

of the requirements for the Degree of

Doctor of Philosophy in Earth Sciences

at the

University of Waikato

by

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2002



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Abstract

Aspects of the Neogene palaeoceanographic history of the southern Tasman Sea are described in this thesis from DSDP Site 593 records of oxygen and carbon isotopes, and sediment texture and compositional data. Site 593 occurs in 1068 m water depth on the western flanks of the Challenger Plateau, west of central New Zealand. Through the last 40 Ma the plateau has accumulated up to 600 m of pelagic carbonate oozes.

The modern physical oceanography of the region is reviewed to form a basis for describing the Neogene palaeoceanography. The Subtropical Front lies south of Site 593, and has done so throughout the Neogene, separating surface waters of tropical- and antarctic-origin. Cool Subtropical Waters (CSTW) at the modern surface are underlain by Subantarctic Mode Water (SAMW) sourced from the Southern Ocean, which in turn is underlain by Antarctic Intermediate Water (AAIW), which bathes the seafloor at Site 593. The Neogene equivalent watermasses are qualified as Southern Component waters, for example Southern Component Intermediate Water (SCIW), because the specific physico-chemical parameters used to define the modern watermasses are not known for their ancient analogues.

The sediments are nannofossil ooze changing upcore to foraminifera-bearing nannofossil ooze. This change in texture has been attributed to intermittent winnowing at the site and experimentally determined to be due to selective removal of grains sized 3-13 μm, which comprise nannofossil placoliths. The core log includes an unusual 'orange unit' dated from 18.5-15.1 Ma, previously speculated to be associated with faster bottom water flow rates that introduced highly oxygenated water over the site. The textural data from this study support this contention and show that an invigorated SCIW at this time caused pronounced winnowing, sufficiently intense to form a condensed sediment section from c. 18-14 Ma. Invigorated circulation has been attributed to climate cooling and ice build-up on the Antarctic continent through the Neogene.

Stable oxygen and carbon isotopic analyses of both planktic and benthic foraminifera are used to establish a mid-latitude, southern hemisphere CSTW and SCIW record. This differs from previous Southern Ocean palaeoceanographic reconstructions which used tropical planktic data, being the only records then available, or Deep Water benthic data which describe conditions not representative of Site 593. The SCIW and CSTW $\delta^{18}O$ records from Hole 593 contain all of the globally-recognised major Early-Late Miocene glacial zones, namely Zones Mi1b to Mi6. The Hole 593 benthic $\delta^{13}C$ record also contains the major Miocene carbon events, including the Monterey Excursion, most of the carbon maxima CM1-7 events, and probably the Messinian Carbon Shift. This is the first time these glacial zones and carbon events have been recorded in intermediate-depth waters. Significantly, the SCIW glacial zones exhibit step-wise ice volume increases in contrast with the Deep Water records where they are identified as single-point events, and the higher than expected absolute $\delta^{13}C$ values are interpreted to be due to thermodynamic tagging of the antarctic surface waters, from which SCIW is derived.

The study documents the difficulties in establishing sea water $\delta^{18}O_w$ values during the Neogene for use in palaeotemperature calculations, due to the unknown ice budget. A staggered value over time is established and applied to the Hole 593 $\delta^{18}O$ data. Previous attempts at determining sea water palaeotemperatures often use microfossil assemblages described as 'cool temperate' or 'subantarctic' without actually specifying a temperature. SCIW palaeotemperatures of 8.5-12°C through the Early to Middle Miocene cool slightly to around 8-10°C during the glacial Mi Zones, but are consistently warmer than those of modern AAIW (3.5-7.5°C) through this interval. During the Late Miocene Zones Mi6 the SCIW palaeotemperatures reached those of modern AAIW for the first time in the record, and remain in the range 5-9°C until 5 Ma. Neogene surface water palaeotemperatures are not dissimilar to modern CSTW values in the range 10-17°C, interpreted to reflect a relative thermal stability of the southern Tasman Sea CSTW during the Miocene.

Globorotalia (Globoconella) miotumida is a planktic foraminifera which exhibits distinct coiling excursions, where the dominant shell coiling direction changes from sinistral, which dominates the record, to dextral over very short intervals. Coiling

direction changes in other species have been linked to water temperature. The $\delta^{18}O$ data from both sinistral and dextral shells of *Globorotalia miotumida* do not support water temperature as a controlling factor. However, the $\delta^{13}C$ record hints that dextrally coiled individuals secreted calcite slightly shallower in the water column than the sinistral individuals. Sediments from Hole 593 contain three coiling zones, all of which are associated with glacials, specifically Zones Mi5 and Mi6, and an un-numbered glacial interval. This co-occurrence is interpreted as reflecting oceanic reorganisation caused by the glacials, resulting in slight shallowing of the permanent thermocline. This shallowing impacted on the reproductive success of sinistral individuals by restricting juveniles returning to the surface waters to become adults. As a result, dextral individuals temporarily became the dominant contributors to the sea floor sediments.

Recognition of bolboforms in the Late Miocene Hole 593 sediments resulted in an unexpected palaeoceanographic opportunity. By analysing many published core logs, isotopic data sets, and microfaunal assemblages it has been established that the bolboforms, now extinct, were associated with warm subantarctic conditions, and lived between the Subantarctic and Subtropical Fronts in the Southern Ocean. This has led to an assessment of the Cenozoic palaeoceanographic history of the Southern Ocean, including the evolution and migration of the various oceanic fronts. Transport via a subsurface route is proposed to explain the presence of bolboforms in the Hole 593 sediments, and their occurence in North Atlantic locations. Events are depicted on a series of palaeogeographical reconstructions of the Southern Ocean at eight time intervals during the Cenozoic.

Finally, palaeoceanographic proxies have previously been used to establish orbitally-driven climate periodicities, specifically Milankovitch orbital frequencies. The standard method has been Fourier analysis, but this technique has problems when the data set is not continuous, such as the drilling-related gaps in Hole 593. Using several of the Hole 593 data sets, time-series analysis has been undertaken using Wavelets software which has successfully identified orbital frequencies in the data, and is the subject of continued study.

Acknowledgements

I wish to acknowledge the tremendous support I received from my supervisors Cam Nelson, Chris Hendy and Peter Kamp (all University of Waikato) and George Scott (IGNS). Thankyou for all the time and effort you put into reading and editing chapters, and discussing results. I also wish to acknowledge funding from the Marsden Fund awarded to Cam and others (UOW523), and to the Department of Earth Sciences and Chairperson Roger Briggs for fees support. Helen Neil (NIWA) and Steve Cooke (University of Southampton) are thanked for their assistance with some of the isotope analyses. I must also acknowledge the Deep Sea Drilling Project/Ocean Drilling Program for collecting and supplying the samples.

Huge thanks must also go to a number of BSc (Tech) students, Pam Bromley, Glenn Nichols, Leslie McConnell, Julie Poot and Loretta Garrett for their help with sample processing, lasersizer operation, and various other tasks too numerous to mention. The project could not have been completed without their help. Technical assistance and encouragement from Peter Jarman and Helen Turner when the mass spec. was playing up, usually managed to help! I would also like to heartily thank the technical staff in the Department of Earth Sciences for their 'here to help' attitude.

The support of, and discussions with, fellow palaeoceanographers Helen Neil (NIWA) and Ingrid Hendy (University of British Columbia), cannot be underestimated, and I don't. My partner in crime in the Tauranga teaching, Kathrin Cass (and family) has become a firm friend, thanks for all the wine! For discussions and suggestions, I thank fellow students Craig Cook, Rochelle Hansen, Avon MacIntyre, Vincent Caron, Jayanthi Jayawardane and Jo Horrocks, and I also really need to thank Adam Vonk and Arne Pallentin for graphics help, especially with posters. All the staff from the Department of Earth Sciences are truly thanked for their support, especially Steve Hood, Barbara Hobden, Richard Smith and David Lowe. Thanks also to Martin Crundwell for discussions (sometimes heated) and for sharing data and ideas on the project, Steve Chiswell (NIWA) for his patience when I asked yet another oceanography question, and Willem deLange (University of Waikato) for help with data analysis. I also wish to acknowledge the help I received from various people who got sent emails by me which started '...you don't know me, but I have a question....', and who offered constructive suggestions.

I must also acknowledge the love and support of my family and friends, who still can't believe I'm actually finished!

Lastly, but by no means least, I want to acknowledge the dear friendship and unfailing 'don't worry you'll finish' encouragement from colleague Jeanette Gillespie (1959-2000), whose sudden and tragic death means she will never have the opportunity to finish her thesis.

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Introduction

This report, lengthy as it appears, has no pretence to completeness, indeed a lifetime might be spent upon the collections of which it treats without exhausting their points of interest. But in a publication of this sort there are certain limits as to time which must be respected; and the present volume is offered as an instalment in which the details of the subject have been pursued as far as has been practicable...The method of treatment has been made as comprehensive as possible, in the hope that the results may be of service as a starting point for further research.

H.B. Brady (1884)
H.M.S. Challenger Report

Introduction

In 1972 and 1973 Legs 21 and 29 of the Deep Sea Drilling Project (DSDP) commenced ocean coring of sediments in the New Zealand region using the drilling vessel Glomar Challenger, namesake of HMS Challenger, which undertook the first global oceanographic research cruise from 1872-1876. Coring of Leg 29 represented the first time such a project had been undertaken in the southern Tasman Sea deep waters offshore from New Zealand. Coring was undertaken at 10 sites, located along the Lord Howe Rise and Challenger Plateau to the northwest of New Zealand, and around the Campbell Plateau to the south (Kennett et al., 1975). Many of the sites recovered sediments which, when analysed, contained excellent Miocene to Holocene palaeoceanographic and palaeoclimatic proxies. Such proxies included sediment texture and composition, oxygen and carbon stable isotopes, and microfaunal assemblages. However, the quality and core recovery were often compromised because the cores were obtained by rotary drilling. One site on the Challenger Plateau, Site 284, contained what was thought to be a nearly complete record of the palaeoceanographic history of the southern Tasman Sea over the last c. 8 m.y. However, it was felt at the time that the record probably continued much further back in time to include the entire Neogene (Miocene-Recent). As a result, the next DSDP Leg to revisit the region, Leg 90, aimed to reoccupy several of the Leg 29 sites (including Site 284) to extend the records using the newly developed, and less disruptive hydraulic piston corer. In late 1982, Site 593 was drilled as the reoccupation of Site 284 and indeed fulfilled expectations by recovering sediments which extended back as far as the middle Eocene (c. 45 Ma).

A number of textural and isotopic studies have been undertaken on the Hole 593 sediments in the Department of Earth Sciences, University of Waikato, concentrating on the Neogene record from the hole. In this study, the Neogene is taken to include the Miocene through to and including the Quaternary Period, following the DSDP/ODP convention. This study provides an offshore comparison with the very good Neogene onland records of shallow to deep marine sediments from New Zealand. These onland sediments have been uplifted and exhumed by

the development and evolution of the modern plate boundary through New Zealand and associated increase in tectonic tempo.

This study involves the generation of a palaeoceanographic history for different portions of the Neogene in the southern Tasman Sea using certain palaeoenvironmental proxies, specifically sediment texture and composition (Chapter 2), and oxygen and carbon stable isotopes (Chapter 3 and 4). While considerable new data have been generated, the study also incorporates and integrates data obtained in other University of Waikato research projects. Owing to the quantity of data generated, the thesis is split into two volumes, with Volume I containing the chapters of text, and Volume II the data appendices. In a parallel PhD study using the same samples, the microfaunal history of the region is being established by Martin Crundwell. Aspects of both studies will subsequently be combined for publication consideration.

The format of this thesis comprises a series of seven chapters, each covering potentially publishable topics, with the references included within the chapter. Chapter 1 details the modern oceanographic setting of the Southwest Pacific region. This was undertaken in an attempt to clarify the relationships amongst the diverse oceanographic studies previously conducted in the region, many of which had developed their own classification schemes for watermass nomenclature. Certain oceanographic parameters (e.g., water temperature) cannot be measured directly in ancient oceans and must be interpreted from the various proxy parameters which are available, so clarity of the modern situation was necessary so as to know what to anticipate in the Neogene palaeoceanographic proxy data. This chapter ends with a general summary of the palaeoceanographic understanding of the New Zealand region to date, from a deep-water perspective, in the knowledge that this study focuses on intermediate and shallower water depths.

Chapter 2 details the sedimentology of the Miocene sediments from Hole 593. The sediments consist of carbonate pelagic ooze. While textural analysis of deep-sea terrigenous sediments has been related to oceanic circulation and current invigoration, there have been very few palaeocirculation studies on pelagic carbonate sediments (e.g., Gardner et al., 1986). This study details the textural

changes at a fine size interval of 0.25 ϕ, and establishes that there was a specific size range being intermittently winnowed from the Neogene Challenger Plateau sediments. The compositional study determined that this winnowed size range can be attributed to calcareous nannofossils, a major component of the mud fraction. In the textural synthesis section of Chapter 7, the Miocene records are integrated with previously unpublished Pliocene to Quaternary textural records from parallel studies on the core. This has been done to general a full Neogene record.

Early to Late Miocene oxygen and carbon stable isotopic data are presented in Chapter 3, with the Late Miocene section representing the entirely new data generated in this study. The late Early to Middle Miocene isotopic and textural data were obtained during the course of a parallel Masters thesis study (Elkington, 2000) that was co-supervised by the author of this thesis. The records have been integrated into a fairly comprehensive Miocene isotopic record for the site, and involved re-interpretation. The isotopic information from Hole 593 provides one of the first detailed Neogene records established for intermediate waters, where most other deep-sea records reflect the histories of Deep Water or Bottom Water. In this Southern Component Intermediate Water record the global Miocene glacial Zones Mi1b to Mi6 have been identified, along with the Miocene carbon maxima CM1 to CM7 associated with and following the Monterey Excursion.

In an additional isotopic study detailed in Chapter 4, the coiling history of *Globorotalia (Globoconella) miotumida* is investigated. This species exhibits predominantly sinistral coiling, but in three intervals of the Late Miocene core the coiling direction changes to become predominantly dextral. Coiling direction changes in other planktic foraminifera have been linked to various oceanographic parameters, such as water temperature, depth, and salinity. These parameters may be distinguished using stable isotopes, so this represented a chance to determine which, if any, of these controlled the coiling direction changes. This study is the first time that the isotopic signature of both coiling directions from a given sample has been established, and is the first isotopic record for *Globorotalia (Globoconella) miotumida*.

While picking foraminifera from the Hole 593 sediments, some 'unusual' shells were found and suspected to be the radiolarians referred to by Boersma (1986) in her study of benthic foraminifera in the hole. In contrast, Caulet (1986) did not detect radiolarians in the Hole 593 sediments in his study of the siliceous microfossils. In an attempt to clarify the situation, and if they proved to be radiolarians to use them for palaeoceanographic control, Martin Crundwell took some SEM micrographs of the microfossils. He was informed by Anthony Edwards (retired from IGNS) that the microfossils could be calcareous bolboforms. Subsequent contact with one of the world's experts on these microfossils, Dorothee Spiegler (GEOMAR, Kiel), confirmed this. While the detailed analysis of the Late Miocene bolboform population has been undertaken by Martin Crundwell, the Cenozoic palaeoceanographic history of this enigmatic microfossil group is detailed in Chapter 5. The additional database needed for this study was obtained from the site logs of numerous Southern Ocean DSDP/ODP cores, and from the microfossil biostratigraphies related to them. Interpretation of the sediments which formed as a result of specific overlying oceanographic conditions forms the basis of this study, and has enabled construction of a history of oceanic frontal development and migrations in the Southern Ocean linked to the Cenozoic development of glaciation on Antarctica. The *Bolboforma* have been shown to be indicators of warm subantarctic conditions, formerly living between the Subantarctic and Subtropical Fronts. Once recognition of these microflora becomes more common-place, they should prove very useful biostratigraphic and palaeoceanographic markers. This chapter has been published *Palaeogeography, Palaeoclimatology, Palaeoecology* (2002) 188:73-100 (authorship: Cooke, Nelson, Crundwell and Spiegler). A companion paper by Nelson and Cooke (2001), related exclusively to tracking the Ceonzoic evolution of oceanic fronts in the New Zealand sector of the Southern Ocean, is included in Volume II with the appendices.

Chapter 6 arose from recent software developments using Wavelet analysis and Holocene climate change records. It analyses the Hole 593 latest Miocene to Holocene oxygen isotopic data, and the Late Miocene textural data using Wavelets software. This program is used for time-series analysis where periodic signals vary in both amplitude and frequency. Previous studies have applied Fourier analysis to deep-sea core records and have determined that these records contain repetitive

climatic signals. Wavelets has the advantage over Fourier analysis in that it can be applied to data with irregular spacing, without generating aliased frequencies. The chapter details the Wavelet methodology, and hints at some interesting palaeoclimatic signals from Hole 593 data, but is not intended to be a complete time-series analysis of the data sets, which will be considered in the future. This chapter is currently in preparation for submission to the journal *Paleoceanography* (authorship: de Lange, Cooke and Nelson).

Chapter 7, the last, provides a synthesis of the Neogene surface and bottom water palaeoceanographic history of the southern Tasman Sea by combining all of the Hole 593 textural and isotopic data. The work integrates all previous studies carried out on this core in the Department of Earth Sciences, University of Waikato. The compilation indicates that the Hole 593 sediments have recorded all the major Neogene palaeoclimatic events evident in other deep-water studies. While not unexpected in the oceanic system, nonetheless this study details the Southern Component Intermediate Water and mid-latitude Cool Subtropical Water histories of the Tasman Sea. In order to establish $\delta^{18}O$ events in the Hole 593 records as glacial events, comparison of intermediate water with surface water records was necessary because ice volume changes will affect the whole water column, whereas local changes might only affect part of it.

Finally, several editorial practices are applied in this thesis, as follows:

1) The referencing style mainly follows that of the *New Zealand Journal of Geology and Geophysics*.
2) The large number of abbreviations used in this thesis, all of which are listed in the glossary, are nevertheless not used in the conclusions of each chapter to assist with clarity when summing up.
3) Full taxonomic names of microfossil species have been used throughout both for clarity and in order to help reduce the number of abbreviations.
4) Because most publication figures are typically reproduced in black and white, those in this thesis are also. However, to assist the reader, several figures, mentioned in the relevant captions, have been repeated in colour at the end of certain chapters.

In the course of this study, several aspects of it have been presented at national and international conferences, and one co-authored paper has been published and another is in review, as follows:

Refereed publications

Nelson, C.S. & Cooke, P.J., 2001. History of oceanic front development in the New Zealand sector of the Southern Ocean during the Cenozoic – a synthesis. *New Zealand Journal of Geology and Geophysics 44*: 537-555.

Cooke, P.J., Nelson, C.S., Crundwell, M.P. and Spiegler, D., 2002. *Bolboforma* as monitors of Cenozoic palaeoceanographic changes in the Southern Ocean. *Palaeogeography, Palaeoclimatology, Palaeoecology, 188*:73-100.

Conference publications and presentations

Cooke, P.J., Nelson, C.S., Crundwell, M.P. and Spiegler, D., 2002. *Bolboforma* as monitors of Cenozoic palaeoceanographic changes in the Southern Ocean. *In*: Brock, G.A. and Talent, J.A. *eds.* First International Palaeotological Congress (IPC2002), Sydney, Australia. Geological Society of Australia, Abstracts 68:196-197.

Crundwell, M.P., Nelson, C.S. and Cooke, P.J., 2002. A biochronology for Late Miocene bolboforms and planktic foraminifers in the New Zealand region of the temperate Southwest Pacific. Forams 2002, International Symposium on Foraminifera, Perth, Western Australia. Abstracts 29-30.

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The physical oceanography of the Southwest Pacific: A palaeoceanographic approach

ABSTRACT

The modern circulation of the world's oceans is driven by an extreme temperature gradient between the tropics and the poles. In addition, salinity and therefore density contrasts between watermasses contribute to ocean circulation. This paper attempts to define the modern physical oceanographic setting of the Tasman Sea and Southwest Pacific, as a prelude to unravelling the Neogene palaeoceanography over DSDP Site 593 (southern Tasman Sea), and to consider global oceanic circulation as it affects this region. An attempt is made to correlate the available oceanographic data to standardise the watermass names, and to provide a southern hemisphere view of the regional oceanography.

From north to south in the region, the surface watermasses and their intervening fronts are named below, together with the subsurface watermasses linked to particular fronts which generate them:

Surface Waters and Fronts	Abbreviation	Subsurface Waters	Abbreviation
Warm Subtropical Water	WSTW		
Tasman Front	TF		
Cool Subtropical Water	CSTW		
Subtropical Front	STF		
Subantarctic Surface Water	SASW		
Subantarctic Front	SAF	Subantarctic Mode Water	SAMW
Circumpolar Surface Water	CSW		
Antarctic Polar Front	AAPF	Antarctic Intermediate Water	AAIW
Antarctic Surface Water	AASW	Circumpolar Deep Water	CPDW
Antarctic Divergence	AAD	Antarctic Bottom Water	AABW

Site 593 is bathed by Cool Subtropical Water at the surface and Antarctic Intermediate Water at the sea bed, and so the bottom water at the site is not true Bottom or Deep water.

Having determined a baseline using the modern oceanography, previous palaeo-reconstructions are integrated using proxy data to a regional Neogene palaeoceanographic setting. The palaeo-reconstructions as they impact on the Southwest Pacific are discussed using sediment texture and compositional changes, microfaunal assemblages and stable isotopes. The objective is to provide a regional palaeoceanographic model with which to consider the Hole 593 data generated by this study.

Many of the modern oceanographic features are recognised in the Hole 593 palaeo-proxy record, including the Tasman Front through to the Subtropical Front, and the mode and intermediate waters. However, as the properties of the palaeo-watermasses cannot be directly measured, the term Southern Component Water is applied to indicate an Antarctic origin for such waters. Thus, Southern Component Mode and Intermediate Water are the Neogene equivalents of modern Subantarctic Mode and Antarctic Intermediate Water, respectively.

Chapter 1

The Physical Oceanography Of The Southwest Pacific: A Palaeoceanographic Approach

...the Challenger expedition (1872-1876) fundamentally and significantly advanced numerous fields in the earth, life, and ocean sicences....it also hearalded the dawn of a new, modern, multidisciplinary era of oceanography....

R. Wynn Jones (1994)
The Challenger Foraminifera

MODERN PHYSICAL OCEANOGRAPHY

Seafloor topography

The major topographic feature of the South Pacific Ocean is the East Pacific Rise spreading ridge separating the Southeast Pacific Basin from both the Southwest Pacific and Central Pacific Basins (Fig. 1). The oceanographic significance of the East Pacific Rise is that watermass flow from the south below c. 2000 m can only cross this ridge via the large transform faults, otherwise deep flow is restricted to the southern side of the ridge. The large Southwest and Central Pacific basins are interconnected with deep water flow between them.

The seabed topography of the New Zealand microcontinent acts as the dominant control on oceanic circulation in the southwest Pacific (Heath, 1985). The main features include the Lord Howe Rise, Norfolk Ridge, Challenger Plateau, Tasman Basin and Campbell Plateau (Fig 2). The sill dividing the Tasman Basin from the Coral Sea Basin along the Cato Trough sits at 2850 m water depth and restricts deep water flow to the north from the Tasman Basin (Wyrtki, 1961). This results in deep watermasses being either recirculated southwards (e.g., Jenkins, 1985, 1992) or upwelled and mixed into sub/surface watermasses (W. deLange, 2000 pers. comm.).

Basic circulation

On a hypothetical water-covered Earth the wind systems would not be deflected by continents and would be symmetrical about the equator along the Intertropical Convergence Zone (ITCZ). However, the effect of the large landmasses is to distort the ITCZ towards the pole during the summer in each hemisphere (Brown et al., 1998). In addition to this, variations in heat distribution around the globe (landmasses heat up more than the surrounding watermasses) distort the regular pathways of the hypothetical model, such as deflection of the west wind drift southwards around New Zealand.

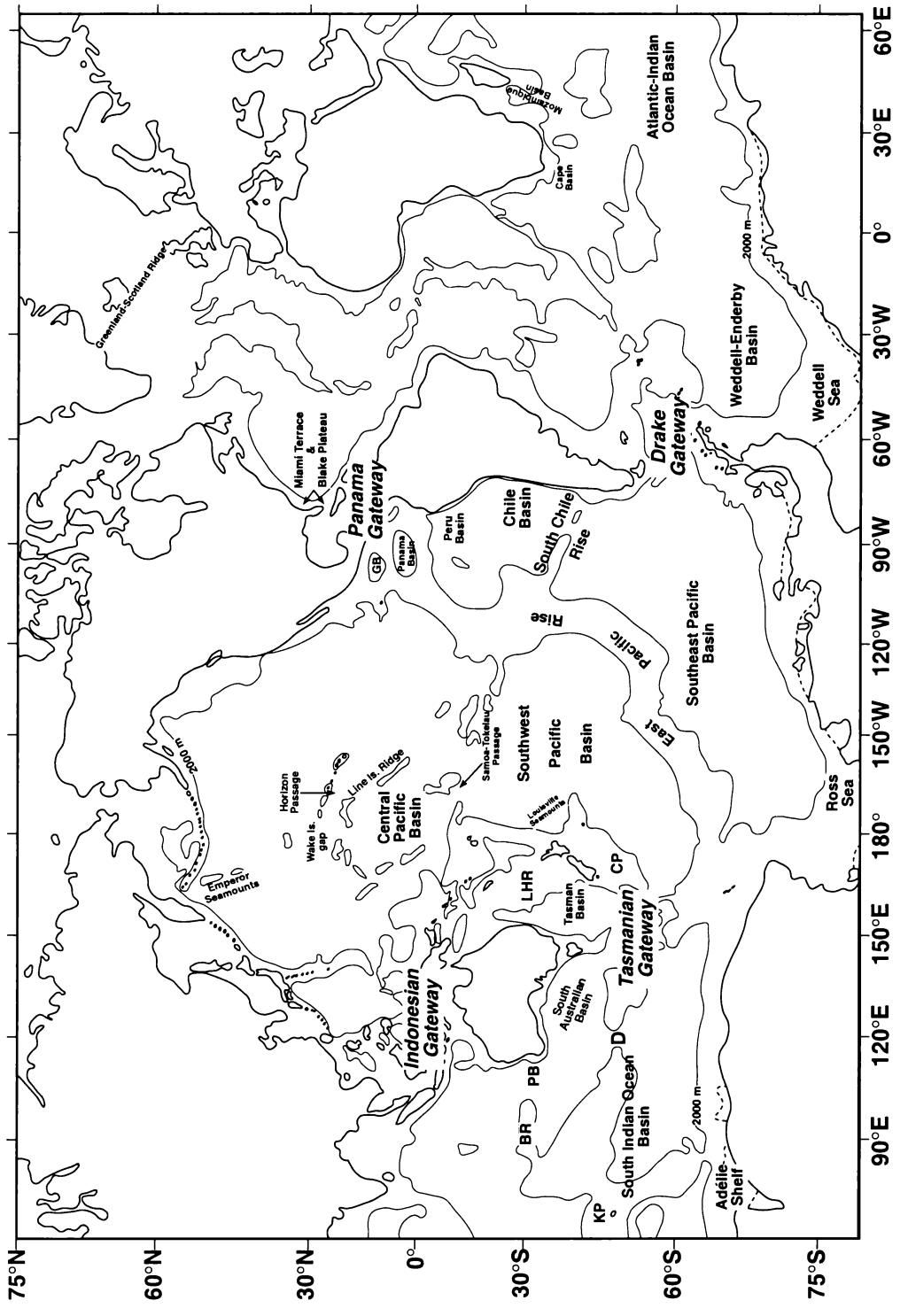


Figure 1 Physical topography of the oceans showing the main features for the Pacific Ocean: LHR = Lord Howe Rise, CP = Campbell Plateau, D = Australian/Antarctic Discordance, PB = Perth Basin, BR = Broken Ridge, GB = Guatemala Basin. After Circum-Pacific Map Project (1978) and Kennett and von der Borch (1986a).

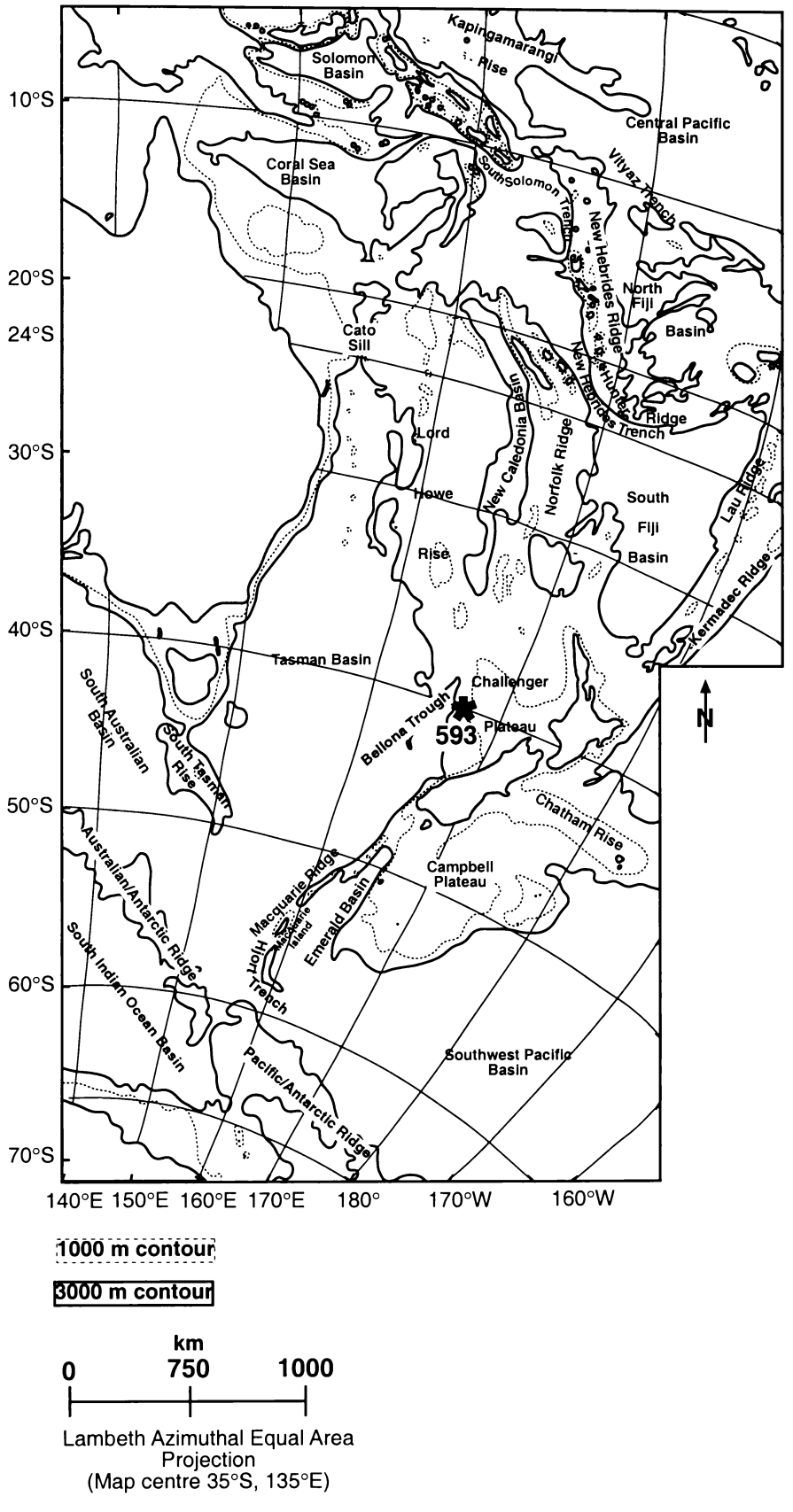


Figure 2 Physical topography of the Southwest Pacific and location of Site 593. After Circum-Pacific Map Project (1978) and Kennett and von der Borch (1986a).

Surface watermasses and currents

Wind stress at the sea-surface results in both horizontal and vertical water motion. The horizontal flow forms the surface currents and the vertical flow is generated by the convergence and divergence of these horizontally flowing watermasses (Brown et al., 1998). When the prevailing wind stress results in convergence, the water sinks or subducts. Where it results in divergence the water rises or upwells. In the subtropical gyres the water motion results in surface convergence, so the centre of the gyres is being subducted. For example, subduction of high salinity subtropical surface water by Ekman pumping along the Subtropical Front forces this water down and then sideways to form a salinity maximum below the surface layer.

In addition to wind-induced water flow, as soon as water starts moving it is subjected to the Coriolis force (Brown et al., 1998). This force is directed perpendicular to the direction of flow, specifically to the left of the flow in the Southern Hemisphere (Tomczak and Godfrey, 1994). As the moving water 'piles up' against the continents it results in a sloping sea-surface. This becomes important as it forms a hydrostatic pressure gradient through the water and generates water flow, in the same way that winds blow from high to low pressure, so as to even out the lateral pressure differences. In the real ocean, the flow will not be uniform with depth across this pressure gradient because density increases with depth. As a result, the isobaric surfaces (surfaces of equal pressure through the ocean) will not only be parallel to the sea-surface but also to the isopycnic surfaces (surfaces of equal density), a condition known as barotropic (Brown et al., 1998). Barotropic conditions are found in well-mixed, shallow surface waters and in the deep ocean below the permanent thermocline. However, where there is lateral variation in density, the isopycnic surfaces are not parallel to the sea-surface and intersect the isobaric surfaces at an angle. When this happens and the surfaces are inclined with respect to each other, the conditions are known as baroclinic (Tomczak and Godfrey, 1994; Brown et al., 1998). Baroclinic conditions result in fast surface current flow, typically above the permanent thermocline.

In addition to these causes of water movement, there are many local influences on flow, including friction with the seafloor and other currents, restrictions to flow and local accelerations (Brown et al., 1998). The most important additional cause of

water movement in the polar regions is the cooling and density differences in surface waters between seasons. When dense surface waters cool, they sink and are then acted on by the other water movement mechanisms. Surface waters warm in the tropics and cool at the poles and most heat and freshwater exchange occurs at the surface of the ocean, resulting in characteristic temperature and density values. Where subducted 'packets' of surface water retain their physical properties (e.g., temperature and salinity) over a wide scale, they can be described as a watermass. For example, warm, high salinity surface waters carried northwards by the Gulf Stream slowly cool and sink to form North Atlantic Deep Water, a southwards-flowing cool, high salinity deep watermass (Tomczak and Godfrey, 1994).

The ocean carries large amounts of heat towards the poles, but on a longer timescale than the atmosphere, so that the ocean has a damping effect on rapid climate change, with the possibility that heat would be released from the ocean during periods of cooling climate (Tomczak and Godfrey, 1994). In addition to bottom water formation, deep water flow and Antarctic circumpolar current transports, the main method of heat transfer in the oceans is via Rossby waves (large wavelength, planetary-scale waves) which carry energy from the centre of the gyres to the western boundary current regions (Tomczak and Godfrey, 1994). It is the accumulation of this energy on the western side of all oceans that leads to intensification of western boundary currents (Tomczak and Godfrey, 1994). These waves take between 6 months (at 5°N - 5°S) and c. 20 years (at 40°N and S) to cross the Pacific Ocean (Tomczak and Godfrey, 1994) and the thermocline response to any thermal changes is also likely to be on about this timescale (J. Pedlosky, 2000 pers. comm.).

Oceanic fronts

The combination of both horizontal and vertical water motion contributes to the 'ocean circulation'. The convergences and divergences are known as fronts and are particularly pronounced when water properties such as temperature and salinity are significantly different on either side of the front (Brown et al., 1998). Oceanic fronts are features of the surface water flow and can extend down only as far as the permanent thermocline. The frontal position is due to atmospheric circulation cells acting on the ocean circulation (Tomczak and Godfrey, 1994), superimposed on the

continental configuration. Where the front boundary extends over a fairly wide area it is often referred to as a 'frontal zone'.

Seasonal and permanent thermoclines

In ocean watermasses the surface mixed layer represents the zone of active mixing between the ocean and the atmosphere. Below this is a layer of transition where temperature decreases rapidly with depth corresponding to the seasonal thermocline (Fig. 3). In surface waters, temperature is regulated by surface diabatic processes and advection of watermasses (Perry and Walker, 1977). During summer, Ekman pumping (flow below the surface generated by vertical water movement either up or down) subducts surface water which is caught up in the expanding surface mixed layer before it can reach the permanent thermocline (Tomczak and Godfrey, 1994). The seasonal thermocline therefore gets deeper during summer (reaching to c. 300 m) and watermass formation can only occur in the late autumn and winter, when the seasonal thermocline may disappear altogether (Tomczak and Godfrey, 1994).

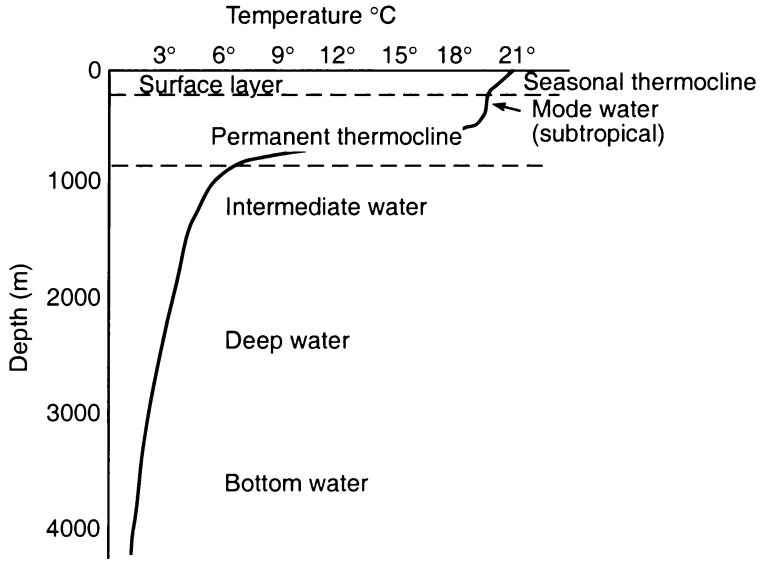


Figure 3 General thermal structure of the ocean illustrating the relative position of the watermasses to the thermoclines. Note that the isothermal mode water in this diagram is subtropical. subpolar mode waters are colder. After Brown et al. (1998).

The permanent thermocline lies below this seasonal feature with intermediate waters spreading northwards (in the southern hemisphere) just below it. As a result, deep water below the permanent thermocline is insulated from the atmosphere except at high latitudes (Perry and Walker, 1977). The main ocean thermocline

shallows and reaches the surface along the Subtropical Front allowing ventilation (ocean-atmosphere gas exchange) of the deep waters south of the front (Luyten et al., 1983a, b; Tomczak and Godfrey, 1994). Late winter breakdown of surface stratification also results in ventilation and produces seasonal upwelling which brings nutrients to the surface and enables gas exchange to take place with deeper waters (Toggweiler et al., 1991). Upwelling of deep waters around Antarctica also allows the transfer of heat from depth to the surface as oceans carry as much heat towards the poles as the atmosphere does, but they release it more slowly (Tomczak and Godfrey, 1994). Hence long-term climate change may be related to the ocean slowly releasing heat stored from earlier climate regimes (Luyten et al., 1983a).

Mode water

Subpolar mode waters are defined as having considerable vertical homogeneity and are formed during winter convection in subpolar regions, specifically the southeastern corner of the Pacific Ocean where it makes a substantial contribution to the intermediate water (McCartney, 1982). Subantarctic Mode Water (SAMW) forms by winter cooling of surface waters between the Subantarctic Front (SAF) and Subtropical Front (STF). This cool surface layer sinks in the summer and is isolated again by winter surface waters forming a distinct thermostad, a layer characterised by a minimal vertical temperature gradient (Passlow et al., 1997). Western South Pacific Central Water (Sverdrup et al., 1942) is a general term for surface waters north of the STF which are formed by the mixing of mode water with surface waters (Thompson and Edwards, 1981; McCartney, 1982; Sprintall and Tomczak, 1993). These waters are now referred to as Warm and Cool Subtropical Water (WSTW and CSTW, respectively) and may extend to c. 400 m depth (Thompson and Edwards, 1981). Mode water is generally considered to form the upper part of the permanent thermocline (Brown et al., 1998)

Intermediate water

Intermediate waters form at high latitudes and flow between the thermocline and deep waters. They are characterised by a salinity minimum as they form from subducted surface waters in areas where precipitation exceeds evaporation. Antarctic Intermediate Water (AAIW) originates at the Antarctic Polar Front (Belkin and Gordon, 1996) and is the most widespread intermediate watermass, occurring

in most oceans. In the southern hemisphere it lies at depths of between 600 and 1400 m (Wyrtki, 1962b; Heath, 1985; Tomczak and Godfrey, 1994). Winter cooling causes the cold, fresh, Antarctic Surface Water to sink, entraining some North Indian Intermediate Water (Gordon, 1971a, b; Molinelli, 1981), Circumpolar Surface and Deep Water to produce AAIW, which is also well oxygenated and has a relatively high nutrient concentration. As both AAIW and SAMW are produced by subduction, mixing and convection (not Ekman pumping), they flow along isopycnal surfaces towards the equator (Tomczak and Godfrey, 1994). The base of the permanent thermocline occurs between SAMW and AAIW.

Deep waters and thermohaline circulation

Variations in surface water temperature and salinity control the density of a watermass. When a surface watermass becomes more dense and/or colder than the underlying water, it sinks. This happens near the poles, where warm, tropically-derived surface waters rapidly lose heat to the atmosphere (Broecker, 1987) to produce cold, dense surface waters that then rapidly descend at several tens of cm per second (Perry and Walker, 1977). These cold dense waters form deep waters (Arctic) and bottom waters (Antarctic) and it is the transport of the these watermasses that are involved in the so-called ocean conveyor belt (Broecker, 1987; Schmitz, 1995). As the deep water circulation is controlled by both the temperature and salinity of the water, it is referred to as thermohaline circulation.

In the Pacific Ocean watermasses flowing below the intermediate water are variously described as Circumpolar Deep Water, Pacific Deep Water, Pacific Overflow Water and Pacific Common Water, all of which spread out through the Pacific basins. This study uses the term Circumpolar Deep Water (CPDW) which comprises three units, upper, lower 1 and lower 2 (Carter et al., 1996; Carter and McCave, 1997). These watermasses derive from deep water flow, eastwards around Antarctica via the Antarctic Circumpolar Current (ACC), which have sometimes retained properties from their 'source' surface watermasses. The two lower units can be detected in both the Pacific and Indian Oceans, but in the Atlantic southward-flowing North Atlantic Deep Water (NADW) blocks the CPDW from travelling too far north (Fig. 4).

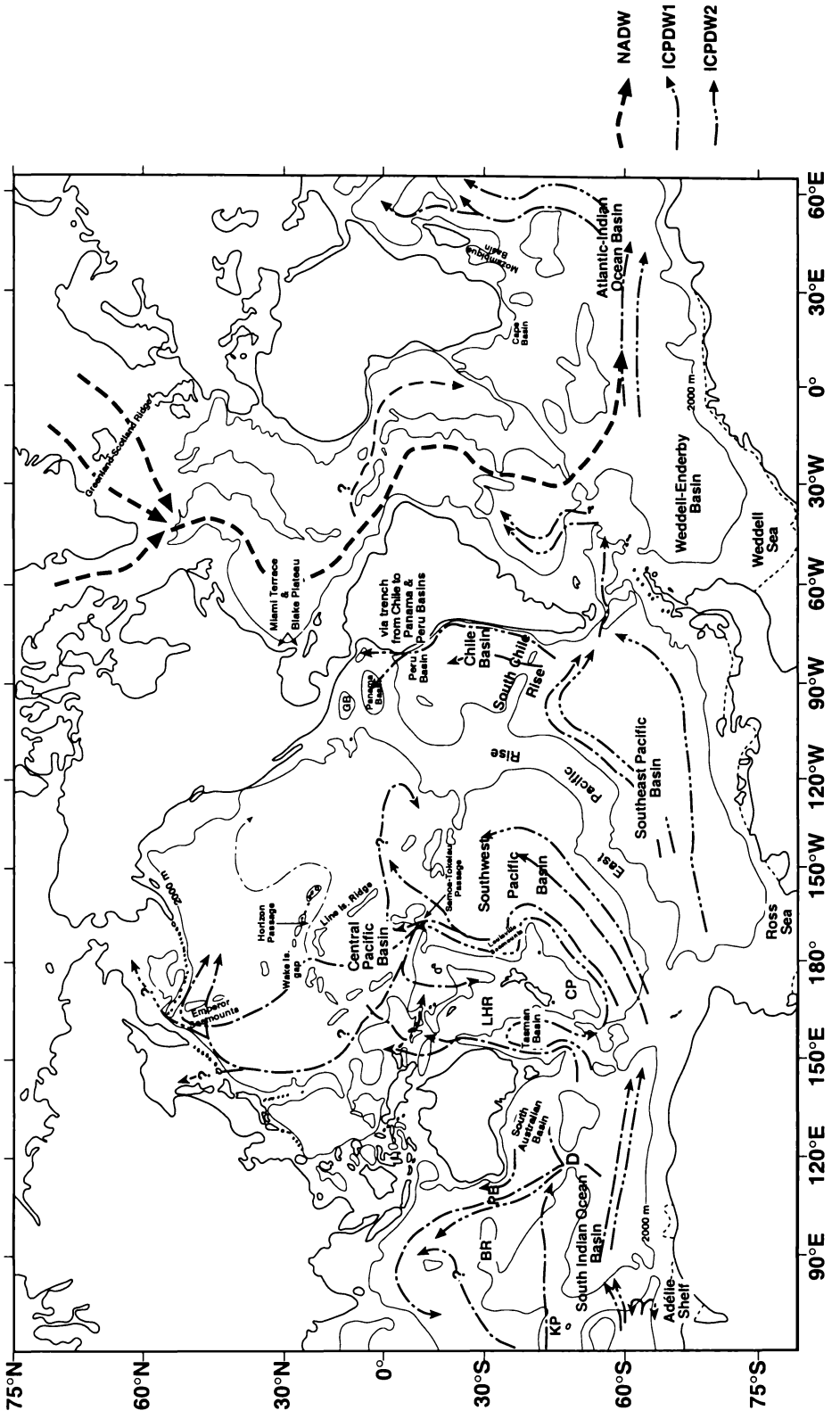


Figure 4 Modern Circumpolar Deep Water (CPDW) and North Atlantic Deep Water (NADW) distribution. After Wyrtki (1961; 1973), Edmond et al. (1971), Craig et al. (1972), Gordon (1975), Lonsdale (1976), Kolla et al. (1976), Edmond et al. (1979), Mantyla and Reid (1983), Osborn et al. (1983), Aagaard et al. (1991), Speer and McCartney (1991), Jenkins (1992), Park et al. (1993), Fine et al. (1994), Johnson et al. (1994), Tomczak and Godfrey (1994), Warren et al. (1994), Hautala (1996), Roemmich et al. (1996), Carter and McCave (1997) and Carter et al. (1998).

The only deep watermass generated in the Pacific Ocean is North Pacific Deep Water (NPDW) which is formed by upwelling of antarctic-derived deep water in the North Pacific, where as NADW is derived from high salinity upper ocean waters which cool and sink in the high-latitude North Atlantic and flow southwards to reach the antarctic.

The physico-chemical parameters used to distinguish the various deep watermasses are as follows (Fig. 5): the upper CPDW (*u*CPDW) corresponds to the oxygen minimum below AAIW (Gordon, 1971b); the lower CPDW 1 (*l*CPDW$_1$) shows a salinity maximum due to a large component of NADW plus some AAIW and Antarctic Bottom Water (AABW); and the lower CPDW (*l*CPDW$_2$) is distinguished as a colder and less saline layer below *l*CPDW$_1$ comprising a large component of AABW and Antarctic Surface Water, but no NADW (Gordon, 1971b, 1975, 1990; Gordon et al., 1977; Mantyla and Reid, 1983; Gordon and Molinelli, 1986; Carter and McCave, 1994; Neil, 1997). Circumpolar Deep Waters shallow to a few 100 m at c. 60°S in the Pacific as they approach the southern margin of the polar front, hence there is no Deep Water south of this front (Deacon, 1977).

Bottom waters

True bottom water is only formed at the margins of the Antarctic coast and involves the mixing of cool dense shelf and slope waters. The two major sites of production are the Weddell Sea (very cold and quite fresh) and Ross Sea (slightly warmer and saltier), with a small amount formed at the Adélie Shelf (Fig. 1) (Gordon, 1971b; Gordon and Tchernia, 1972; Deacon, 1977). These watermasses are mostly produced during winter under the ice shelves where the density of the shelf waters gradually increases until in late winter a density maximum is reached and it flows off the shelves and into the adjoining basins (Gordon, 1971b). Bottom water flow is westwards around, and northwards away from, the continent (opposite to, and below ACC flow) (Deacon, 1977).

Cyclonic gyres in both the Weddell and Ross Seas are regions of deep water upwelling where water from c. 2000 m depth ends up at c. 400 m depth (Gordon, 1971a). The northward and downwelling flow of AABW is compensated by the southward and upwelling flow of the deep watermasses, NADW and NPDW, and

some CPDW. This is extremely important as it allows a steady heat flux from the ocean to the atmosphere along this zone of upwelling.

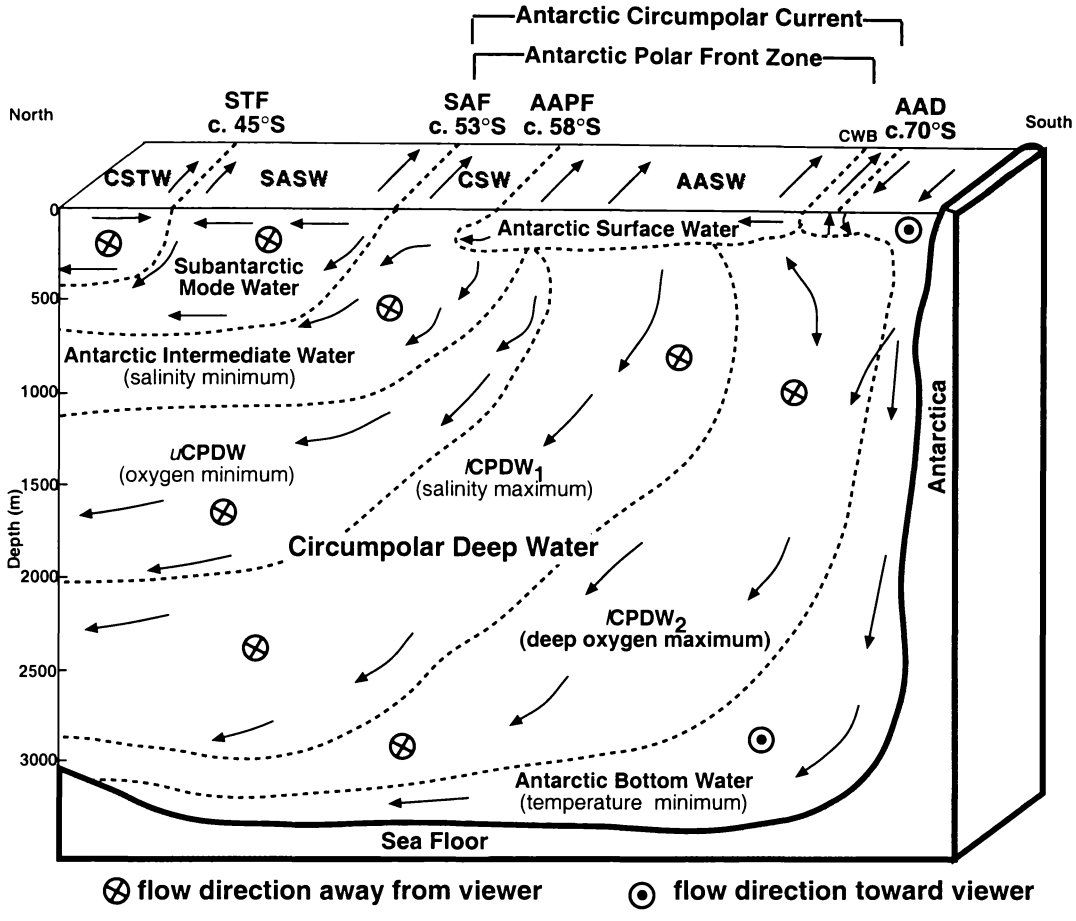


Figure 5 Cross section showing relationship between deep watermasses and their flow directions and associated sub/antarctic watermasses in the Southern Ocean, south of the Pacific Ocean. CSTW = Cool Subtropical Water, SASW = Subantarctic Surface Water, CSW = Circumpolar Surface Water, STF = Subtropical Front, SAF = Subantarctic Front, AAPF = Antarctic Polar Front, AAPFZ = Antarctic Polar Front Zone, AAD = Antarctic Divergence, CWB = continental water boundary. After Gordon and Goldberg (1970), Gordon (1971a; 1971b), and Tomczak and Godfrey (1994).

A large amount of AABW occurs in the Atlantic-Indian Ocean Basin and surrounds (Mantyla and Reid, 1983) and originates from the Weddell Sea as Weddell Sea Bottom Water (WSBW), which is the coldest and least saline component of AABW (Deacon, 1977). As WSBW flows westwards its path is blocked by the Antarctic Peninsula and this forces the water northwards and into the Weddell Sea Gyre (Deacon, 1977). In the northern part of the gyre, most of the WSBW is mixed into the ACC to form CPDW and is transported to the east, however a small amount continues westward through the Drake Passage (Deacon, 1977).

The mixing of WSBW and CPDW is evident in the silica values of the watermasses (Fig. 6). WSBW has low dissolved silica values (Edmond et al., 1979), with the average flux of silica from siliceous sediments into the bottom water being c. 3 µmol cm^{-2} yr^{-1}. The high silica values of WSBW within the Weddell-Enderby Basin cannot be accounted for by the simple addition of WSBW (low silica) to CPDW (high silica) and requires a large-scale in situ addition of silica to the bottom waters (Edmond et al., 1979). The high silica productivity region in the eastern part of the Weddell-Enderby Basin corresponds with sediments showing the highest silica values in the whole circum-Antarctic region. The waters in the Cape and Mozambique Basins, east of the gyre, reflect the mixing of the high silica WSBW with the relatively low silica NADW (Edmond et al., 1979).

Ross Sea Bottom Water (RSBW), comprising Ross Sea Shelf Water and *u*CPDW, has lower density and oxygen values but higher temperature, salinity and silica values than WSBW (Mantyla and Reid, 1983). Some of the RSBW travels northwestwards into the South Indian Ocean Basin (Gordon and Tchernia, 1972; Rodman and Gordon, 1982) and undergoes mixing with deep waters, so reducing its density and allowing flow over the Discordance on the Australian/Pacific Ridge and into the South Australian Basin. This modified bottom water continues flowing northwestwards into the Perth Basin and towards Broken Ridge (Gordon, 1971a; Rodman and Gordon, 1982; Mantyla and Reid, 1983). The westwards-flowing RSBW mixes with the Adélie Shelf Water and is forced up along the Kerguelen Plateau where it gets mixed into the ACC and contributes to the eastward-flowing deep waters, thus preventing RSBW from reaching the Weddell Sea (Gordon, 1971a; Rodman and Gordon, 1982). Some RSBW flows into the Southeast Pacific Basin, mixes with deep waters (forming *l*$CPDW_2$) and is transported via the ACC through the Drake gateway. RSBW is too dense to get over the Drake sill without some mixing (Gordon, 1971a).

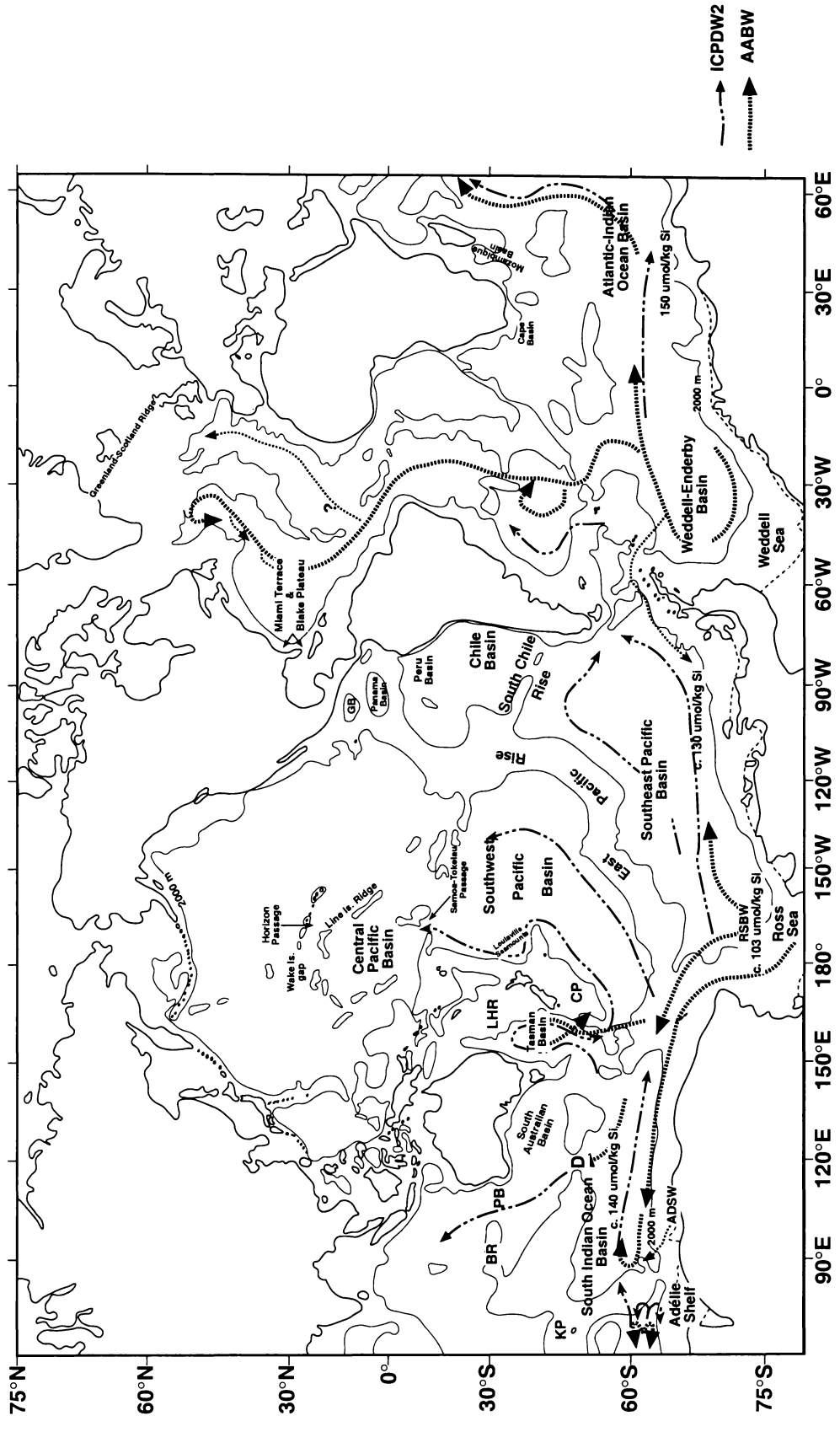


Figure 6 Modern Antarctic Bottom Water (AABW), associated ICPDW$_2$ distribution, and dissolved silica values used to track watermass flow directions. For source references see Fig. 4.

The flow paths are also evident in the silica distribution of the watermasses. RSBW at 170°W has lower silica values (103 µmol cm^{-2} yr^{-1}) than the CPDW overlying it (130 µmol cm^{-2} yr^{-1}), but by 130°W the bottom water core has dissipated (temperature >-0.1°C) and the silica profile increases to bottom (Edmond et al., 1979). This indicates the mixing of RSBW into CPDW to form $ICPDW_2$. The bottom water of the Drake gateway retains temperatures and silica maxima similar to that in the northern Ross Sea, but the silica maximum is slightly higher indicating bottom dissolution of silica-rich sediments (Edmond et al., 1979) and presumably the inflow of NPDW.

As a general rule, AABW is confined to the southern side of the circum-Antarctic ridges and does not flow into the Southwest Pacific Basin (Mantyla and Reid, 1983). The overall height of the ocean ridges prevents bottom waters flowing over them, but deep transverse troughs associated with transform faults across the tops of the ridges do allow bottom water to pass rapidly through active spreading centres (Lonsdale, 1976). AABW (high silica, high nutrients, low salinity, low O_2) does however flow into the North Atlantic where it gradually warms, mixes and shoals to transform into lower NADW (overall NADW is a silica minimum) before being recirculated southwards (Dickson and Brown, 1994). Thus AABW is the major contributor of silica to lower NADW. As some NADW properties originate from Southern Ocean watermasses, global circulation needs to be viewed from a Southern Hemisphere perspective (see also De Deckker, 1997).

ANTARCTIC CIRCUMPOLAR CURRENT (ACC) AND DEEP WESTERN BOUNDARY CURRENT (DWBC)

ACC is the large body of water travelling eastwards around Antarctica extending from the surface to about 3500 m depth between the Subtropical Front and the Antarctic Divergence. The formation of such a circumpolar current has only been possible since the opening of the Tasmanian and Drake Gateways between 33-25 Ma (Lawver et al., 1992; Lawver and Gahagan, 1998; Nelson and Cooke, 2001). The ACC entrains southward-flowing watermasses from all oceans, with major inflow from NADW (relatively warm and saline), as well as RSBW and WSBW (Gordon, 1971a; Gordon and Tchernia, 1972) and NPDW (Craig et al., 1972; Lonsdale, 1976; Carter et al., 1994), to form CPDW. All watermasses entrained by

the ACC (SASW, CSW, SAMW, AAIW and CPDW) flow eastwards, dragged along by the high-latitude westerlies called the West Wind Drift (Tomczak and Godfrey, 1994). In addition, the NADW contribution in the South Atlantic, results in ACC circulation which is due to thermohaline differences. Close to the coast of Antarctica (south of the Antarctic Divergence) easterly winds predominate which account for the westward flow of AABW and its derivatives (Deacon, 1977). The ACC is forced up and over the Kerguelen Plateau, Pacific/Antarctic Ridge south of New Zealand and Drake Sill, with the resultant mixing of the watermasses (Gordon, 1975; Gordon et al., 1977; Edmond et al., 1979).

To the south of New Zealand, the Campbell Plateau and Macquarie Ridge deflect the ACC southward, with the Macquarie Ridge dividing the flow into three parts (Fig. 7). This ridge has two gaps, either side of Macquarie Island (Fig. 2), at 53.3°S and 56°S (Gordon, 1972; 1975). The two smaller flows, pass through the gaps and the deep waters merge to form the northward-flowing Deep Western Boundary Current (DWBC) south and east of the Campbell Plateau (Fig. 7) (Gordon, 1972; Carter et al., 1994). The bulk of DWBC flow is CPDW. Most of the ACC flow is south of the Pacific/Antarctic Ridge at c. 58°S and continues eastwards following this ridge (Gordon, 1972, 1975). The DWBC contributes to the main source of deep water into the Pacific as it is the largest current of its kind (Carter et al., 1994), with a volume transport of c. 15.8 +/- 9.2 $x10^6$ m^3/s (Warren, 1970; 1973; Ward et al., 1987; Warren et al., 1994). Note: 1 x 10^6 m^3/s = 1 Sverdrup. It flows northward along the Tonga-Kermadec Ridge, between Tokelau and Samoa (Johnson et al., 1994) and into the northwestern Pacific via the Wake Island Passage, west of the mid-Pacific Ridge and Hawaii (Edmond et al., 1971), where it is often referred to as Pacific Deep Water. There is also a small flow (not more than 20%) through the Horizon Passage south of Hawaii, into the northeastern Pacific (Fig. 4). The main flow continues northward and then eastward at about 46°N through the Emperor seamount chain and is recorded in the Aleutian Trench (Edmond et al., 1971). It is this eastward flow which, with mixing and shoaling, becomes NPDW.

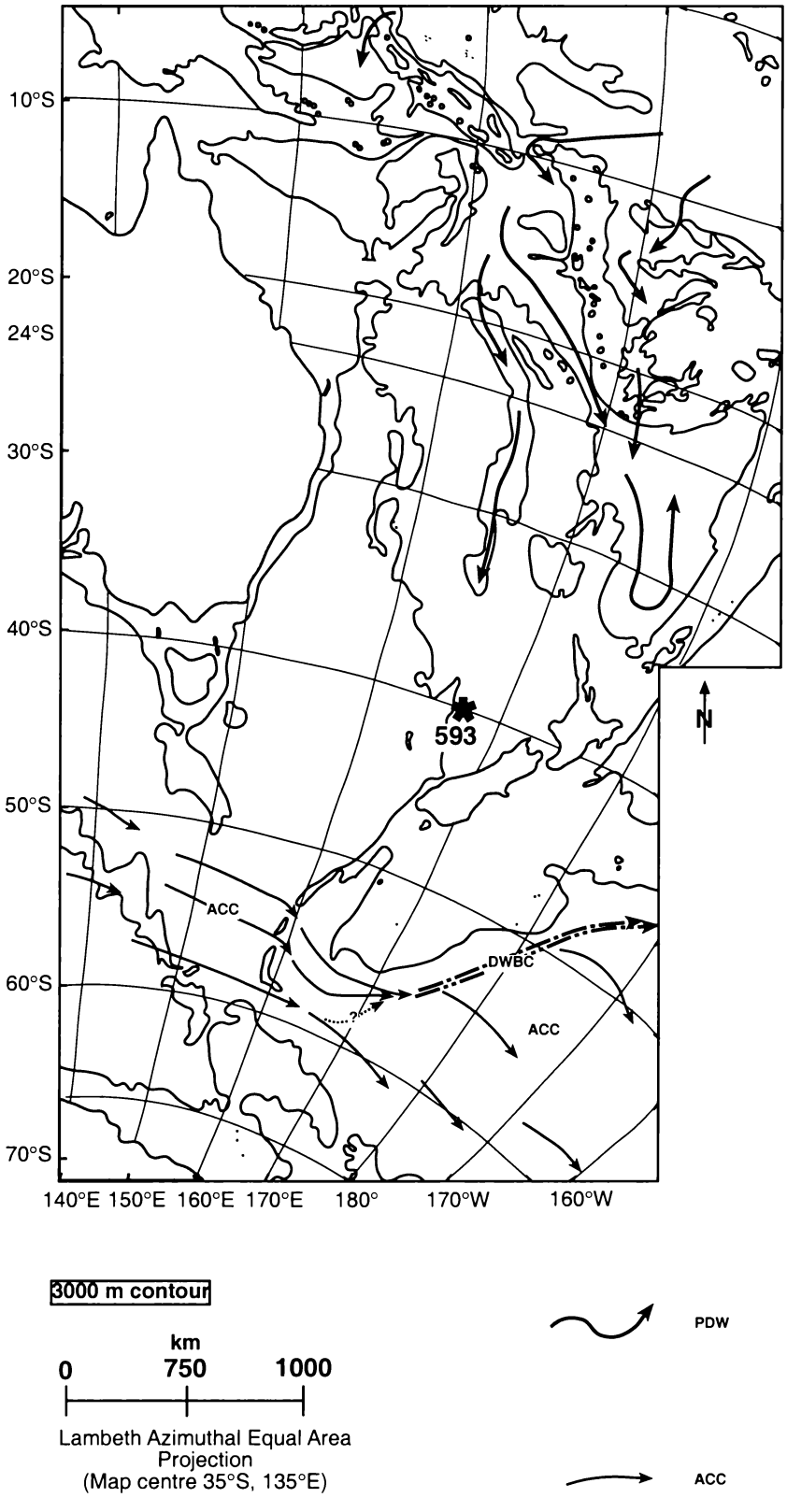


Figure 7 Antarctic Circumpolar Current (ACC) and the Deep Western Boundary Current (DWBC) in the Southwest Pacific. Note deepwater flow into basins north of New Zealand is Pacific Deep Water (PDW), a derivative of DWBC flow (Kolla et al., 1976). For source references see Fig. 4.

North Pacific Deep Water (NPDW)

NPDW is a southward-flowing deep watermass (Sverdrup et al., 1942) located in the South Pacific Ocean between c. 2500-3500m, above *l*CPDW$_1$ and below AAIW (Reid, 1986) and *u*CPDW (Craig et al., 1972). The 'terminus' of CPDW/DWBC flow in both the Northeast Pacific and North Indian Oceans coincides with a region of high diatomaceous productivity and siliceous-rich sediments (Edmond et al., 1979). The silica maximum of NPDW (140-180 µmol/kg) is due to the dissolution of these silica-rich, diatomaceous sediments by the northward-flowing low silica bottom waters (Edmond et al., 1979), as part of the DWBC extension into the northern Pacific. Hence, NPDW is recognised as a regional silica maximum in the Southwest Pacific Basin, and it is recorded east of the Louisville Seamount Chain (east of North Island) (Reid, 1986; Carter and McCave, 1994) and west of the East Pacific Rise (Craig et al., 1972; Lonsdale, 1976; Mantyla and Reid, 1983). The presence of NPDW is recorded in the Samoa-Tokelau Passage, but is intermittent (Johnson et al., 1994) and may represent the western boundary of this watermass (Craig et al., 1972) (Fig. 8).

NPDW joins the ACC in two parts, one via Southeast Pacific Basin (Lonsdale, 1976; Edmond et al., 1979), and the other via Southwest Pacific Basin (Carter and McCave, 1994). The bottom water in the Peru Basin is a mixture of NPDW which spills over the East Pacific Rise through the transform faults at 2500-3000 m depths, and northward flowing upper and lower CPDW (Lonsdale, 1976; Edmond et al., 1979). Further south, in the extreme northeast of the Southeast Pacific Basin (the apex between East Pacific Rise and South Chile Rise, 80-100°W, 40-50°S), the water temperature at c. 2700 m is 1.6°C and has a high silica content (Lonsdale, 1976; Edmond et al., 1979), indicating the presence of NPDW.

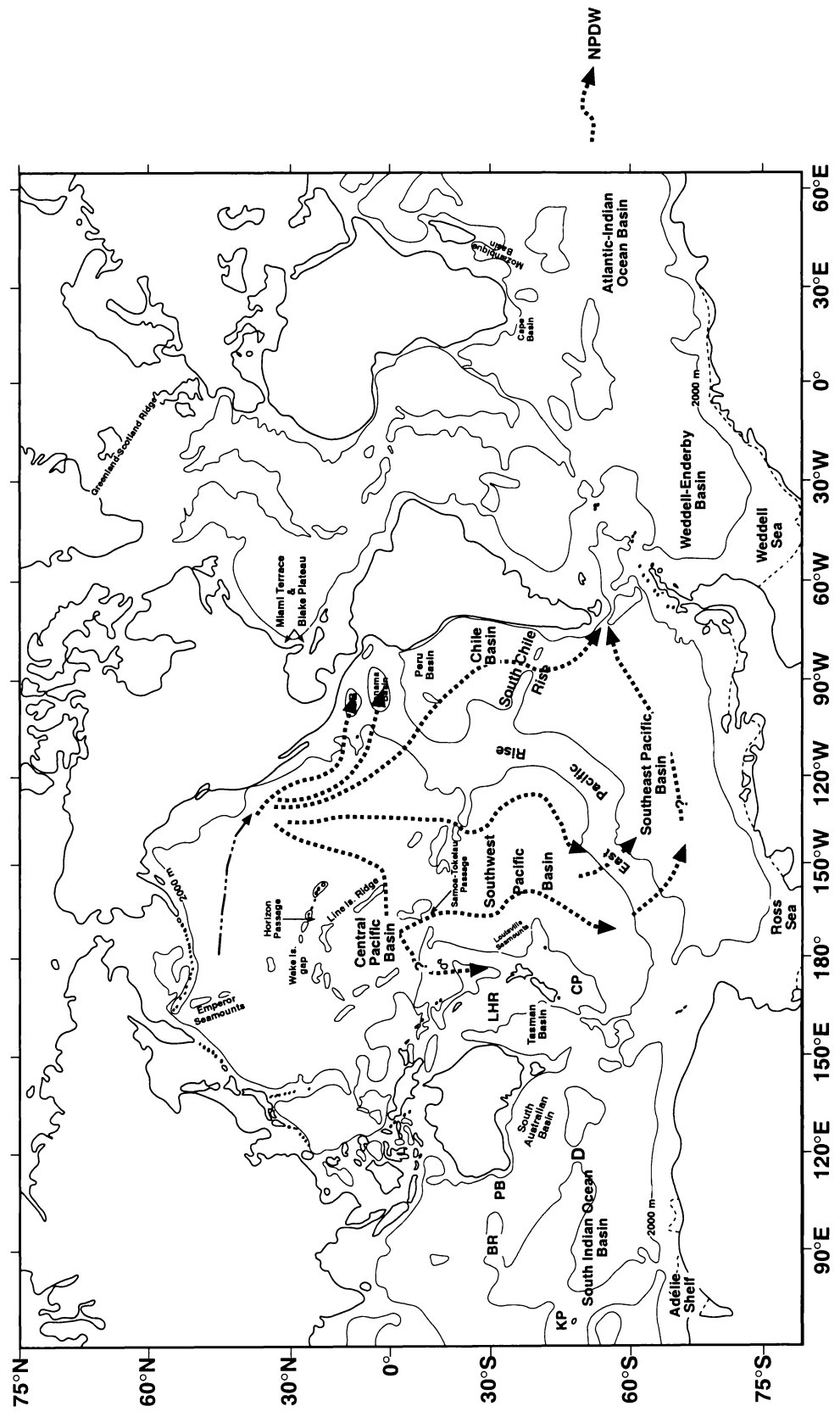


Figure 8 North Pacific Deep Water (NPDW) and flow pathways. For source references see Fig. 4.

SURFACE CIRCULATION IN THE PACIFIC OCEAN

The general circulation of the southern Pacific Ocean is governed by the wind-driven, anticyclonic, southern subtropical gyre, centred on 20-30°S and 100-150°W (Fig. 9), which extends to a depth of c. 1000 m (Wyrtki, 1961; Warren, 1970; Thompson and Edwards, 1981). The northern arm of the gyre flows westwards (at around 20°S) as the Southern Equatorial Current (SEC) carrying warm, high salinity water towards the Coral Sea (Garner, 1959; Wyrtki and Kilonsky, 1984). Part of the SEC is turned southwards as a western boundary current in the form of the East Australian Current (EAC) (Hamon, 1970; Warren, 1970; Heath, 1985; Sprintall and Tomczak, 1993), which is a baroclinic structure largely determined by source waters in the northern Tasman and Coral Seas (Heath, 1985). At around 33-35°S the EAC splits in two, with the larger branch crossing the northern Tasman Sea as a zonal jet and forming the Tasman Front (Stanton, 1973). This branch continues travelling southeastwards along the eastern coast of North Island as the East Auckland Current, then as the East Cape Current before turining east to form the western arm of the subtropical gyre north of the Chatham Rise (Heath, 1985; Reid, 1997; Stanton et al., 1997). The southern arm of the gyre continues eastwards across the Pacific and turns northwards along the coast of South America as an eastern boundary current (Warren, 1970; Heath, 1985).

The smaller branch of the EAC continues southwards along the coast of Australia as a series of large eddies (Bennett, 1983; Rochford, 1983) and is turned eastwards at about 45°S along the Subtropical Front as the Tasman Current (TC) (Stanton, 1973, 1976). On reaching the west coast of South Island (southeastern Tasman Sea), this current splits to form the northward-flowing Westland Current which also splits with one branch flowing through Cook Strait as the D'Urville Current and the other continuing northwards to rejoin the flow along the Tasman Front around northern New Zealand. The southern arm of the Tasman Current flows south and then eastwards between South Island and Stewart Island as the Southland Current (Stanton, 1973; Stanton et al., 1997).

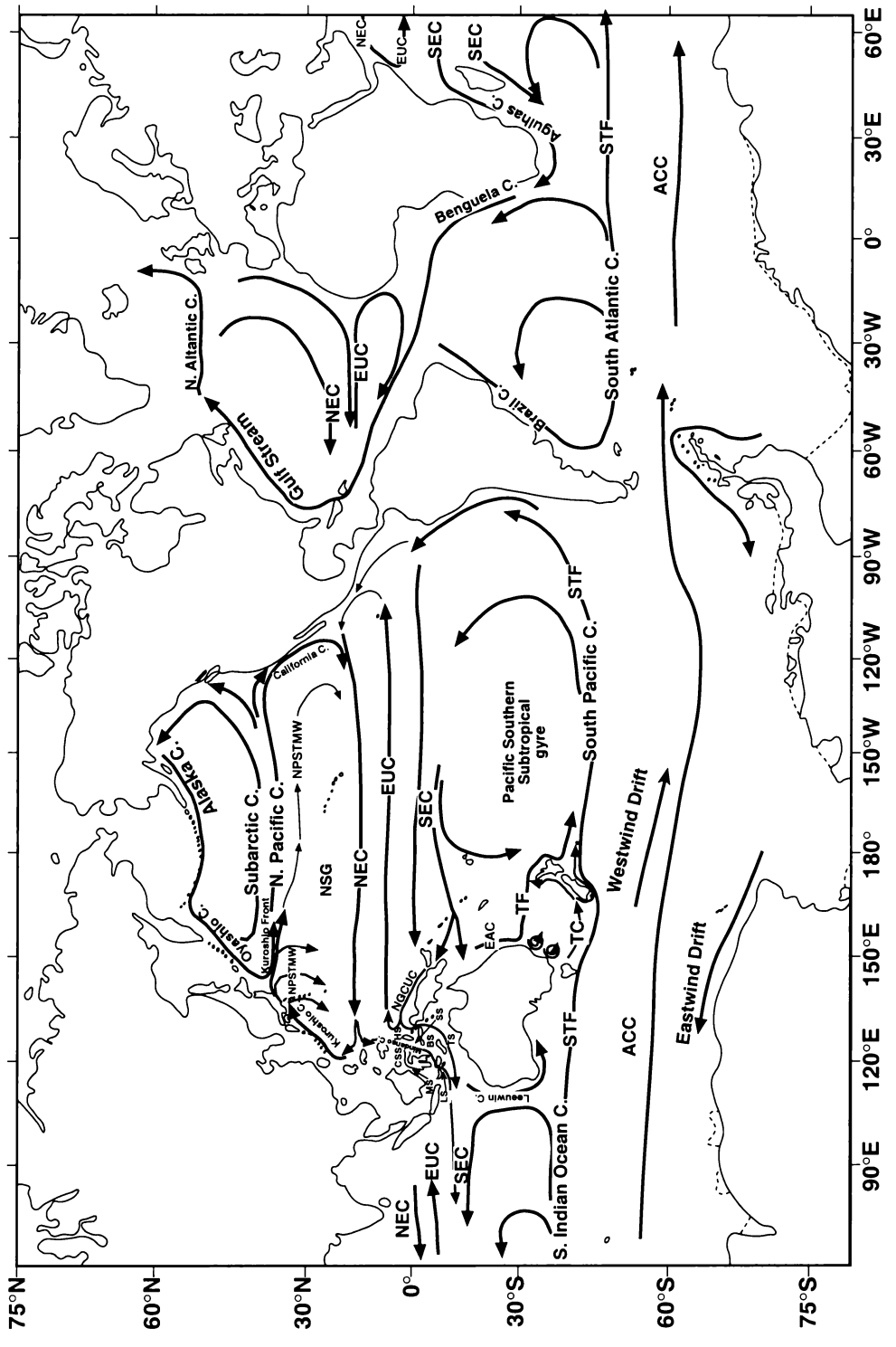


Figure 9 General Pacific Ocean surface circulation and currents (not all details for other oceans is shown). TS = Timor Sea, BS = Banda Sea, HS = Halmahera Sea, SS = Saram Sea, CSS = Celebes/Sulawesi Sea, MS = Makassar Strait, LS = Lombok Strait. NSG = Northern Subtropical Gyre, NEC = Northern Equatorial Current, SEC = Southern Equatorial Current, EUC = Equatorial Undercurrent, EAC = East Australian Current, NGCUC = New Guinea Coastal Under Current, TC = Tasman Current, ACC = Antarctic Circumpolar Current, NPSTMW = North Pacific Subtropical Mode Water, TF = Tasman Front, STF = Subtropical Front. After Tsuchiya (1982), Wyrtki and Kilonsky (1984), Gordon (1986; 1995), Bingham and Lukas (1992), Fine et al. (1994), Tomczak and Godfrey (1994) and Stramma et al. (1995).

Due to the continental configuration, circulation in the North Pacific circulation is governed by two gyres, one north of 30°N and the other at 20-30°N and extending further eastward (Fig. 9). The use of bomb tritium, which entered the oceans in northern high latitudes in the mid-1960s, as a means of tracking water flow distinguishes North Pacific waters (high tritium) from South Pacific waters (low tritium) (Fine et al., 1994). CFCs (which are fairly well mixed in the atmosphere) can also be used to distinguish high latitude waters (higher concentrations) from low-latitude ones as they dissolve in water depending on solubility, resulting in higher concentrations in colder surface waters (Fine et al., 1994).

North Pacific Tropical Water is a subsurface (100-150m depth), high salinity layer which outcrops in winter at c. 20°N, 140°E-160°W and is noted for extremely high CFC concentrations (Fine et al., 1994). This watermass flows westward in the Northern Equatorial Current (NEC), feeding into the Mindanao Current and through the Indonesian Gateway (Gordon, 1986; Fine et al., 1994). Northern Subtropical Mode Water which has high tritium and CFC values, forms on the warm side of the Kuroshio Current (along 24°N, west of 170°W) and extends westward via the Northern Equatorial Current into the Mindanao Current (Bingham and Lukas, 1994; Fine et al., 1994). North Pacific Intermediate Water is a regional salinity minimum at 300-700 m depth and forms east of Hokkaido, possibly by subsidence at the Oyashio/Kuroshio Fronts (Talley, 1993). It flows eastwards in the North Pacific Current then south and westward in the NEC where it can be traced at its maximum salinity in both the Kuroshio and Mindanao Currents (Talley, 1993; Bingham and Lukas, 1994). Apart from the Indonesian Gateway flow, North Pacific Intermediate Water does not cross the equator (Talley, 1993).

The Mindanao Current is a southward flowing Low Latitude Western Boundary Current extending to 600 m depth, most of which flows through the Indonesian Gateway into the Indian Ocean (Gordon, 1986, 1995; Talley, 1993; Fine et al., 1994; Gordon and Fine, 1996). After extensive mixing in the Celebes/Sulawesi Sea, a small proportion of the Mindanao Current flows eastwards via the Northern Equatorial Counter Current (NECC) (Bingham and Lukas, 1994; Fine et al., 1994). The low salinity, well ventilated, North Pacific flow through the Makassar Strait and Banda Sea is surface and upper thermocline water, whereas the higher salinity,

South Pacific flow through the Halmahera and Saram Seas and into the eastern Banda Sea is lower thermocline water (i.e., SAMW and some AAIW; Fine et al., 1994; Gordon and Fine, 1996) (Fig. 9). This gateway was effectively closed to deep water throughflow by 12-11 Ma (Kennett et al., 1985) by movement of the Australian plate into Indonesia (Hamilton, 1988).

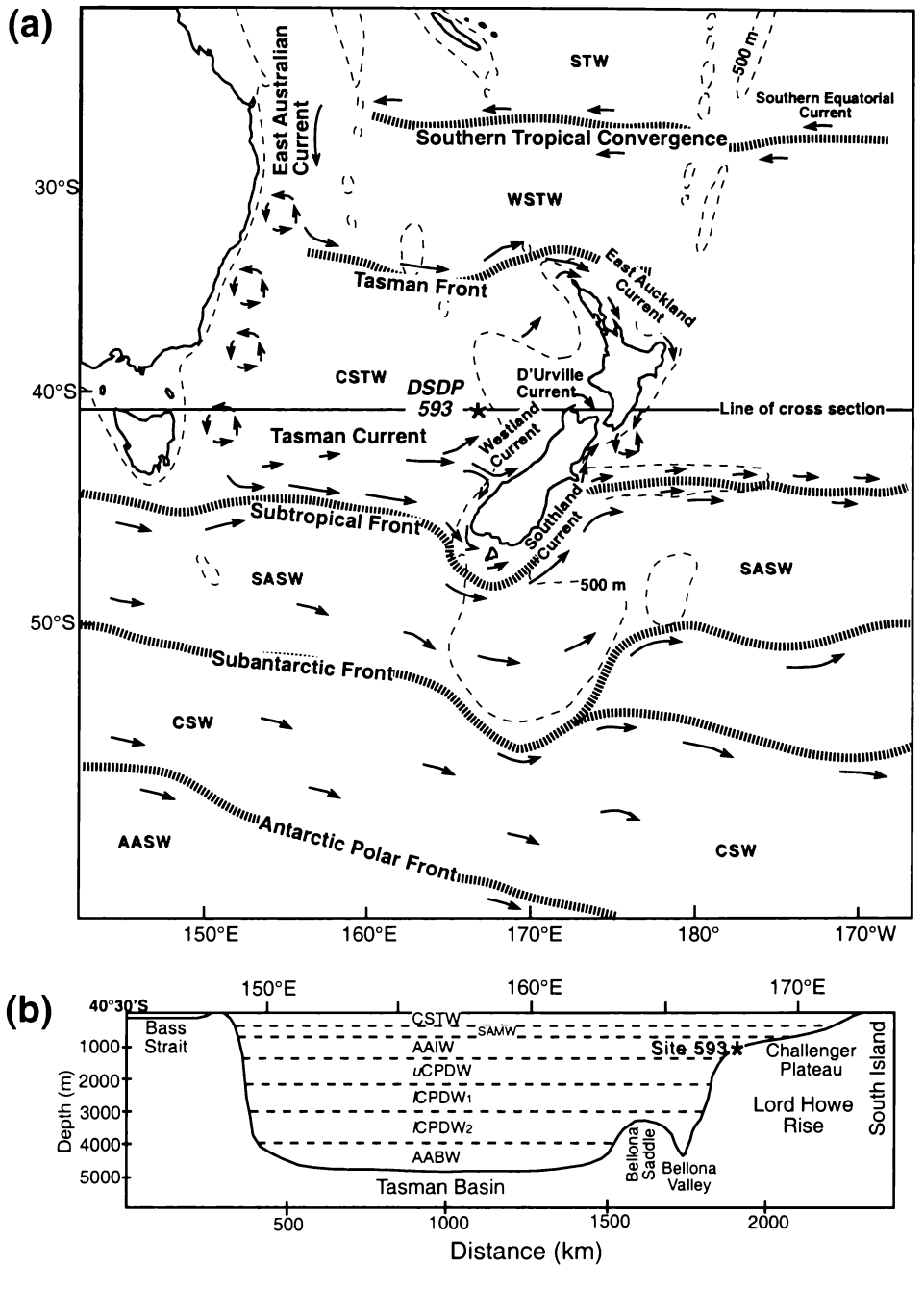
Although originating in the southern hemisphere, AAIW contributes to flow through the Indonesian gateway because some mixes into the New Guinea Coastal Undercurrent (Fig. 9) which flows at 300-900 m depth (Tsuchiya, 1982). This current splits into three pathways: (1) continues further north via the Mindanao Undercurrent towards 20°N; (2) flows via the Mindanao Current into the Celebes Sea and through the Indonesian gateway; and (3) flows eastward across the central Pacific in the NECC and Equatorial Undercurrent (Fine et al., 1994).

SOUTH PACIFIC OCEANIC FRONTS

The oceanic fronts in the Southwest Pacific mark the boundaries between the major surface watermasses and can be defined using temperature/salinity cross sections (Gordon and Molinelli, 1986; Webb et al., 1991) and underlying sediments (Nelson, 1996; Nelson and Cooke, 2001). The four oceanic fronts significant to the Southwest Pacific are the Tasman, Subtropical, Subantarctic, and Antarctic Polar (Fig. 10a).

The significant feature of the Tasman Front is that it is not a boundary between two watermasses as such, but results from the dynamics of water flow (Hamilton, 1992). Temperature changes across the front are only about 1-2°C and salinity varies by only 0.5-1.0x10^{-3}, both of which are significantly less than the variation across other fronts. The position of the Tasman Front changes, probably as a result of flow across the Lord Howe Rise and Norfolk Ridge and from variability in the flow of the EAC (Denham and Crook, 1976; Stanton, 1979; 1981; Heath, 1985; Mulhearn, 1987). The position of the Tasman Front also migrates seasonally, northwards in winter and southwards in summer (Wyrtki, 1962a, b). In the southern Tasman Sea the boundary between tropical-derived and antarctic-derived surface watermasses is marked by the Subtropical Front (STF) (Chiswell, 1994; 1995; Chiswell et al., 1997). This front marks a region of enhanced sea surface salinity and temperature

gradients within the Subtropical Convergence Zone (Szymanska and Tomczak, 1994). The surface watermasses south of the STF are dragged northwards in the West Wind Drift by the prevailing westerly wind system, contributing to the water subducting along this front. They are separated into the Subantarctic Surface Water (SASW) and Circumpolar Surface Water (CSW) south of Australia and New Zealand at c. 51°S by the Subantarctic Front (Burling, 1961; Heath, 1985). The Antarctic Polar Front (AAPF) separates the Antarctic Surface Water (AASW) from the subantarctic watermasses (Gordon, 1975; Thompson and Edwards, 1981; Heath, 1985).



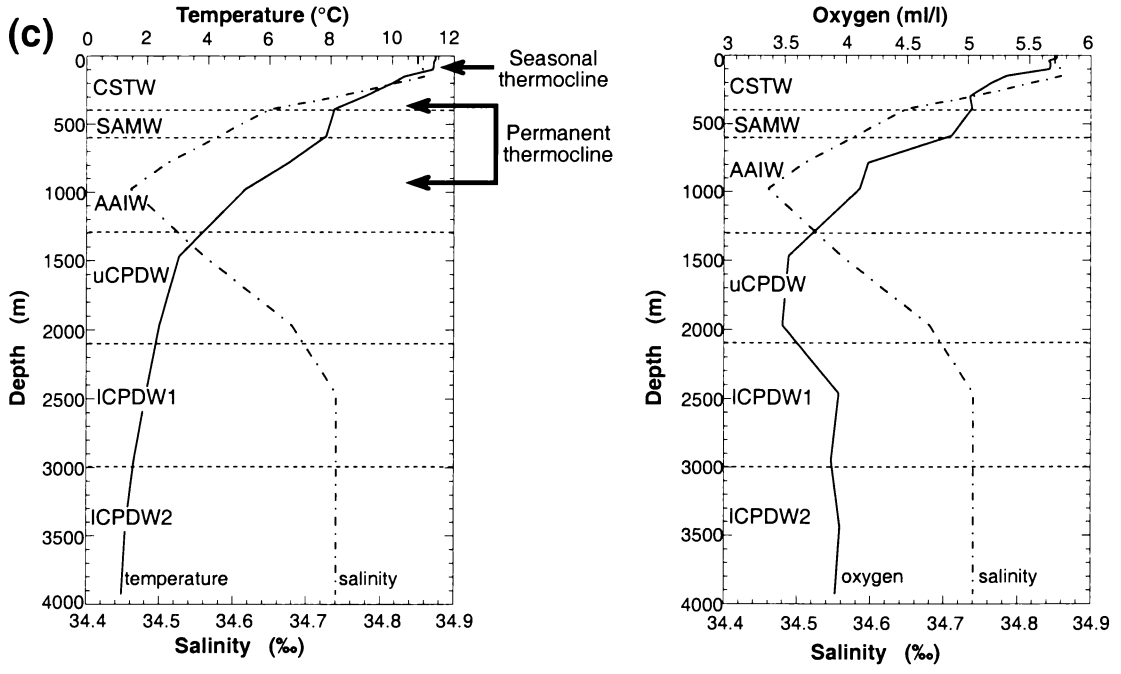


Figure 10 (a) Oceanic fronts and surface watermasses in the Southwest Pacific region; (b) cross section through 40°30'S using STD profiles to define the watermasses in the Tasman Sea; (c) winter salinity, temperature and depth (STD), and oxygen profiles from station Di924, just south of Site 593; CSTW = warm and saline surface watermass; SAMW = subsurface oxygen maximum and thermostad; AAIW = regional salinity minimum; *u*CPDW = oxygen min below salinity min; *l*CPDW$_1$ = deep salinity max; *l*CPDW$_2$ = deep oxygen max. STD profile is not deep enough to record AABW, which would be a deep temperature minimum if present. After Garner (1962; 1967) and Garner and Ridgway (1965).

WATERMASSES ABOVE THE PERMANENT THERMOCLINE IN THE TASMAN SEA

In vertical profile, the watermasses of the southern Tasman Sea, cross section at 40°30'S in Fig. 10b are established using STD profiles (Fig 10c), and their properties are noted in Appendix A.

Warm and Cool Subtropical Water (WSTW and CSTW)

Warm Subtropical Water (WSTW) in the Tasman Sea north of the Tasman Front is a mixture of Subtropical Surface Water (SSW) and Subtropical Lower Water (SLW) (Wyrtki, 1962b; Heath, 1985). The SSW originates in the central South Pacific as a high salinity surface watermass associated with the subtropical gyre, and SLW derives from it (Wyrtki, 1962b). SLW can be split into northern and southern components, with the northern component sinking near its area of origin and travelling westwards within the gyre in the lower layers of the SEC (the sinking is evident as the loss of oxygen once it reaches the Coral Sea), but still remaining as

a subsurface salinity maximum north of 20°S (Wyrtki, 1962b). Some of the northern SLW that reaches the Coral Sea becomes entrained into the southward-flowing East Australian Current and then along the Tasman Front. The southern component of SLW spreads along 23-33°S and remains at the surface as an oxygen maxima (Wyrtki, 1962b). The limit of southern SLW approximates the northern edge of the Tasman Front (Rochford, 1983; Heath, 1985). However, there may be some direct entry of southern SLW into the Tasman Sea south of the Tasman Front, which travels southwards as subsurface flow along the west coast of New Zealand (Heath, 1985; Vincent and Howard-Williams, 1991).

South of the Tasman Front, Cool Subtropical Water (CSTW) is formed by winter subduction along the Subtropical Front, southeast of Tasmania at c. 150°E (Szymanska and Tomczak, 1994). This watermass can be separated into lower and upper CSTW, with the upper unit marked as a salinity maximum with temperatures of 9-12°C at no more than 200 m depth and representing the active ventilation of the lower layer (Szymanska and Tomczak, 1994). The lower layer is subducted from the surface mixed layer during winter, and below this the temperature/salinity profile displays the smooth, nearly linear relationship usually found in central/mode water (Szymanska and Tomczak, 1994). In the southern Tasman Sea the seasonal thermocline and surface mixed layer, extending to c. 200-300 m (Garner, 1962; Garner and Ridgway, 1965; 1967; Rahmstorf, 1992), block off the surface from the permanent thermocline. Water downwelled from the surface during summer by Ekman pumping gets incorporated into the winter mixed layer before it can escape into the permanent thermocline. Although Ekman pumping moves the warm surface water downwards during summer, it is too weak to allow this water to significantly change the CSTW properties (Szymanska and Tomczak, 1994). Because the seasonal thermocline disappears altogether during winter in the Southwest Pacific, the lowest part of the seasonal thermocline has winter characteristics that persist all year (Tomczak and Godfrey, 1994). In summer the deep surface mixed layer and seasonal thermocline restrict upwelling to localised areas and as a result the surface waters of the Tasman Sea are relatively nutrient-depleted (Bradford and Roberts, 1978).

Bass Strait Water (BSW) enters the southern Tasman Sea predominantly in winter and can be traced as a cold saline water mass which cascades down the shelf under the warmer, less saline and slightly less dense CSTW (Godfrey et al., 1980; Tomczak, 1981; Villanoy and Tomczak, 1991). BSW sinks to c. 400 m and is recorded many kilometres offshore but is eventually mixed into the CSTW by the large eddies generated from the EAC (Tomczak, 1981). Significantly, BSW is slightly warmer (12-15°C) and more saline (35.7‰) than SAMW (6-9°C, 34.6-34.7‰), but is slightly less dense. This may explain why it does not sink below c. 400 m depth which is recorded as the upper depth limit of the mode water.

Subantarctic Mode Water (SAMW)

In the Australian-New Zealand Sector of the Southern Ocean, south and east of Australia, formation of SAMW south of the SAF has been observed but does not make any contribution to AAIW (Thompson and Edwards, 1981). This is unlike the situation in the southeastern Pacific where the bulk of this watermass is generated and SAMW and AAIW formation are directly linked (McCartney, 1982). SAMW is recognised as a subsurface oxygen maximum in the Southwest Pacific as it moves north and eastwards from source (McCartney, 1982), reaching the continental margin of Australia in the southern Tasman Basin at 450-850 m depth (Edwards and Emery, 1982) (Fig. 11). SAMW in the Tasman Sea is slightly warmer than it is over the Campbell Plateau (Heath, 1985).

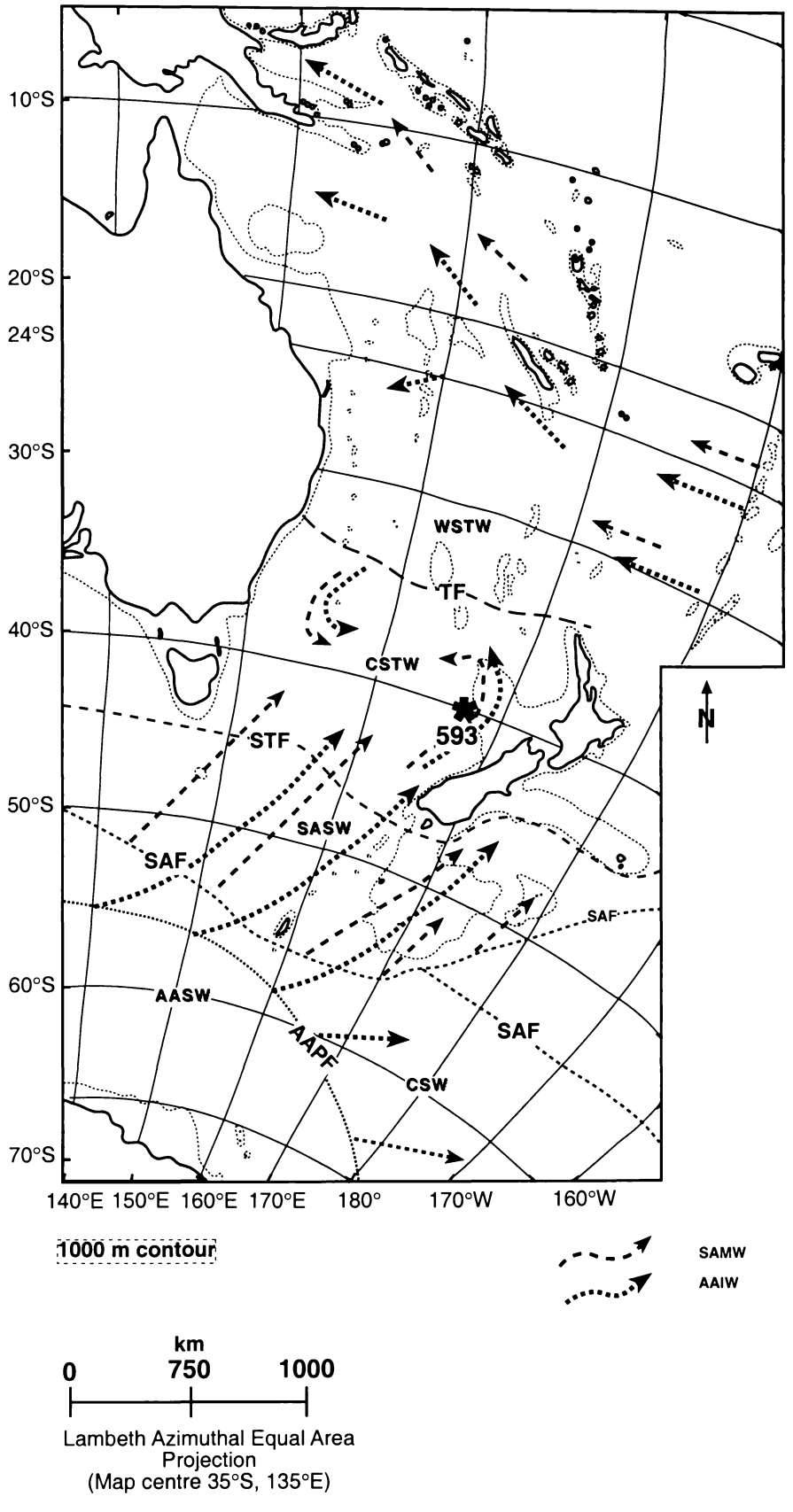


Figure 11 Modern Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW) in the Tasman Sea region. After Wyrtki (1961; 1973), Bingham and Lukas (1994), Fine et al. (1994), Tomczak and Godfrey (1994) and Hautala et al. (1996).

WATERMASSES BELOW THE PERMANENT THERMOCLINE IN THE TASMAN SEA

Antarctic Intermediate Water (AAIW)

Antarctic Intermediate Water (AAIW) in the southwest Pacific region originates at the Antarctic Polar Front (AAPF) between 52-62°S in the Australian-New Zealand sector of the Southern Ocean (Belkin and Gordon, 1996; Nelson, 1996) (Fig. 11). It is defined by a regional salinity minimum (c. 34.3-34.4‰ in the Tasman Sea) at depths between 600 and 1300 m (Wyrtki, 1962b; Johnson, 1973; Piola and Georgi, 1982; Heath, 1985; Ridgway and Loch, 1987). AAIW forms below the surface between the AAPF and SAF and therefore does not contain SAMW in the Southwest Pacific (Thompson and Edwards, 1981).

AAIW enters the Tasman Sea from two directions, the northern route between New Zealand and Fiji at c. 25°S with a core depth of c. 700 m, and the southern one between Tasmania and New Zealand with a core depth of c. 1000 m (Rochford, 1960a, b; Wyrtki, 1962b; Thompson and Edwards, 1981; Heath, 1985). The southern AAIW does not travel very far north into the Tasman Sea, with a zone of mixing of the dual-sourced AAIW waters between 30-40°S (Wyrtki, 1962b). Limited AAIW flow from the south into the Tasman Sea is linked to the opposing southerly flow of the EAC (Rochford, 1960a, b).

The northern AAIW route arrives north of New Zealand via the subtropical gyre and the eastern Pacific, rather than from flow directly northwards around the Chatham Rise (Wyrtki, 1962b; Reid, 1986; Tomczak and Godfrey, 1994; 1997). Recent studies (Neil, 1997; Weaver et al., 1997, 1998) of foraminiferal stable isotope values from core samples across the Chatham Rise have shown that the two routes of AAIW can be distinguished based on their $\delta^{13}C$ records, with the southern route AAIW exhibiting a more enriched $\delta^{13}C$ signal indicating the watermass is younger and more ventilated. The modern vertical gradient of $\delta^{13}C$ near 35°S and the Tasman Front is about 0.4‰ (Kroopnick, 1985), indicative of mixing between surface and bottom waters, probably by upwelling.

Circumpolar Deep Water (CPDW)

In the Tasman Sea all three CPDW watermasses have been identified (Wyrtki, 1961). The salinity and temperature data for the Coral Sea indicate that $lCPDW_2$ does not flow over the Cato Sill at 2850 m, but that $lCPDW_1$, indicated by the salinity maximum in both the Coral and Solomon Seas, does (Wyrtki, 1961) (Fig. 12). The deep water in basins on the eastern side of the Lord Howe Rise (New Caledonia, South Fiji and New Hebrides Basins) originates from the north (Fig. 7) as southward-flowing PDW (Wyrtki, 1961) which is most likely modified CPDW arriving via the DWBC (see below).

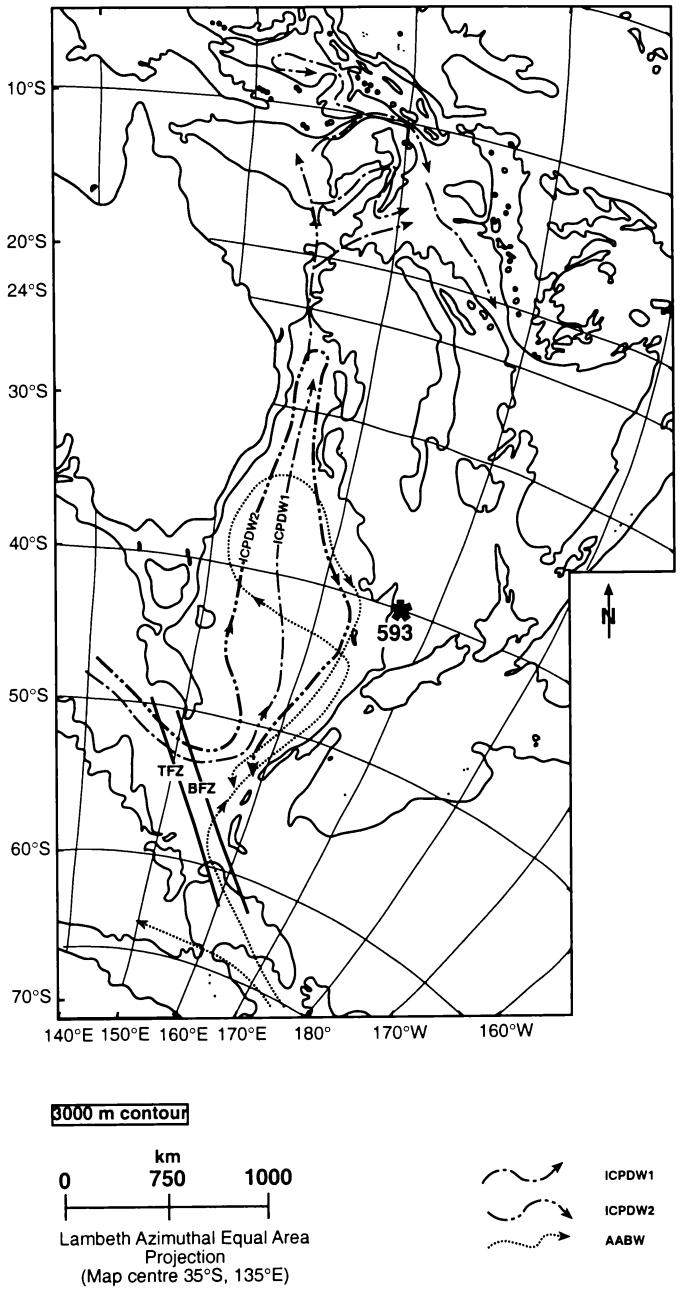


Figure 12 CPDW and AABW in the Tasman Sea. BFZ = Balleny Fracture Zone, TFZ = Tasman Fracture Zone. For source references see Fig. 4.

Antarctic Bottom Water (AABW)

In the southern part of the Tasman Basin AABW (mainly unmodified RSBW) is recorded entering the basin along the Tasman and Balleny Fracture Zones (Fig. 12) (Rodman and Gordon, 1982). These authors show that the deep waters of the eastern South Australian Basin are significantly warmer than those in the western part, proving the transfer of cold *l*CPDW$_2$ over the discordance (a distortion of the fracture zones along the crest of the Indo-Australian spreading ridge - see Fig. 1) does not spread to the east (i.e., *l*CPDW$_2$ does not enter the Tasman Sea from the west, but continues northwest towards the Indian Ocean) (Fig. 6).

Within the southern part of the Tasman Basin sediment erosion patterns are consistent with deep bottom flow from the southeast travelling northwestwards towards the coast of Australia (Jenkins, 1992). However, as there is no evidence for bottom water activity north of a large sediment drift off southwestern South Island (Jenkins, 1985; 1992), and bottom waters cannot escape from the northern Tasman Basin, some southwards return flow must occur. Osborn et al. (1983) suggested that the return flow travels southwards along the western edge of the Campbell Plateau and gets entrained into the ACC to flow through the Macquarie Ridge.

MODERN GATEWAYS

Oceanic gateways are used to describe areas where ocean flow can be, or is, controlled by regional tectonics (Crowley, 1992; Nelson et al., 1993; Carter and McCave, 1994; Heinze and Crowley, 1997; Leg 181 Shipboard Scientific Party, 1999). Gateways can be open, closed or restricted, and the degree of water flow exchange may vary with depth. The four major gateways which control circulation in the Pacific and Southern Ocean are the Tasmanian, Drake, Panamanian and Indonesian gateways. Of these, the Tasmanian (between Tasmania/South Tasman Rise and Antarctica) and Drake (between South America and Antarctic Peninsula) have been open since the Late Oligocene, c. 33-25 Ma (Kennett et al., 1972; Kennett et al., 1975; Lawver et al., 1992). With the opening of these gateways, complete circumpolar flow (ACC) around Antarctica became possible. The Panamanian Gateway has been closed since c. 3 Ma with restriction starting at about 15 Ma (Duque-Caro, 1990; Collins et al., 1996; Burton et al., 1997). Flow through the

modern Indonesian Gateway is restricted and dominated by water originating in the North Pacific (Fine et al., 1994; Gordon, 1995; Gordon and Fine, 1996). Nof (1995) reports a total throughflow of 7 Sv, with 6 Sv originating in the North Pacific and 1 Sv from the South Pacific, although there is considerable annual variation as the throughflow is very dependent on monsoon directions (Gordon, 1995). The combination of thermohaline flow and gateway access results in the modern heat and flow conveyor belt (Fig. 13).

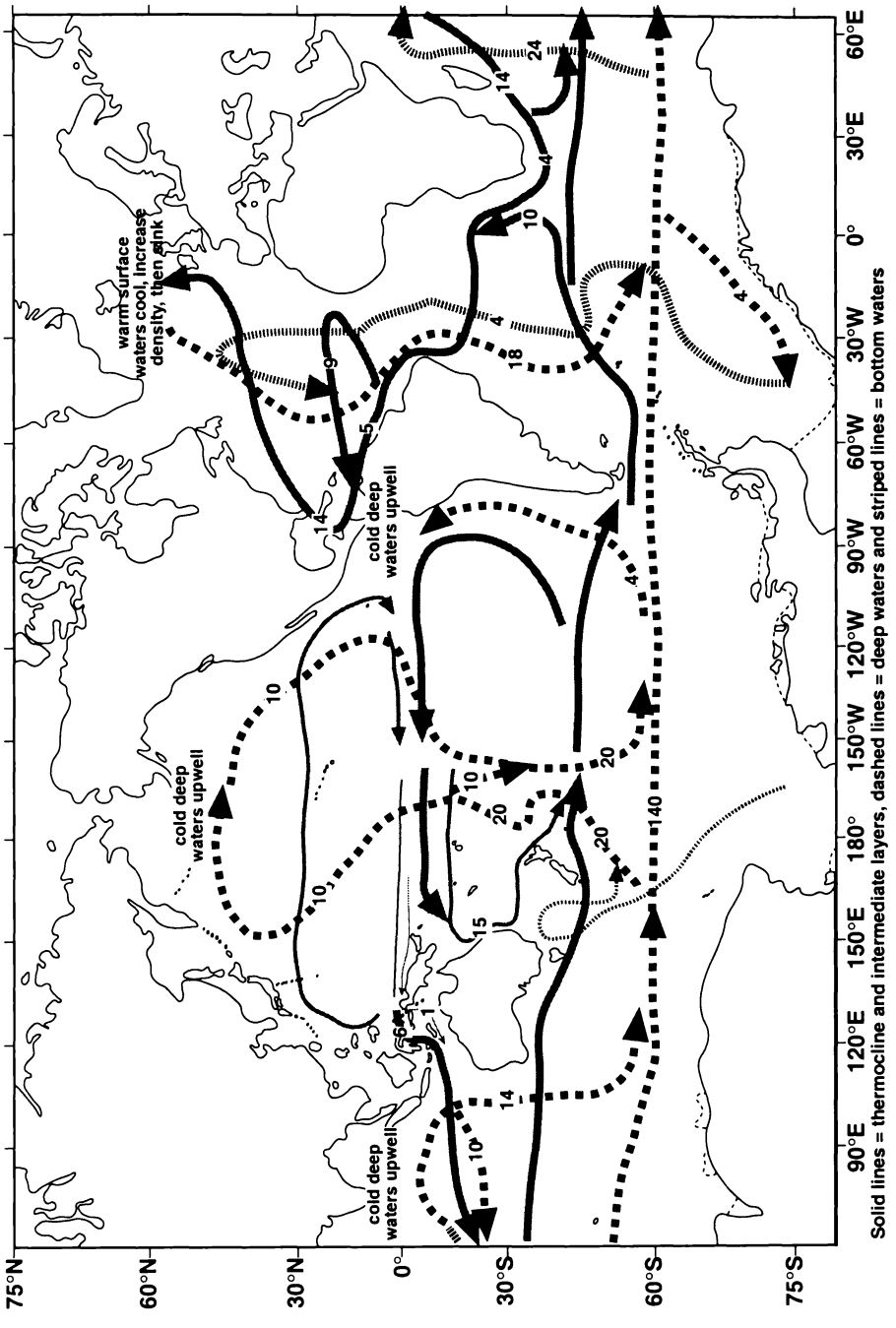


Figure 13 The global thermohaline conveyor belt, showing flow rates in Sverdrups (where 1 Sv = 10^6 m^3s^{-1}). After Patterson and Whitworth (1990), Tomczak and Godfrey (1994), Schmitz (1995), Gordon and Fine (1996), Roemmich et al. (1996) and Broecker (1997).

PALAEOCEANOGRAPHY

Palaeo-watermass nomenclature

Most watermasses are defined in terms of their salinity, temperature, oxygen concentration, silica content and/or density, and as these properties cannot be measured in the palaeo-oceans the use of modern watermass nomenclature (defined by these properties) may be inappropriate for describing palaeocirculation. To partly overcome this, the term Component Water has been used, where Northern Component Water (NCW) and Southern Component Water (SCW) are palaeo-watermasses originating in the North Atlantic and Southern Ocean, respectively (e.g., Wright and Miller, 1993). NCW is the pre-modern proxy for NADW, and SCW for Antarctic-derived waters which may be further divided into intermediate and bottom water, namely SCIW and SCBW for AAIW and AABW, respectively. However, the modern names are used if a more specific distinction is needed and known. A list of abbreviations appears in the glossary.

Use of proxies

As it is not possible to actually sample ancient oceans, the use of proxy measurements which can be linked to specific oceanic conditions is necessary (Wefer et al., 1999; Table 1). The proxy parameters used in this study include: sediment texture and composition, microfossil assemblage biogeography, and stable oxygen and carbon isotopes.

Sediment texture

Grain size in open ocean sediments is dependent on sediment supply, transport mechanisms and bioproduction. As a general rule, larger grains require higher energy to be transported any distance from source, and so the relative proportions of the sand-, silt- and clay-sized fractions in sediments can be used to elucidate transport history (Rao, 1997). In many studies this is done using the terrigenous fraction as the carbonate fraction may have been variably dissolved by corrosive bottom waters (e.g., McCave, 1984; McCave et al., 1986, 1995). On carbonate platforms such as the Lord Howe Rise, terrigenous grains typically constitute <10% of the sediment (Robert et al., 1986), and so textural analysis can only be done on the available carbonate fraction.

Table 1. List of parameters used as palaeoclimatic proxies data for reconstructing palaeoenvironmental conditions (SST = sea surface temperature; SSS = sea surface salinity; BWT = bottom water temperature; CCD = carbonate compensation depth). After Diepenbroek et al. (1999).

Parameter type	Parameter	Source	Proxy
microfossil	planktic forams		SST; surface productivity
assemblage	benthic forams		bottom water oxygen; BWT
	coccoliths		SST
	radiolarians		SST; export productivity
	diatoms		SST; sea ice distribution
	silicoflagellates		SST; export productivity
	ostracods		SST; SSS; BWT
	pollen		terrestrial vegetation
stable isotopes	Oxygen $\delta^{18}O$	forams	SST; BWT; salinity
	Carbon $\delta^{13}C$	forams	utilisation of organic carbon; productivity
	Nitrogen $\delta^{15}N$	organic matter	nutrients; surface productivity
	Strontium $^{87}Sr/^{86}Sr$	sediment	continental weathering
	Osmium $^{187}O/^{186}O$	sediment	continental weathering
	Boron	forams	pH
sediments	Ice rafted debris	sediment	continental ice sheets and glaciers
	Texture	sediment	velocity of bottom currents
	Clay minerals	sediment	velocity and direction of bottom currents
	Mineralogy	sediment	source of sediment; direction of transport
biogenic compounds	organic carbon TOC	sediment	pCO_2; export productivity; terrestrial input
	Calcite $CaCO_3$	sediment	export productivity; CCD history
	Opal SiO_2	sediment	export productivity
	Biomarker Uk37	coccoliths	SST; pCO_2; surface productivity
radio-nuclides	Lead ^{210}Pb	sediment	particle flux
	Thorium ^{230}Th	sediment	partical flux
	Protactinium ^{231}Pa	sediment	particle flux
elements	Rare earth elements	sediment	particle flux
	Sr/Ca	corals	SST
	Ge/Si	bio-opal	nutrients; continental weathering
	Cd/Ca	forams	nutrients
	Ba/Ca	forams	alkalinity
	Barium	sediment	productivity
	Vanadium	forams	distribution of anoxic sediment
	Uranium	forams	carbon cycling in ocean/atmosphere
	Phosphorus	sediment	nutrients; continental weathering
	Fe/Mn hydroxides	sediment	redox conditions

As foraminiferal shells weaken due to dissolution they break into smaller fragments and as a result transfer grains from the coarse- to fine-sized fraction of the sediment (usually from sand to silt) (Wefer et al., 1999). This enables textural changes to be

used as a proxy for dissolution. Sitting at only c. 1100 m water depth, Site 593 sediments are bathed by non-corrosive (to carbonate) Antarctic Intermediate Water (Fig. 10c). As the Hole 593 carbonate content throughout the Neogene is consistantly greater than 90% (Mycke et al., 1986), this supports the assertion that dissolution has not greatly affected these sediments and it is inferred that any textural changes are not due to dissolution. The use of bulk carbonate content in sediments to monitor dissolution rates is more useful than textural changes at it reflects loss or addition of calcite to the system rather than just a transfer to smaller size fractions (Dittert et al., 1999).

Sediment composition

The composition of oceanic sediments comprises a mixture of biologically-produced "in situ" grains and any grains (either biogenic or detrital) transported into the area. Distinction between them is necessary. Changes in composition within one size fraction over time at any one site can provide information on changing ocean conditions. One such compositional change, used to track deep water circulation changes during the Cenozoic, is the proportion of biogenically produced silica to carbonate in sediments. Silica is often the limiting factor in both diatom and radiolarian growth, as the concentration in ocean waters is dependent on erosion of silica-rich landmasses and the transport of dissolved silica around the ocean. Any area with silica-rich sediments is likely to reflect upwelling, where the dissolved silica is brought to the surface and incorporated into the diatom and radiolarian tests. Calcareous sediments usually represent a mixture of phyto-bioproduction in surface waters and zoo-bioproduction in both surface waters and in/on bottom sediments.

Generally sluggish bottom water circulation through the Eocene to middle Oligocene when no circum-Antarctic current was possible, resulted in limited upwelling and consequently low surface water productivity as few nutrients, specifically dissolved silica, were brought into the photic zone (Kennett et al., 1975; Brewster, 1980; Kennett and Stott, 1990). The main phytoplankton group was the coccoliths and the global ocean was marked by a shallow Carbonate Compensation Depth (CCD) with consequently limited carbonate sediment preservation (Brewster, 1980). By the Late Oligocene, the global CCD lowered (as a result of circulation changes, see below) resulting in increased preservation of calcareous sediments (Brewster,

1980). It has been estimated that the Late Oligocene CCD in the South Pacific at approximately 4200 m, shoaled by about 500 m to around 3700 m in the Early Miocene, but deepened again by the Middle Miocene to about 4100 m (Rea and Leinen, 1986). Prior to the Early Miocene no distinct lysocline above CCD is evident in the central southern Pacific (Rea and Leinen, 1986). By c. 18 Ma increased SCBW production 'forced' the separation of CCD and lysocline, reaching a steady state by c. 14 Ma with the lysocline about 600 m above CCD (Rea and Leinen, 1986). An increase in the coccolith 'calcite rain' production reflecting increased palaeoproductivity could also account for this separation, but the sedimentation rates at sites above and below the CCD are similar, so this is unlikely (Rea and Leinen, 1986).

By the Early Miocene (23-18 Ma) calcareous sediment distribution is found in a band between 50°N and 50°S in the western Pacific and in a narrower band between 20°N-20°S in the eastern Pacific and the central and southern Atlantic (Keller and Barron, 1983). The Middle-Late Miocene (13-8 Ma) eastern equatorial Pacific 'carbonate crash' and shallowing of the regional CCD is associated with closure of the Panama Gateway to deep waters, forcing non-corrosive NCW to remain in the Atlantic (Lyle et al., 1995). This reorganisation of the palaeocirculation, associated with increased NCW production (Wright and Miller, 1996), could account for the increase in carbonate sedimentation in the Atlantic between c. 12-7 Ma (Keller and Barron, 1983; Lyle et al., 1995).

Prior to the Middle Miocene, siliceous sediments tended to dominate in equatorial regions. The Middle Miocene (c. 16 Ma) increase in Southern Ocean, eastern equatorial Pacific and northern Pacific siliceous sedimentation, associated with a decline in siliceous sediments in the Central Atlantic, has been described as the 'Silica Switch' (Leinen, 1979; Keller and Barron, 1983). The gradual northward restriction of siliceous sediments to the North Atlantic during the Middle Miocene also coincides with initial restriction to deep waters through the Panama Gateway (Duque-Caro, 1990) and initiation/intensification of NCW flow (see Wright and Miller, 1996). The southwards-flowing NCW could have acted as a barrier to the upwelling of silica-rich SCBW at lower latitudes in the Atlantic Ocean (Wright and Miller, 1996). With restriction on upwelling, no silica and nutrients reached the surface, and

therefore no siliceous biosediment was produced (Keller and Barron, 1983). Some areas of local upwelling in the northern North Atlantic could still have occurred and would account for the small amount of siliceous sediments found. This suggests that 'forcing' the bulk of the silica-rich SCBW to remain in the Southern Ocean resulted in greater volumes of this watermass flowing into the Pacific (via the DWBC) and Indian Oceans. Consequently, increased dissolved silica availability to organisms in these oceans contributed to production of biosiliceous sediment.

During the Cenozoic, intensification of the westerly winds due to ice build-up on Antarctica and regional cooling, increased the surface water transport away from Antarctica and resulted in greater upwelling (probably at the Antarctic Divergence) to compensate (Brewster, 1980). This upwelling enriched the surface waters of the Southern Ocean in dissolved silica and resulted in an increase in biosiliceous sediment production (Brewster, 1980). In addition, the increased cooling would produce greater volumes of SCBW and SCIW and therefore invigorate circulation patterns globally. In the 'modern' ocean, that surface productivity increases during glacials is a result of the greater upwelling bringing nutrients to the surface, and not due to cooler temperatures which have a limited effect on productivity (Burckle, 1984; Burckle and Cirilli, 1987). As the production of antarctic-sourced waters increased, so the silica-rich, antarctic surface waters spread northward, along with the underlying sediment boundary (Keller and Barron, 1983; Nelson, 1996). The general Neogene, Southern Ocean trend in biogenic silica production has been for colder temperatures to be associated with increased biogenic opal contents and warmer ones with decreased contents (Brewster, 1980).

The Silica Switch cannot be explained just by a change in the location of biosiliceous palaeoproductivity, and requires an additional supply of silica (Leinen, 1979). Two hypotheses have been proposed which link the silicate-carbonate geochemical cycle with atmospheric CO_2 (see constructive summary of Sundquist, 1991). One approach looks at CO_2 levels through the Phanerozoic and suggests that they have varied in order to maintain chemical weathering and carbonate sedimentation in a steady-state (Berner, 1991; 1994; 1997). The other suggests that uplift and chemical weathering of the Tibetan Plateau and Himalaya (granitic silicate rocks) draw down CO_2 as well as supplying dissolved silica to the oceans (Raymo and

Ruddiman, 1992; Raymo, 1994; 1997). The links for both systems occur through the following simplified reactions, illustrated using calcium, but equally apply to magnesium silicate minerals (sodium and potassium silicate minerals also consume CO_2 during weathering, but are not recycled by carbonate mineral formation) (Sundquist, 1991):

$$3H_2O + 2CO_2 + CaSiO_3 \rightarrow Ca^{2+} + 2HCO_3^- + Si(OH)_4$$

(a) weathering

$$Ca^{2+} + 2HCO_3^- + Si(OH)_4 \rightarrow CaCO_3 + SiO_2 + 3H_2O + CO_2$$

(b) sedimentation

$$CaCO_3 + SiO_2 + 3H_2O + CO_2 \rightarrow 3H_2O + 2CO_2 + CaSiO_3$$

(c) decarbonation (during subduction recycling).

The increase in dissolved silica (equation a) supplied to the oceans results in a relative increase in siliceous bioproductivity (mainly diatoms; equation b) and less coccoliths. This results in less calcite reaching the sea floor which lowers pCO_2 and bottom waters become less corrosive to carbonate (Harrison, 2000). In addition, the formation of the Tibetan plateau disrupted and altered atmospheric circulation to the extent that evaporation and precipitation in the areas of deep water sources were affected (Raymo and Ruddiman, 1992; Raymo, 1994; 1997).

Microfossil assemblages

Modern microfaunal and floral assemblages have been shown to have discrete habitats (Hemleben et al., 1989). This appears to apply to the past where tropical assemblages can be distinguished from say, polar ones. Some planktic foraminiferal distributions have been linked to either high or low phytoproductivity, used to indicate changes in the nutrient content of surface waters (Wefer et al., 1999), often the result of upwelling. Often it is the assemblage rather than individual species which provide latitudinal or palaeoenvironmental information. While a very important part of palaeoceanographic studies, this proxy does not form part of this study, but is used in a parallel study (Crundwell, in prep.).

Oxygen isotopes

The isotopic composition of marine calcite is influenced by both the metabolic incorporation of CO_2 into the calcite (the vital effect), the temperature of calcification and by variations in sea water $\delta^{18}O$ values. As the mean $\delta^{18}O$ of the whole ocean varies with the quantity of isotopically light ice stored on the continents (Fig. 14), the record from foraminiferal calcite is a blend of global (ice volume) and local (temperature) components (Emiliani, 1955; Kennett, 1986). Some species incorporate oxygen molecules into shell calcite in equilibrium with sea water and others actively fractionate the isotopes resulting in a 'vital effect' (Rao, 1996). The $\delta^{18}O$ record of planktic foraminifera may also be affected by surface watermass salinity and changing species seasonal growth and depth habitats. Benthic foraminifera are less subject to changes in water temperature and salinity, and therefore provide a less complicated record of global ice volume (Chappell and Shackleton, 1986). The difference between benthic and planktic $\delta^{18}O$ values in the same sample provides a measure of the vertical temperature gradient in the absence of measurable temperature records. For example, during most of the Eocene the $\delta^{18}O$ records indicate that bottom and surface water temperatures were only a few degrees different (Frakes et al., 1992) whereas in the modern ocean the difference may be 15-20°C (Rao and Nelson, 1992).

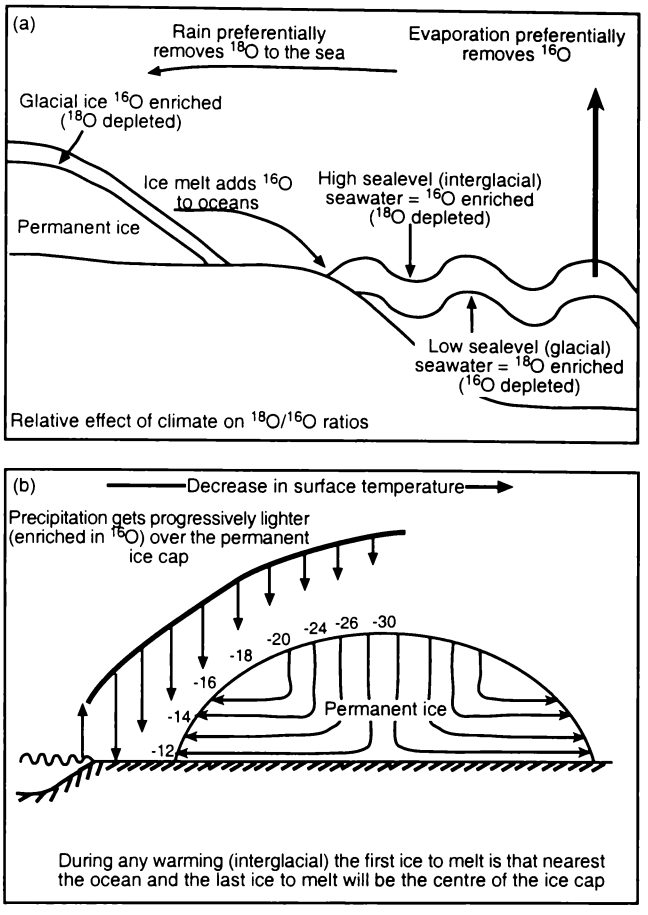


Figure 14 (a) Relative effect of climate on the $^{18}O/^{16}O$ ratio; (b) ice accumulation on an ice sheet in relation to the isotopic composition. After Shackleton (1987), Rao (1996), C. Hendy (pers. comm., 2000).

Isotopic evidence for palaeotemperatures and ice volume changes

In order to make estimates of sea water palaeotemperatures and of ice volume, the $\delta^{18}O$ of the sea water is needed. Use of tropical planktic foraminiferal $\delta^{18}O$ records has been suggested to help in this regard. For example, Site 807 lies within the tropical warm pool on the Ontong Java Plateau, and the isotopic record for the last two glacial cycles, when converted to glacio-eustacy, matches the sea-level change indicated by coral-reef records (Prentice et al., 1993). This would appear to indicate that the warm pool is thermally stable and that global ice-volume history can be read directly from western equatorial Pacific planktic $\delta^{18}O$ records (Prentice et al., 1993). But this may not always have been the case because in the early Miocene the Site 807 planktic record is enriched in $\delta^{18}O$ and it would appear that the site was bathed by different equatorial currents, having different salinity and/or temperature values at this time (Prentice et al., 1993). However, in the tropical Atlantic Ocean SSPTs (sea surface palaeotemperatures calculated from isotopes) remained within 2°C of

the mean Holocene SSTs during the Last Glacial Maximum (LGM; having corrected for ice volume effect) indicating tropical Atlantic surface waters really did not get colder during the LGM (Stott and Tang, 1996). Calculated SSPTs in the western equatorial Pacific are at most c. 4°C cooler during LGM and a slight decrease in the sea surface to thermocline temperature gradient in the eastern equatorial Pacific is consistent with increased upwelling during LGM due to invigorated trade winds (Patrick and Thunell, 1997). This suggests that the tropical SSPTs values can be used only as a guide for ice volume calculations during glacial events.

Carbon isotopes

Carbon isotopic values of shell calcite can also be related to the environment of secretion. Carbon values are related to the cycling of ^{12}C due to biological activity, and the overall dissolved carbon dioxide (ΣCO_2) gradient in the ocean is a function of the productivity of the surface waters. Hence changes in $\delta^{13}C$ of foraminiferal calcite can provide information on palaeoproductivity (Fig. 15). As ^{12}C is preferentially taken up by marine phytoplankton and incorporated into organic material this enriches surface waters in ^{13}C. As a result, planktic foraminiferal calcite $\delta^{13}C$ is highest in shallow-dwelling species and regions of high surface water productivity, exhibit well developed vertical gradients of ΣCO_2 (Kroopnick, 1985). Planktic foraminifera which live at depths below the surface (deep-dwelling species) reflect this by exhibiting slightly less enriched $\delta^{13}C$ values.

Deeper waters contain increasingly higher concentrations of ΣCO_2 due to the high ^{12}C organic material 'raining' down onto the seafloor. This organic carbon is subject to decomposition which recycles ^{12}C-rich CO_2 back into the water via respiration and results in benthic foraminiferal calcite becoming enriched in ^{12}C, hence showing a depleted $\delta^{13}C$ signal compared with planktic foraminifera. This all assumes that no active fractionation, or 'vital effect' (Grossman, 1987; Spero et al., 1991) occurs during calcite secretion, or if it does, that it can be corrected for. Since the $\delta^{13}C$ value of sea water is partly a reflection of productivity, the nutrient status of the water is contained within in the isotopic values, with low benthic calcite $\delta^{13}C$ usually associated with high nutrient concentrations (Kroopnick, 1985 Mackensen, 1993). Hence estimates of palaeoproductivity can be established from $\delta^{13}C$ records.

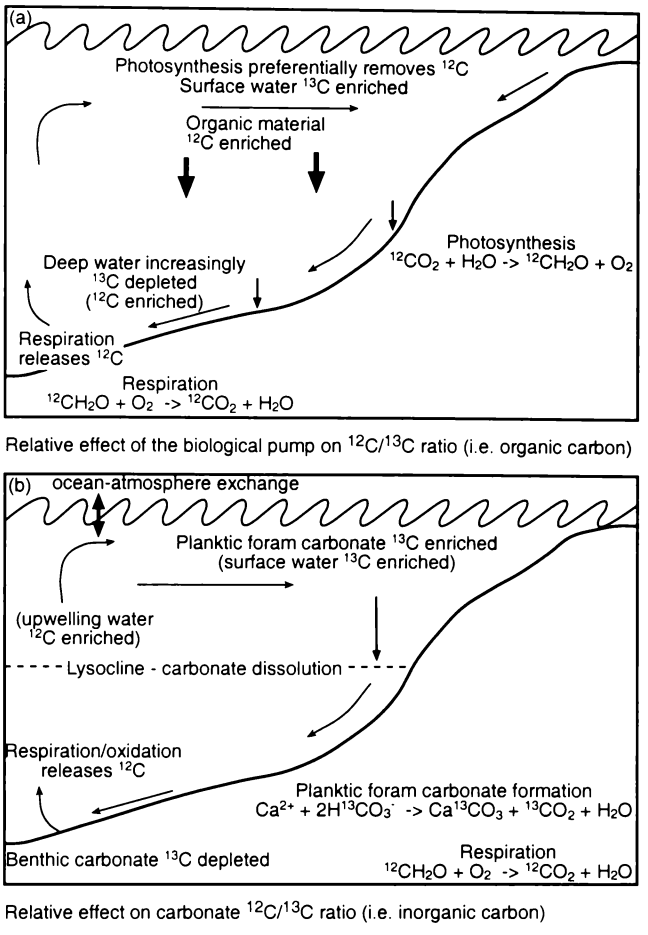


Figure 15 (a) Relative effect on the organic carbon $^{13}C/^{12}C$ ratio of the biological carbon cycle; (b) relative effect on the carbonate $^{13}C/^{12}C$ ratio for inorganic carbon. After Vincent and Berger (1985).

In addition, the mixing of watermasses and the time since each watermass was in contact with the atmosphere becomes important and provides an 'ageing' or 'ventilation' signal. The longer the watermass is isolated from the atmosphere, the more depleted it will become in $\delta^{13}C$ (Berger, 1981; Berger and Vincent, 1986). Modern NADW has high $\delta^{13}C$ values (1.0‰) because the Atlantic Ocean has a short residence time (NADW is largely composed of upper ocean waters; Wright et al., 1991) and overlying surface productivity is low, limiting any significant accumulation of oxidised organic matter. The Pacific and Indian Ocean changes in $\delta^{13}C$ result from deep water aging (residence time >1000 years) as they are ventilated by AABW with lower $\delta^{13}C$ values of 0.4‰ (it does not contain much surface water, and any it does contain originates as shelf/slope waters which have low phytoproductivity; Wright et al., 1991) and due to the relatively high phytoproductivity

in equatorial regions (Kroopnick, 1985). CPDWs have a relatively uniform $\delta^{13}C$ signal because they are well mixed (Kroopnick, 1985).

At high latitudes the ocean-atmosphere exchange of CO_2 enriches surface waters in $\delta^{13}C$ relative to the atmosphere and isotopic fractionation (during gas exchange) increases with decreasing temperature (Charles and Fairbanks, 1990; Charles et al., 1993). Ocean-atmosphere equilibration at 0°C would result in $\delta^{13}C$ about 3‰ higher than equilibration at 25°C (Mook et al., 1974), but oceanic mixing is fast enough that complete equilibration is never reached (Charles et al., 1993). However, there is about 1‰ enrichment in surface water $\delta^{13}C$ at the Antarctic Polar Front suggesting that persistently high gas exchange occurs there resulting in partial equilibrium with the atmosphere (Charles and Fairbanks, 1990). This has been termed 'thermodynamic tagging' and any watermasses which contain 'tagged' surface water will reflect this enrichment in $\delta^{13}C$ (Charles and Fairbanks, 1990; Charles et al., 1993). Climate modelling has demonstrated that the tagging imprint would increase in colder waters with the result that glacial southern sourced intermediate waters would have a greater thermodynamic signal than during interglacials (Mackensen et al., 1996). AAIW can be distinguished from SAMW at LGM using $\delta^{13}C$ (Neil, 1997).

Planktic foraminifera which lived and secreted calcite in surface waters would be expected (vital effects aside) to reflect light $\delta^{18}O$ and heavy $\delta^{13}C$ values. Conversely, benthic foraminifera should exhibit the opposite, with the heavy $\delta^{18}O$ reflecting the much colder bottom waters in which they lived and the light $\delta^{13}C$ the release of the ^{12}C-rich CO_2 (Shackleton and Kennett, 1975a; Erez and Honjo, 1981; Erez and Luz, 1983; Shackleton et al., 1985). Deep water circulation patterns based on $\delta^{13}C$ reflect modern patterns by c. 7 Ma, and possibly as early as 9.8 Ma (Wright et al., 1991).

Change from halothermal to thermohaline circulation

During the Early Palaeogene, when it is generally acknowledged that there was little or no ice on Antarctica, the ocean circulation was limited by the landmass configuration. Antarctica sat over the South Pole with the Antarctic Peninsula linked to South America and with the South Tasman Rise linked to coastal Antarctica

(Frakes et al., 1992). The lack of ice resulted in ocean circulation being density driven rather than thermally driven (Kennett and Stott, 1990). Although halothermal (density-driven) circulation is likely to be more sluggish, the Coriolis force would still have been acting on the water and the Earth would still have had wind systems attempting to approach the ideal (landless) situation. The intensity of the winds is likely to have been less because there was not the degree of cooling at the poles, resulting in reduced atmospheric thermal gradients (Kennett and Stott, 1990).

Eocene (and possibly Late Palaeocene) deepwater circulation (Fig. 16a) was driven by halothermal processes (deep water convection) consisting of warm saline deepwater overlain by a colder, fresher watermass with surface waters warmer than today (Kennett and Stott, 1990). The Warm Saline Deep Water originating from the Tethys Sea (also called Tethys/Indian Saline Water; Woodruff and Savin, 1989) created the densest watermass, with a colder but less dense (only reaching intermediate depths) Southern Ocean watermass overlying it (Kennett and Barker, 1990; Kennett and Stott, 1990). This warm deep water flowing towards Antarctica contributed to the transport of meridional heat to southern high latitudes, designated as the Proteus Ocean (Kennett and Stott, 1990). Prior to the Oligocene any ice volume on Antarctica would not have been sufficient to have influenced isotopic composition of the oceans, suggesting changes in $\delta^{18}O$ of shell calcite prior to the Oligocene are likely to be attributed to changes in water temperature and not to ice volume (Kennett and Barker, 1990; Kennett and Stott, 1990).

During the Oligocene, as ice volume on Antarctica increased, the circulation pattern changed (Fig. 16b) to a transitional system between halothermal and thermohaline circulation (Kennett and Stott, 1990). The ocean consisted of three components: two cold, relatively fresh watermasses originating in southern high latitudes, separated by a warm saline, southward flowing layer (determined using oxygen isotopes by Kennett and Stott, 1990). The deepest watermass was analogous to Antarctic Bottom Water (i.e., SCBW) and may have been formed as a result of sea ice around East Antarctica (Kennett and Barker, 1990). The existence of the Antarctic Polar Front in the Oligocene (Nelson and Cooke, 2001) with the implied SCIW and SCBW formation represents the beginning of modern biogeographic and ocean zonation. Kennett and Stott (1990) suggested the production of SCBW

flowing below WSDW, would displace WSDW toward the surface and contribute to its mixing into surface waters. This would increase the salinity of surface waters and once the mixed waters cooled, would reinforce sinking of cold, saline SCBW.

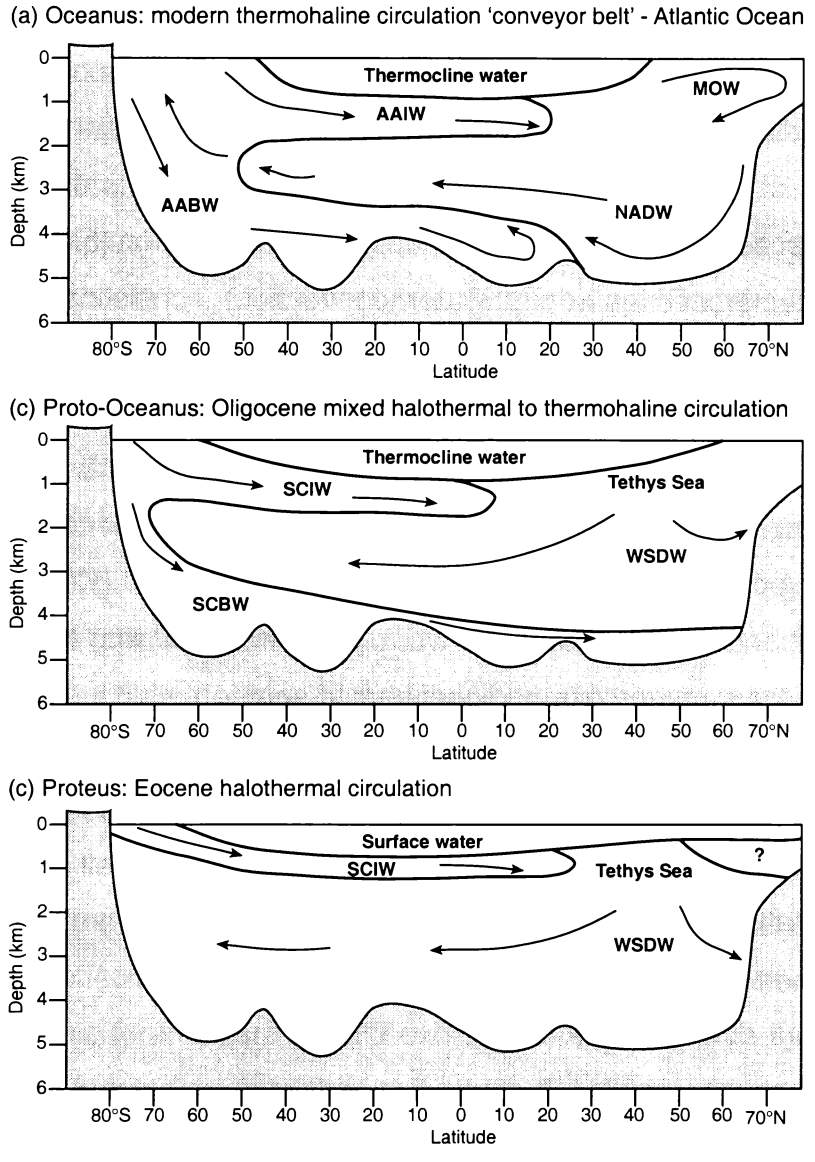


Figure 16 (a-c) General ocean structure changes through the Cenozoic as inferred from oxygen and carbon isotopic results. AAIW = Antarctic Intermediate Water; AABW = Antarctic Bottom Water; NADW = North Atlantic Deep Water; MOW = Mediterranean Overflow Water; SCIW = Southern Component Intermediate Water; SCBW = Southern Component Bottom Water; WSDW = Warm Saline Deep Water. After Kennett and Stott (1990).

The Neogene deep oceans (Oceanus) were ventilated by thermohaline circulation resulting from freezing conditions at high latitudes (Fig. 16c) where cold, dense deep water sinks and travels from high latitudes towards the equator, and warmer more saline surface waters flow towards the poles, forming a 'conveyor belt' (Fig. 13) (see Schmitz, 1995; Broecker, 1997). The northward-flowing SCIW and SCBW were

compensated for by southward-flowing deep waters (Kennett and Stott, 1990), although it appears no NCW was produced prior to 20 Ma (Wright and Miller, 1996). Residual Tethys-derived deep waters did not reach below intermediate depths (<1500 m; Woodruff and Savin, 1989; Kennett and Stott, 1990), and on reaching the Southern Ocean would have been mixed into the circumpolar current. This may have contributed to the early Middle Miocene warming of Antarctic as inferred by the benthic oxygen isotopic data (Savin et al., 1981). By the Middle Miocene Tethys Sea input was greatly reduced with a consequent reduction in the meridional heat transport to the Southern Ocean, resulting in complete thermal isolation of the Antarctic region (Woodruff and Savin, 1989).

Oceanic fronts and palaeocirculation

In addition to tectonic controls, the position of oceanic fronts is mostly a function of the global wind system and secondarily of the meridonal thermal gradient (Tomczak and Godfrey, 1994; Brown et al., 1998). Consequently, as the antarctic region cooled through the Oligocene and Miocene, the wind system would have intensified and migrated northwards, 'migrating' some/all of the established Southern Ocean fronts with it (Nelson and Cooke, 2001). This is evident in the vegetation history of Australia where the Oligocene vegetation in the central region is cool-temperate forest dependent on an absence of seasonal changes in rainfall, attributed to the development of the ACC forcing the northward-migration of rain-bearing westerly wind systems which contributed ample rainfall to the area (White, 1999). Through the Early Miocene the vegetation of southern Australia indicates the region was well watered, but from c. 15 Ma onwards central and northern Australia dried out due to increasingly dry anticyclonic atmospheric circulation over the region (White, 1999). By the Late Miocene there is increasing seasonal rainfall and further aridity throughout central and western Australia (White, 1999).

Any increase in the ACC baroclinic (lateral variations in density) component would require an increase in the strength of the stratification within the southern hemisphere subtropical water column (Gordon, 1990). Changes in SSPTs on the Queensland Plateau from tropical (>20°C) during the Middle Miocene (c. 15 Ma), when the plateau was latitudinally on the tropics/subtropics boundary at 24-29°S, to 'temperate' or warm subtropical (16-19°C) by the Late Miocene (c. 10.4 Ma) (Isern

et al., 1993), reflect the reorganisation of palaeocirculation in the Southwest Pacific. Effectively this amounted to an increase in the number of latitudinal climatic 'zones', specifically, partitioning into tropical, warm subtropical, cool subtropical, and subantarctic. It is worth noting that the large increase in SSPTs from c. 16-19°C to c. 25°C on the Queensland Plateau during the Pleistocene, is actually the result of subsidence allowing warmer, tropical waters to flow across the platform, and not from any real increase in sea surface temperatures (Isern et al., 1993). A reduction in the number of climatic zones has been inferred during the Middle Miocene warming, where there is expansion (i.e., northward migration) of the subtropical zone in the Northwest Pacific (Gladenkov, 1994), suggesting the climatic zonation was reduced due to the increase in global temperatures.

The general components of circulation of the South Pacific is not likely to have changed much through the Neogene, with a subtropical gyre and tradewinds and west wind drift. Prior to ACC, the gyre probably extended southwards through the Tasman Sea and south of New Zealand. However, the intensity of these general components did change, e.g., Robert et al. (1986). During the Oligocene, tropical waters with siliceous microfossils became restricted to north of Site 592 (central Lord Howe Rise - prior to this the siliceous zone extended farther south; Nelson, 1996). As the ACC developed and the New Zealand landmass had migrated sufficiently northwards, the southern subtropical gyre became displaced to the east of New Zealand via a developing proto-Tasman Front. There is no isotopic evidence that subantarctic surface waters from south of the Subtropical Front have extended into the Tasman Sea during at least the last c. 20 Ma (Kennett, 1986; this study Chapter 3).

Tasman Sea during the Neogene

The basic seafloor topography in the region of Site 593 (Fig. 1) has not changed much since the Tasman Sea rift system ceased spreading by c. 55.5 Ma (Sutherland, 1994). Post-rift subsidence of the Challenger Plateau ceased by the middle Eocene and the plateau has remained stable since then (Burns and Andrews, 1973; Wood, 1993). Because rifting started in the south and extended northwards, the Tasman Basin has a triangular shape with deep-water circulation restricted in the north, forcing some return flow out of the basin through the

Macquarie Ridge (Jenkins, 1985, 1992). Northward migration of the Australian Plate, and with it the Lord Howe Rise, since the Eocene has transported the Challenger Plateau northward across c. 15° latitude, reaching c. 50°S in the Early Miocene and its modern position at 40°S by the Quaternary (Nelson, 1996).

The regional surface-water circulation pattern and position of the ocean fronts have been in place since at least the Middle Miocene (Nelson, 1996; Nelson and Cooke, 2001). However, the mode/intermediate water circulation pattern has developed during this time with vertical $\delta^{18}O$ gradients after c. 15.6 Ma, and especially after 13.8 Ma, indicating increased production of SCIW associated with East Antarctic Ice Sheet growth entering the region (Flower and Kennett, 1995). Sediment textural changes associated with isotopic 'glacial' events support the suggestion of increased velocity, and therefore winnowing of sediments at Site 593 during this period of increased ice sheet growth (this study Chapter 2).

Although Shackleton and Kennett (1975b) reported a substantial increase in surface-water temperatures at Site 281 on the South Tasman Rise in the Late Miocene, the bottom waters were not affected. This is in contrast to the early Miocene warming where bottom-water temperatures increased by 2°C at Site 279, on Macquarie Ridge (Shackleton and Kennett, 1975b), most likely because the mean annual sea temperature around Antarctica rose significantly above 0°C, thus raising the whole ocean bottom water temperature. Any changes in surface-water temperature from Hole 281 during the Late Miocene can be linked to changes in the position of the STF, and may simply reflect the migration of the front across the site (Nelson and Cooke, 2001). During the Last Glacial Maximum, the Subtropical Convergence Zone either side of the STF narrowed, and the temperature and density gradient across the front intensified (Neil, 1997). This may result in the apparent 'migration' of the front as surface-water conditions change above a specific point on the seafloor.

PALAEO-GATEWAYS

Palaeocirculation patterns have been altered in two important ways: (1) the modern thermohaline circulation has only been possible since the advent of large amounts of ice on continental Antarctica (Fig. 17) and the production of cold, dense bottom

waters, concomitant with the closure of the Tethys Gateway and cessation of Warm Saline Deep Water flow into the Indian Ocean at c. 15 Ma (Woodruff and Savin, 1989); and (2) the opening and closing of other oceanographic gateways (Lawver et al., 1992) which forced global circulation patterns to change.

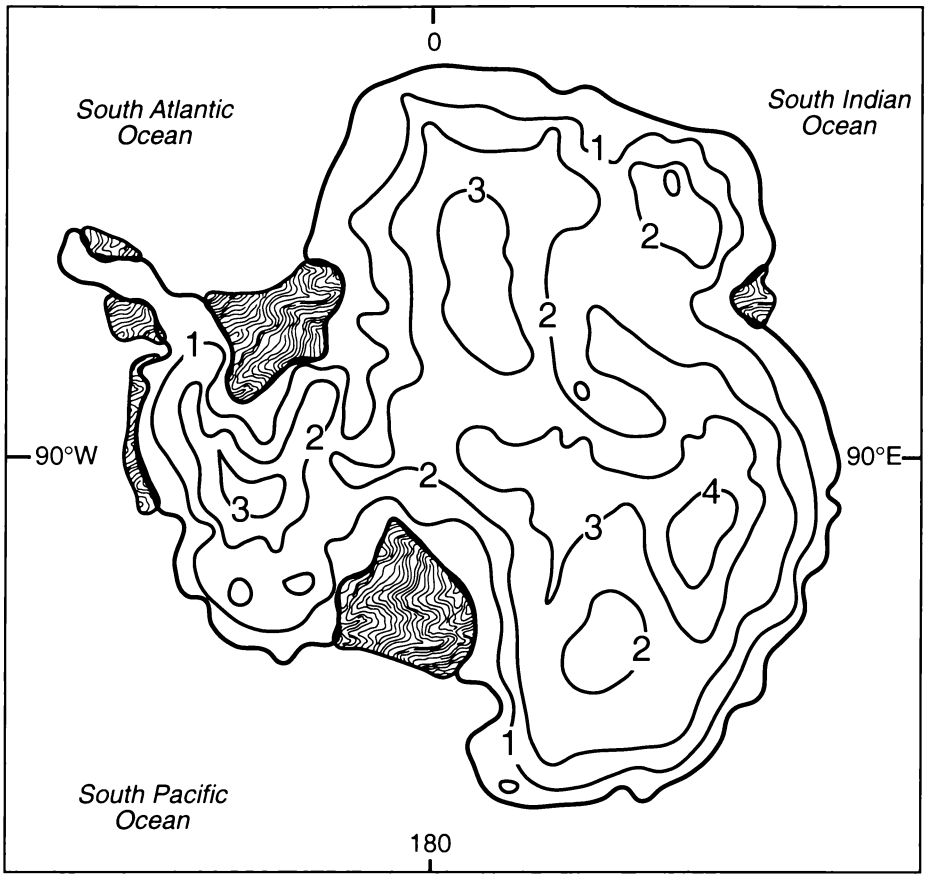


Figure 17 Approximate ice thickness of the Antarctic Ice Sheet in 1 km contour intervals. Major ice shelves indicated by shading. After Oerlemans (1982).

Tasmanian Gateway

This gateway lies between the South Tasman Rise/southern Tasman Sea and eastern Antarctica (Fig. 1). Prior to the latest Eocene this gateway was closed and it started 'leaking' by c. 35 Ma (Lawver et al., 1992). Sediment compositional changes in several South Tasman Rise sites at c. 33 Ma (Leg 189 Shipboard Scientific Party, 2001), and the appearance of Austral Gulf planktic foraminiferal taxa in the Southwest Pacific by c. 31 Ma (Jenkins, 1993), indicate a surface water connection through the gateway by the earliest Oligocene, and that it reached a fully open state by c. 25 Ma (Nelson and Cooke, 2001). Although not obviously as narrow as the Drake gateway, it is as restricted, with consequently increased flow velocities of the ACC through it.

As the Tasmanian gateway opened, the New Zealand landmass was located directly down current and consequently subject to the full impact of initial ACC flow (Fulthorpe et al., 1996). There is abundant evidence for strong shallow-water palaeoflow along and over the New Zealand margin since at least the late Oligocene (Carter and Landis, 1972; Kennett et al., 1972, 1975; Carter, 1988; Carter et al., 1996).

Drake Gateway and West Antarctic Seaway

This gateway is now open and lies between the Antarctic Peninsula and the Andean chain (Frakes et al., 1992), but prior to at least 25 Ma, the two regions were joined and formed a barrier to ACC development (Barker and Burrell, 1982; Barker et al., 1988; Lawver and Gahagan, 1998). The deep-water opening of this gateway may be as young as c. 25 Ma and it is only since it opened that full ACC flow has been possible (Nelson and Cooke, 2001). The absence of ice on Antarctica prior to the late Middle Eocene suggests that the continental basement configuration, comprising the main East Antarctic craton and the West Antarctic archipelago (Fig. 18), should govern the regional palaeocirculation. Reconstruction using the West Antarctic rift system, which underwent significant extension during the Eocene-Oligocene (Cande et al., 2000), and microfaunal assemblages (Lazarus and Caulet, 1993), has indicted that this rift may have provided a shallow, surface water, proto-ACC, connection between the Pacific and Atlantic Oceans, named the West Antarctic Seaway (WAS) (Nelson and Cooke, 2001). With the development of the East Antarctic Ice Sheet, the closure of the WAS by the earliest Miocene and the opening of the Drake gateway (these two may be linked), full ACC flow was possible and associated with it, the initial thermal isolation of the continent (Matthews and Poore, 1980). Forest plants are recorded in the Ross Sea region until the Late Oligocene (White, 1999), and West Antarctic Ice Sheet development (through/ between the archipelago) is inferred from models, to have occurred only once ice reached sea level, and sea level temperatures of –5°C (Fig. 19) (Oerlemans, 1982; Oerlemans and van der Veen, 1984).

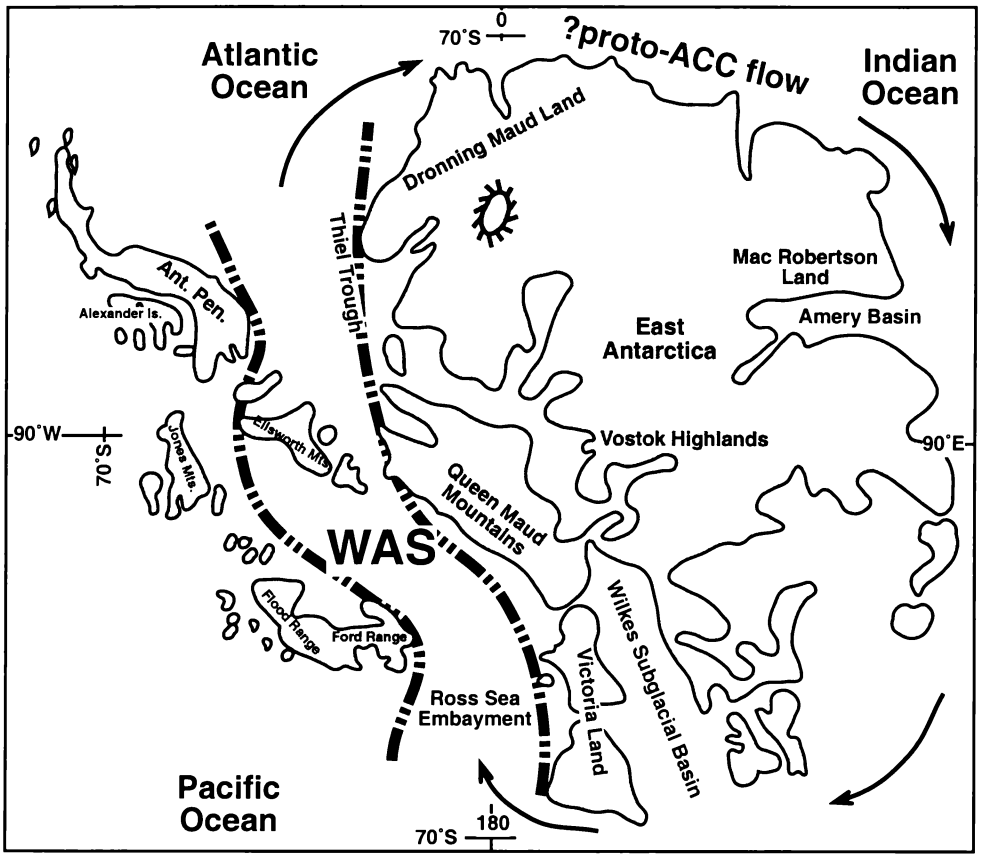


Figure 18 Antarctic subglacial bedrock at 0 m elevation (Drewry, 1983) used to show possible West Antarctic Seaway (WAS) connecting the Pacific Ocean to the Indo-Atlantic Oceans (see Wise et al., 1991; Cande et al., 2000; Nelson and Cooke, 2001). The WAS is inferred to have existed between the Late Eocene to Late Oligocene and may have accommodated circum-Antarctic flow prior to the opening of both the Tasmanian and Drake gateways.

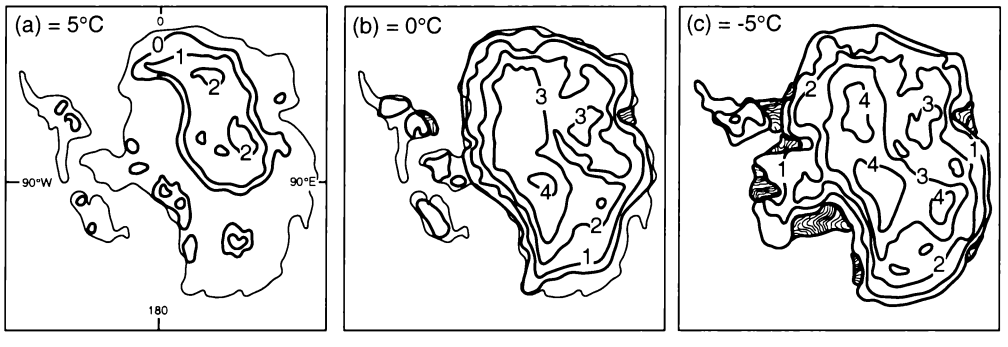


Figure 19 (a-c) Equilibrium states of the model Antarctic Ice Sheet for three annual sea level temperatures. Heavy lines are ice thickness contours in km. Ice shelves indicated by shading. Note a sea level temperature of –5°C leads to the initiation of the West Antarctic Ice Sheet. After Oerlemans (1982) and Oerlemans and van der Veen (1984).

Panama Gateway

The Panama gateway (Fig. 1) has had a dramatic effect on global circulation throughout the Neogene. Evidence for flow through this gateway comes from foraminiferal biogeography and sediment patterns (composition and texture) in the

Pacific Ocean and Caribbean Sea. These show the gateway was open to all water depths prior to about 16 Ma (Duque-Caro, 1990). The deep water flowing from the North Atlantic into the Pacific was probably compensated for by the inflow of warmer, surface/near-surface water from the South Atlantic (Duque-Caro, 1990; Crowley, 1992).

The relevant part of the circulation of the North Atlantic is the link between the Gulf Stream and NADW. The modern Gulf Stream flows northwards over the Blake Plateau (800-1200 m) as the Florida and Antilles Currents, carrying warm, saline (upper permanent thermocline) water to the North Atlantic (Sverdrup et al., 1942; Mantyla and Reid, 1983; Emery and Meincke, 1986). This flow occurs as a deep geostrophic current that includes most or all of the water column (to c. 1200 m depth) along its path (Kaneps, 1979). These warm, saline waters then flow into the Norwegian Sea (Fig. 13) where they cool and sink to form NADW which flows southwards via the Iceland and Greenland Seas (Tomczak and Godfrey, 1994; Bauch et al., 2000). This cycle transports large amounts of heat to the North Atlantic which affects precipitation and snow production and is linked to the development of the late Neogene Fennoscandian Ice Sheets.

In addition to the circulation of the North Atlantic, seafloor topography has had a role in controlling the flow of NCW (proto-NADW). Thermal expansion and subsidence along the Greenland-Scotland Ridge during the Neogene, restricted or enhanced the ability of the northward-flowing, high salinity surface water (via the Gulf Stream) to reach the 'NADW generating sites'. Consequently, if the surface waters cannot extend sufficiently northwards, then NCW cannot form, and any which may form cannot get over the ridge and flow southwards (Wright and Miller, 1996). This reduction in NCW flow is linked to several Miocene glacial events and antarctic ice sheet formation (Wright and Miller, 1996).

General ocean modelling experiments with an open Panama gateway which allows the free exchange of low salinity Pacific waters with the North Atlantic, results in the collapse of the North Atlantic thermohaline cell (Maier-Reimer et al., 1990). This suggests that while the gateway was open, modern thermohaline circulation was not possible. However other models show that some level of thermohaline circulation in

the North Atlantic is possible without complete closure of this gateway (Maier-Reimer et al., 1990; Mikolajewicz et al., 1993; Mikolajewicz and Crowley, 1997).

Deep water flow through this gateway has been inferred using differences in isotopic signatures between the Atlantic and Pacific Oceans. NADW has an unradiogenic neodymium (Nd) composition, whereas AABW contains more radiogenic Nd and has done so throughout the Neogene (Burton et al., 1997). Between 20-12 Ma the open Panama gateway allowed throughflow of deep North Atlantic waters into the Pacific, which diluted the radiogenic Nd signal in Central Pacific sediments. A 'sudden' increase in radiogenic Nd in the Central Pacific around 12 Ma, suggests closure of the Panama gateway to deep waters of North Atlantic origin (Burton et al., 1997). This ties in with changes in benthic foraminiferal assemblages by 12.9-11.8 Ma, indicating disruption to flow through the gateway and possible initiation of the North Atlantic Gyre and Gulf Stream (Duque-Caro, 1990).

The benthic foraminiferal evidence from Sites 502 (Caribbean) and 503 (Guatemala Basin) has been used by McDougall (1996) to infer that both sites were influenced by AABW (probably *l*CPDW$_2$) travelling through a deep open gateway during the Late Miocene. As the deep-water connection was closed by the Late Miocene, it appears more likely that the benthic foraminifera were influenced by the same/ similar watermass flowing either side of South America (i.e., the modern situation where *l*CPDW flows into the South East Pacific Basin and the North Atlantic (Fig. 6).

An active Gulf Stream between 16-10.5 Ma is inferred from erosion patterns on the Miami Terrace where the sediments of the plateau show pronounced upward loss of fines since the Late Miocene, taken to indicate fluctuations in volume transport and velocity which winnowed the sediments (Mullins and Neumann, 1979). There is a dramatic hiatus in these sediments where up to 100 m of section representing c. 1.3 Ma was stripped from the plateau at the Miocene/Pliocene boundary, with this and other hiatuses corresponding to glacials (Mullins and Neumann, 1979).

In general the benthic foraminiferal evidence suggests that by 8 Ma the Panama gateway had become an effective oceanic and biogeographic barrier (Collins et al., 1996), with deflection of the Gulf Stream by this time (Mullins and Neumann, 1979).

There was a slight deepening to a max c. 500 m, of parts of this gateway at c. 6 Ma, allowing a jet of Pacific NECC/EUC (evident by Pacific affinity benthic foraminifera found in the Caribbean sediments) to enter the Caribbean (Collins et al., 1996). However, as it appears the Gulf Stream reached its present configuration by the Late Miocene (c. 6.1 Ma), this influx of Pacific-origin water does not represent fully-open conditions (Mullins and Neumann, 1979). The velocity of the Gulf Stream increased between 4 and 3 Ma, as a result of the complete closure of the Panama gateway (Mullins and Neumann, 1979). Mixed layer $\delta^{18}O$ values from shallow-dwelling planktic foraminifera indicate some surface mixing across the gateway just prior to c. 4 Ma (Keigwin, 1982), but after that the values deviate indicating the final closure between 4 and 3 Ma. The final closure of this gateway and the consequent invigoration of thermohaline circulation in the North Atlantic have been linked to the onset of Northern Hemisphere glaciation and ice sheet development (Shackleton et al., 1995).

The timing of initial Northern Hemisphere glaciation has recently been extended back from the Late Pliocene to the Late Miocene by the presence of ice-rafted debris (IRD) and drop stones in sediments off southern Greenland dated to 7 Ma, indicating full glacial conditions were established in this region of the North Atlantic (Larsen et al., 1994). A recent re-examination of these sediments established that there are IRD grains below these glaciomarine sediments, which are dated to c. 11 Ma, providing a minimum age for the beginning of glaciation in the North Atlantic (Helland and Holmes, 1997). Southeast Greenland would readily support glaciers because of the combination of high precipitation and high topography (Larsen et al., 1994). This suggests that modern thermohaline circulation and initial Northern Hemisphere ice sheet development occurred in association with the effective closure of the Panama gateway at 8 Ma, rather than the absolute closure at c. 3 Ma because the deflection of the Gulf Stream is linked to NCW formation and precipitation.

In the eastern equatorial Pacific the most convincing evidence for deep water closure of this gateway is seen in the Middle-Late Miocene (13-9 Ma) 'Carbonate Crash', where the CCD rapidly rose in the basins east of the East Pacific Rise (Fig. 1) resulting in large-scale dissolution of carbonate sediments (Lyle et al., 1995). The dissolution (the crash) has been attributed to an increase in influence of corrosive

antarctic-origin waters (equivalent to modern NPDW, CPDW or AABW) in the absence of non-corrosive, high $(CO_3)^{2-}$ NCW (Lyle et al., 1995), indicating partial deep water closure of the gateway by this time. Changes in sea level or palaeoproductivity productivity would not produce the extreme changes in mass accumulation rates (Lyle et al., 1995). This suggests that prior to the 'crash', either the flow of NCW prevented CPDW watermasses from reaching the eastern central Pacific Basins (similar to the AABW situation in the North Atlantic - see above), or that after the 'crash', the deflection of NCW into the ACC via the South Atlantic sufficiently invigorated the circulation to increase the CPDW flow into the Panama, Peru and Guatemala basins.

Indonesian Gateway

In the modern constricted gateway the bulk of through flow originates in the North Pacific and is upper thermocline flow, specifically, surface waters travelling via the Makassar and Lombok Straits (Fig. 9) into the Indian Ocean (Gordon and Fine, 1996). There is some lower thermocline flow which originates in the South Pacific, travels via the Halmahera and Banda Seas and reaches the Indian Ocean via the Timor Sea (Gordon and Fine, 1996). There is also a limited AAIW contribution below the lower thermocline flow (Gordon, 1995). Has this always been the case? If not, when might the situation have attained the modern configuration?

Both the Indonesian and Panama Gateways were open during the Early Middle Miocene (Hamilton, 1979; Duque-Caro, 1990; Burton et al., 1997), resulting in largely uninterrupted westward-flowing equatorial surface currents (equivalent to the modern SEC and NEC; Kennett et al., 1985) (Fig. 20a cf. Fig. 9). Without any barrier to flow through the Indonesian archipelago, there was no forcing of return flow back across the Pacific in the form of an equatorial undercurrent (Romine and Lombari, 1985). By the middle Middle Miocene the Indonesian gateway closed sufficiently to stop deep-water flow, but surface waters continued through the archipelago with the island of Borneo diverting some flow into the Kuroshio Current (Kennett et al., 1985). The volume and strength of both the western boundary currents (East Australian and Kuroshio Currents) would have been reduced compared with modern circulation (Kennett et al., 1985).

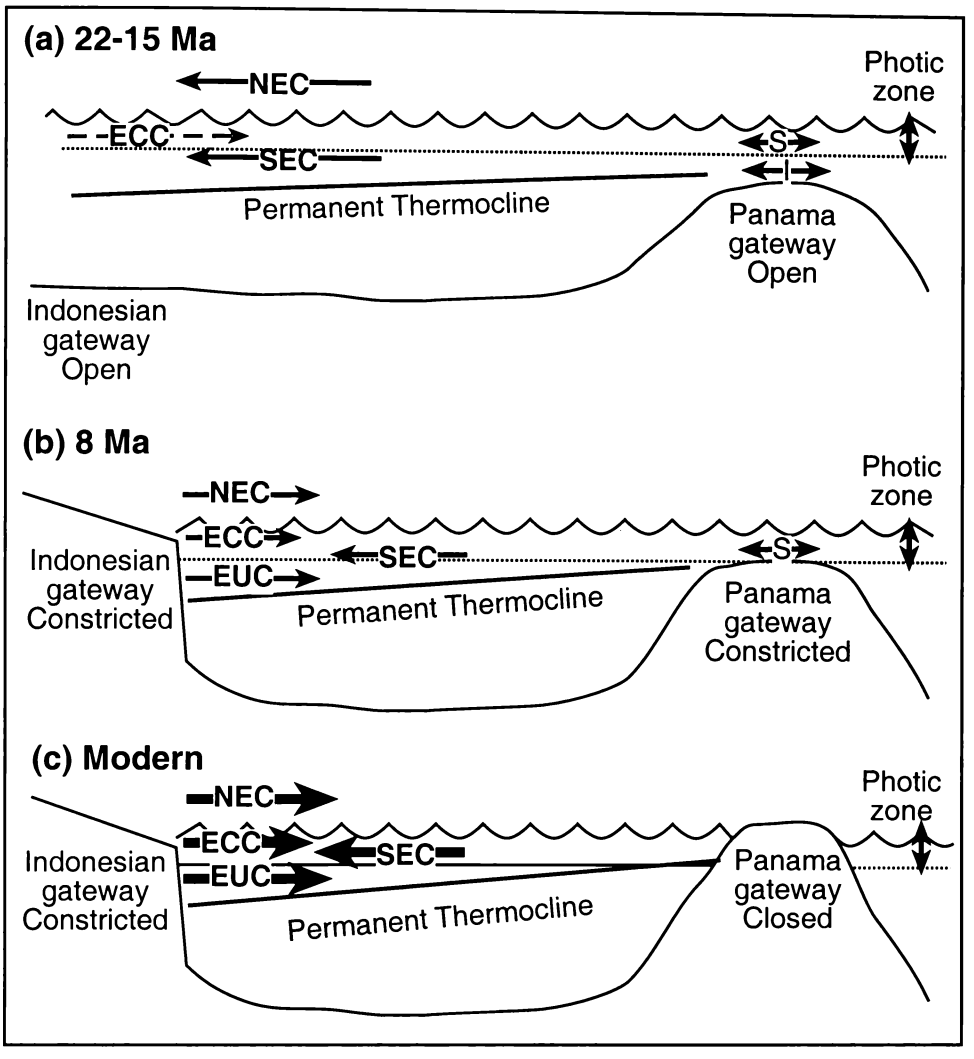


Figure 20 Neogene equatorial Pacific Ocean surface watermass structure for (a) Early Miocene; (b) Late Miocene; and (c) modern. NEC = Northern Equatorial Current, SEC = Southern Equatorial Current, EUC = Equatorial Undercurrent, ECC = Equatorial Counter Current. Panama Gateway: S = shallow flow, I = intermediate depth flow. Note that in the absence of the EUC, the permanent thermocline is relatively deep across the ocean, and as this current develops the thermocline shallows, especially in the eastern equatorial Pacific. Modern circulation is more vigorous and currents stronger. After Mullins and Neumann (1979), Kennett et al. (1985), Duque-Caro (1990), Lyle et al. (1995) and Burton et al. (1997).

Between 16 and 8 Ma planktic foraminiferal biogeographic changes indicate changes to surface water circulation in the Pacific Ocean and that this gateway had effectively closed to its modern position with the implied formation of the EUC (Kennett et al., 1985) (Fig. 20b). However, even in the modern ocean (Fig. 20c) this gateway forms an important throughflow for heat transfer via warm, surface tropical waters from the Pacific to the Indian Oceans (Schmitz, 1995; Broecker, 1997).

The changes in flow through this gateway have implications for conditions in the Tasman Sea. Between the LGM and Holocene the Tasman Sea DSDP cores record

isotopically-derived SSTs which differ only by ice volume – implying the southern Tasman Sea surface waters did not get colder during the LGM (Nelson et al., 1994). The explanation for this rests with the greater than modern constriction during the LGM on the Indonesian gateway which is inferred to have 'piled up' tropical surface water in the Western Pacific Warm Pool on the Ontong Java Plateau. There is no way for warm pool water to flow directly into the Tasman Sea, but it could have acted as a block on SEC flow towards the gateway and forced a larger proportion of this flow into the southern Tasman Sea via eddies in the EAC (Nelson et al., 1994). In support of this, warm subtropical planktic foraminifera have been reported from LGM sediments east of Tasmania, and eddies in the EAC was suggested as the transport mechanism (Martínez, 1994). This increased contribution of warm, tropical surface water during the last glacial (Marine Isotope Stage 2) maintained the surface-water temperature at pre-glacial values. As sea level started to rise at the transition between MIS2 and 1, flow through the gateway would have increased, reducing the block of the warm pool water, and hence decreasing the volume contribution of SEC to the EAC flow.

DEVELOPMENT OF THE DEEP WESTERN BOUNDARY CURRENT (DWBC)

During the latest Eocene to Early Oligocene there are a number of hiatuses and unconformities recorded in deep-sea sediments in the Southern Ocean and around the New Zealand continental margin (Kennett et al., 1972; Carter and McCave, 1994; 1997). The most significant of these erosion surfaces is the mid-Oligocene Marshall Paraconformity (32-29 Ma) recognised in South Island sedimentary sequences (Carter and Landis, 1972; Carter, 1985), the Chatham Rise and Bounty Trough (Carter et al., 1994; Leg 189 Shipboard Scientific Party, 2001) and in several DSDP Holes in the Tasman Sea (Nelson, 1986). This erosion surface is viewed as representing the initiation of circum-Antarctic circulation between 33-29 Ma as a result of the opening of the Tasmanian and Drake gateways (Kennett et al., 1972; Kennett et al., 1975; Lawver et al., 1992; Lazarus and Caulet, 1993; Fulthorpe et al., 1996). Once a circumpolar current was possible, along with the production of cold, deep waters, the potential for large-scale alterations of global circulation occurred, specifically the formation of northward-flowing deep water (DWBC) (Kennett et al., 1972; Kennett et al., 1975). However, this did require a compensating return flow

out of the Pacific Ocean through a gateway at any depth, hence the possible initiation of southward-flowing NPDW in addition to the warm shallow route through the Indonesian Gateway. This return flow is predicted by circulation modelling of the Pacific Ocean in relation to the opening of ocean gateways (Obata et al., 1996).

The formation by the Early Miocene of large sediment drifts to the north of the Campbell Plateau is taken to reflect the establishment of the DWBC with its capacity to transport sediment (Carter and McCave, 1994; 1997). These drifts formed as a result of a reduction in flow velocity, perhaps associated with early Miocene warming when there would be a consequent drop in circulation vigour, rather than as a result of increased sediment supply. This is because the plate boundary and orogeny through New Zealand, initiated by c. 24 Ma (Kamp, 1991), had not yet started to provide large amounts of sediment to the east coast of New Zealand (Carter and McCave, 1994).

Other evidence for DWBC flow comes from the Central Pacific Ocean where in Hole 596 a significant change in sediment composition and sedimentation rate occurs between 25-20 Ma (Zhou and Kyte, 1992). By c. 20 Ma the bottom-water flow velocities had increased sufficiently to carry andesitic glass from sources in the Southwest Pacific to Hole 596 (Zhou and Kyte, 1992), and by c. 14 Ma the increase in global circulation had sufficiently increased volumes of bottom and intermediate waters from cold southern latitudes (Kennett and von der Borch, 1986b; Kennett and Stott, 1990) evident as a hiatus in Southern Ocean and Pacific sediments (Zhou and Kyte, 1992; Carter et al., 1994), possibly hiatus NH2 at c. 16-15 Ma (Keller and Barron, 1983, 1987). In the Central Pacific this hiatus is marked by the formation of manganese hardgrounds (Zhou and Kyte, 1992). The sedimentation rates increase at c. 11 Ma in the Central Pacific, indicating a slight decrease in bottom-water velocities (Zhou and Kyte, 1992) and coincident with secondary drift formation north of the Campbell Plateau between 14-8 Ma (Carter et al., 1994). A second manganese hardground at c. 8 Ma in the Central Pacific suggests bottom-water velocity again increased, with modern sedimentation patterns being established by 6 Ma (Zhou and Kyte, 1992).

The invigoration of DWBC circulation during the Early-Middle Miocene has been linked with the expansion of the East Antarctic Ice Sheet (Carter et al., 1994), and in the Late Miocene to West Antarctic Ice Sheet build-up and increased production of AAIW (Cooke and Nelson, 1997). By backtracking Site 596 (to lie considerably further east and south of its current position at 20 Ma), Zhou and Kyte (1992) speculate that the northward-flowing currents (presumably DWBC and CPDW) prior to 20 Ma must have been spread over a greater area of the Southwest Pacific than the modern DWBC. As the ice sheets developed, circulation intensified (particularly between 20-12 and 10-6 Ma in the Central Pacific), is evident in the winnowing of the fine aeolian component leaving the andesitic glass in Hole 596 (Zhou and Kyte, 1992).

The deflection of NCW into the southern Atlantic and Southern Ocean as a result of the Panama gateway closure, with the consequent increase in ACC volume, is likely to have enhanced DWBC flow to the east of New Zealand (Carter and McCave, 1994). In the modern ocean the ACC carries CPDW, with its capacity to dissolve silica from Southern Ocean sediments and transporting the dissolved silica into the North Pacific (Edmond et al., 1979) where it is upwelled. The now silica-rich NPDW returns southwards, resulting in an increase in siliceous bioproduction and therefore sedimentation, in the northeastern and eastern equatorial Pacific (Keller and Barron, 1983).

While not directly affecting Site 593, DWBC development must be considered because changes in the palaeocirculation in one part of the ocean system (i.e., DWBC) may have 'knock-on' effects in other parts (e.g., the Tasman Sea).

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Chapter 2

A Miocene Textural Record From DSDP Site 593, Southern Tasman Sea: Sedimentary Dynamics In Pelagic Ooze And Its Palaeoceangraphic Implications

Somewhere hearts are happy,
Somewhere children shout,
But there'll be no joy in Mudville.
Til the Miocene gives out.

C. Craddock (1976) Leg 35

A Miocene textural record from DSDP Site 593, southern Tasman Sea: Sedimentary dynamics in pelagic ooze and its palaeoceanographic implications

ABSTRACT

Changes in Miocene sediment texture are used to infer changes in palaeocurrent velocities in pelagic carbonate-rich sediments on the Challenger Plateau, southern Tasman Sea. The most obvious record of this change is the mud/sand ratio. Increases in the sand content are inferred to indicate a general up core trend to increasing winnowing of sediments resulting from increasing flow velocity of Southern Component Intermediate Water (SCIW). In particular, the intervals c. 19-14.5 Ma and c. 9.5-8 Ma are times of inferred increased SCIW velocity and strong sediment winnowing. Within the mud fraction, the medium silt- to medium clay-sized grades from 6-9 ϕ (15.6-2 μm) make the greatest contribution to the sediments and are comprised of nannofossil plates. During extreme winnowing events it is the fine silt- to coarse clay-sized range (6.25-8.25 ϕ, 13-3 μm) which is preferentially removed, so that the 10 μm cohesive silt boundary reported for terrigenous sediments does not apply to calcitic skeletal grains. The winnowed sediment comprises coccolith placoliths and spheres, represented by a mode at 4-7 μm in the mud fraction grain size distribution

Further support for sea floor winnowing is gained from the presence in Hole 593 of a condensed section of sediment from c. 18-14 Ma where the sand content increases to c. 20% of the bulk sample. Associated with the condensed section is a 6 m-thick 'orange unit' representing sediments subjected to particularly oxygen-rich late Early to early Middle Miocene SCIW. Together these are inferred to indicate increased SCIW velocity resulting in winnowed sediment associated with faster arrival of oxygen-rich surface water subducted to form SCIW. Glacial development of Antarctica has been recorded from many deep-sea sites, with extreme glacials providing the mechanism to speed up watermass flow. Zones Mi1b to Mi6 are identified from Hole 593 (see Chapter 3), with consequent palaeocirculation invigoration linked to the winnowing events in the sediment texture record.

INTRODUCTION

Climate change and its effects on ocean circulation can only be monitored in ancient sediments using proxy parameters. Sediment texture can be used as a proxy as it provides a means of determining the mechanism of deposition, reworking and dispersal of sediments in the deep ocean (Gorsline, 1984), which in turn can be linked to palaeocirculation and palaeoclimatic changes. Changes in dominant grain size commonly relate to current velocity in the modern ocean (McCave, 1984; McCave et al., 1995b), and therefore textural changes in ancient sediments can be used to infer changes in palaeocurrent velocity. In the deep ocean the fine fraction (4-63 μm) is often the dominant component, making up to 75% of sedimentary deposits (Gorsline, 1984), and the palaeoclimate record it contains may be rather subtle. Deep-sea currents are rarely able to transport sand but can remove significant amounts of fine sediment, leaving a concentrated or condensed foraminiferal sand deposit (van Andel, 1973). Much of the fine fraction in ocean sediments is terrigenous, but around New Zealand on relatively shallow subsurface platforms and ridges under a kilometre or so of water, carbonate-rich pelagic ooze accumulates (Nelson, 1986b). Inferred palaeocurrent velocity changes can then be made of watermasses at intermediate depths, rather than in deep waters as is the case with many other studies (e.g., Ellwood and Ledbetter, 1977; Blaeser and Ledbetter, 1982; Ledbetter, 1984; McCave et al., 1995a).

Texturally, silt-sized particles (4-63 μm) are particularly diagnostic for studies of deposition and reworking by bottom currents (McCave, 1984). Many studies have concentrated on the non-carbonate silt fraction to infer changes in palaeocurrent velocities in a wide variety of localities, including the Vema Channel, South Atlantic (Ledbetter, 1984; Williams and Healy-Williams, 1984), the South Australian Basin (Allison and Ledbetter, 1982) and the Indian Ocean (Ellwood et al., 1979). In most cases, the non-carbonate sediment fraction was used because the target watermass was Antarctic Bottom Water (AABW), below the Carbonate Compensation Depth (CCD), and so there was a need to eliminate the effects on texture of foraminiferal fragmentation caused by dissolution in carbonate-undersaturated waters. Studies on the grain size and sediment texture of

carbonate-rich pelagic sediments appear relatively few in number (e.g., Oser, 1972; van Andel, 1973; Gardner et al., 1986a; House et al., 1991).

Factors which can affect the sediment texture can be divided into those which affect the supply of sediment, and those which occur post-deposition. Dissolution occurs where the pH of the watermass results in the removal of calcitic tests. Acidity can result from increased dissolved CO_2, and/or decomposition of organic matter. The Carbonate Compensation Depth (CCD) represents the boundary between the rates of carbonate supply and dissolution approximately compensating for each other (Berger, 1970; Berger and Winterer, 1974). The supply of carbonate sediment to the seafloor can be related to biological production over large areas of oceanic surface water and are reflected in the sediment accumulation below the area (Gorsline, 1984). Changes in the biological productivity may alter the sediment texture due to succession in the dominant organism in the overlying ocean waters. *In situ* removal of sediment, or certain sediment grain sizes by winnowing will alter the overall texture. Winnowing involves the selective erosion and transport of some fine fraction components, or the selective non deposition of that fine fraction, leaving the coarse fraction relatively intact. Once erosion or winnowing of fines has occurred, the surface lag deposit of coarser material may shield the underlying sediments from any further erosion which a current might otherwise normally achieve (Jenkins, 1985). Bioturbation is ubiquitous in areas where oxygen is not restricted and is limited only by the lowest oxygen concentration tolerated by seafloor organisms (Gorsline, 1984). When oxygen is not limited, bioturbation is influenced by the sediment accumulation rate and the availability of organic nutrients to the seafloor (Nelson, 1986a). Organisms tend to 'stick' particles together, either by eating and excreting them or by secreting 'slime' around themselves which alters the apparent grain size. The other major consequence of bioturbation is the vertical mixing of sediment, which will ultimately mask or destroy any stratigraphic changes in grain size (Nelson, 1986a). Finally, as pelagic carbonate sediments become increasingly lithified, the sediment type changes from ooze to chalk (Nelson, 1986a). The accompanying textural changes are the result of the response of the foraminiferal and nannofossil tests to a degree of pressure-dissolution during burial (Schlanger and Douglas, 1974). Carbonate recrystallisation will alter the grain size of biogenic particles and therefore the texture of the sediment.

AIMS OF THIS STUDY

This study investigates the nature and possible controls on sediment texture in the carbonate-dominated ooze from the Early-Late Miocene interval from DSDP Hole 593 in southern Tasman Sea. It draws upon both regional and more global palaeoceanographic factors to explain the textural variations evident in the high-resolution record.

PHYSICAL SETTING

Location of Site 593

Site 593 is located in 1068 m of water on the Challenger Plateau (40°30.47'S, 167°40.47'E) and is about 270 km offshore from northwestern South Island, New Zealand (Fig. 1). The site had previously been drilled as Site 284 (Leg 29) to 208 mbsf, collecting well preserved pelagic ooze and bottoming in sediments of latest Miocene age (approx. 7.4 Ma) (Leg 29 Shipboard Scientific Party, 1975). Based on this, Site 593 was drilled as a reoccupation of the site in order to gain a more extensive Neogene palaeoceanographic record for the region. The core contains a relatively undisturbed Late Palaeogene-Neogene pelagic ooze sequence with virtually no terrigenous sediment influence (Leg 90 Shipboard Scientific Party, 1986). It is the Early Miocene to earliest Pliocene interval that is examined in detail here.

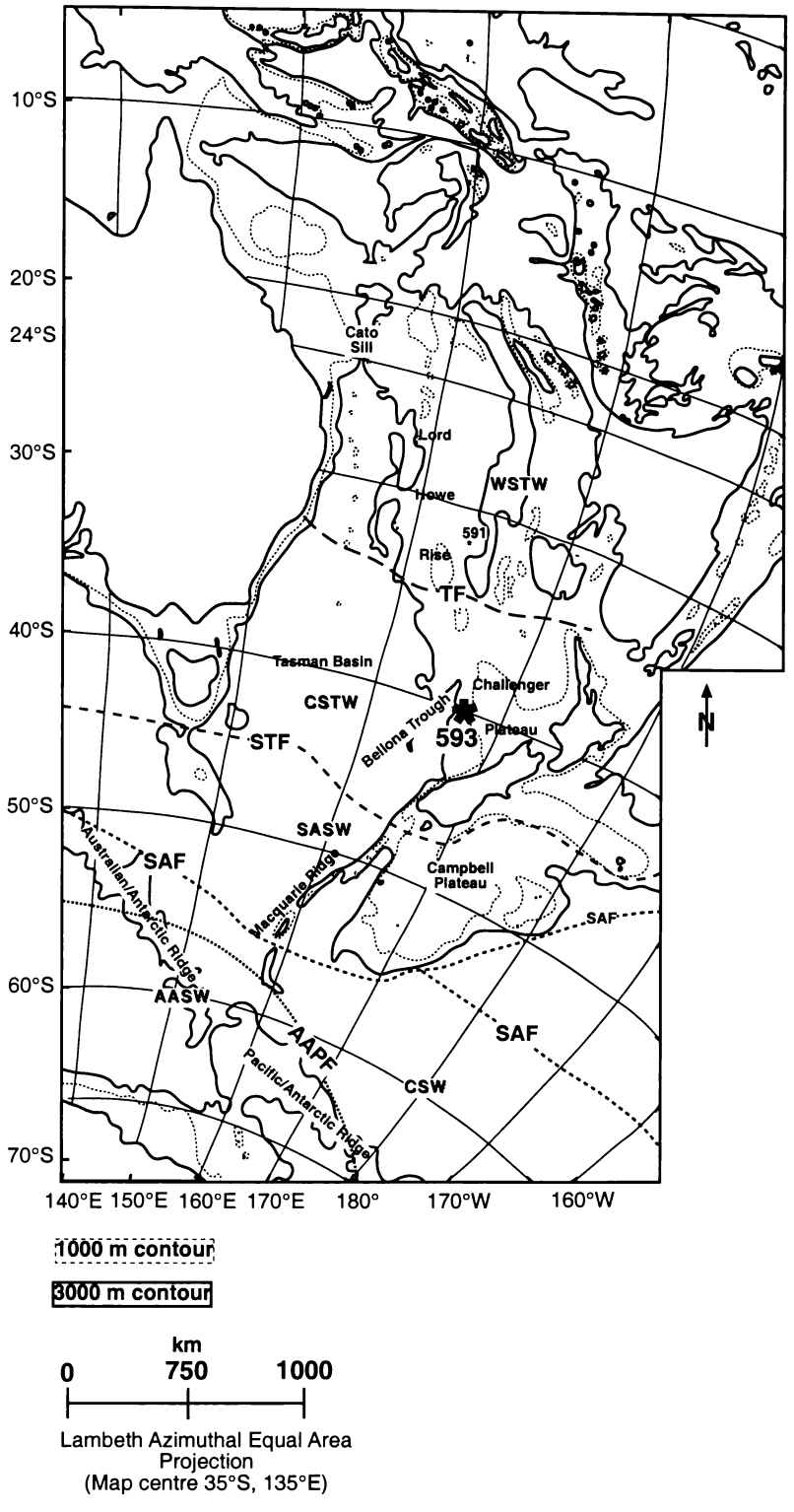


Figure 1 Southwest Pacific bathymetry at both 1000 and 3000 m depth showing the main topographic features of the region in relation to DSDP Site 593. The main oceanic fronts and surface watermasses separated by these fronts are included to illustrate the affect the bathymetry has on the frontal positions. TF = Tasman Front; STF = Subtropical Front; SAF = Subantarctic Front; AAPF = Antarctic Polar Front; WSTW = Warm Subtropical Water; CSTW = Cool Subtropical Water; SASW = Subantarctic Water; CSW = Circumpolar Surface Water; AASW = Antarctic Surface Water. (After Heath, 1985; Kennett and von der Borch, 1986a; Carter et al., 1998). Map source is after Circum-Pacific Map Project (1978).

Geological and geomorphic setting

Site 593 is located on the western margin of the Challenger Plateau, the southwest extension of the Lord Howe Rise (Fig. 1), which together delineate the eastern margin of the Tasman Basin (Leg 90 Shipboard Scientific Party, 1986; Wood, 1993). Development of this basin was associated with rifting and seafloor spreading about the Tasman Rift system between c. 120-56 Ma (Laird, 1994). Initial spreading (c. 83 Ma) of the Tasman seafloor followed the rifting of the New Zealand subcontinent from the eastern edge of Gondwanaland between 100-83 Ma, and then with the opening of the central Tasman seafloor along the Bass Fracture Zone by 72-69 Ma (Sutherland, 1994). The northern Tasman seafloor opened between c. 69-63 Ma and linked the newly formed Tasman Basin to the Cato-Louisiade-Coral Sea (along the Cato Sill) spreading system; the whole Tasman Sea spreading system ceased by c. 55.5 Ma (Sutherland, 1994). Because rifting started in the south and extended northwards, the Tasman Basin has a triangular shape. Post-rift subsidence of the Challenger Plateau ceased by the Middle Eocene and the plateau has remained stable since then (Burns and Andrews, 1973; Wood, 1993). Northward migration of the Lord Howe Rise since the Eocene in response to spreading on the Pacific-Antarctic Ridge has transported the Challenger Plateau northward, across c. 15° latitude, reaching c. 50°S in the Early Miocene and its modern position at 40°S by the Quaternary (Kennett and von der Borch, 1986b).

Oceanography of the southern Tasman Sea

Cool subtropical surface waters (CSTW) of the southern Tasman Sea (previously referred to as Western South Pacific Central Water, WSPCW) flow as a slow anticlockwise gyre via the Tasman Current (Fig. 2a; Heath, 1985; Tomczak and Godfrey, 1994) and are bounded to the north by the Tasman Front, a meandering and eddied feature lying between 30-36°S, and the Subtropical Front (STF) to the south, sitting at c. 45°S (Heath, 1985).

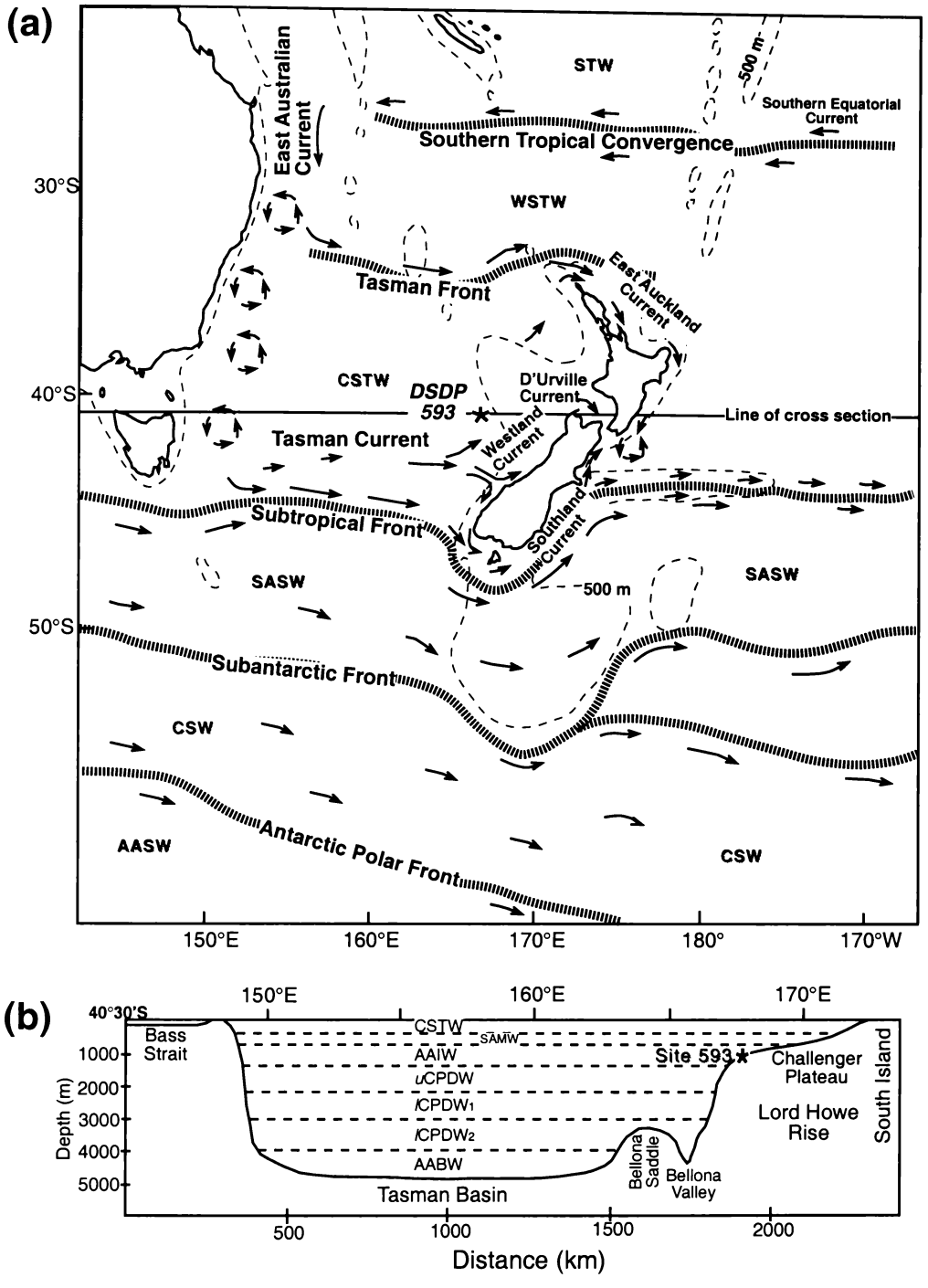


Figure 2 (a) Tasman Sea regional oceanography illustrating the location of Site 593, the 500 m isobath, and the main surface watermasses, currents and oceanic fronts of the region. Abbreviations follow Fig. 1. STW = Subtropical Water (After Heath, 1985; Kennett and von der Borch, 1986a; Carter et al., 1998). (b) Schematic cross-section of the Tasman Basin at 40°30'S, showing the bathymetric position of Site 593 (40°30'S, 167°40'E) in 1068 m water depth, physiographical features of the basin and the subsurface watermasses found in the Tasman Sea; CSTW = Cool Subtropical Water; SAMW = Subantarctic Mode Water; AAIW = Antarctic Intermediate Water; uCPDW = upper Circumpolar Deep Water; lCPDW = lower Circumpolar Deep Water; AABW = Antarctic Bottom Water. (After Wyrtki, 1961, 1962; Rodman and Gordon, 1982; Drewry, 1983; Heath, 1985).

Tropical surface waters are carried along the eastern Australian continental margin by the East Australian Current (EAC), at least half of which deviates as a zonal jet across the Tasman Sea between 30-36°S, forming the Tasman Front (Stanton, 1973, 1979). The remaining EAC flow continues southward as a series of large eddies all the while being turned eastwards by the west wind drift along the STF (Bennett, 1983; Rochford, 1983; Stramma et al., 1995). This eastward surface water flow is the Tasman Current which deviates off western South Island to flow northward as the eastern margin of the Tasman gyre, and southward as the Southland Current (Heath, 1985).

Subsurface watermasses (Fig. 2b) in the southern Tasman Sea enter the region from the south, with the Subantarctic Mode Water (SAMW) flowing between CSTW and Antarctic Intermediate Water (Heath, 1985). Antarctic Intermediate Water (AAIW) enters the Tasman Basin from both the south and the north, the latter from between New Zealand and Fiji, and the zone between 30-40°S contains AAIW mixed from both sources (Wyrtki, 1961) (Fig. 3). At 1068 m, Site 593 sits within the core of AAIW which spans about 700-1300 m water depth in the Tasman Sea (Garner, 1962; Garner and Ridgway, 1965; Garner, 1967; Tomczak and Godfrey, 1994). The site is located on the southern edge of the mixing zone, and so could be influenced by both northern-sourced AAIW, which is more saline, warmer and has an aged $\delta^{13}C$ signal (Tomczak and Godfrey, 1994; Neil, 1997), as well as southern-sourced AAIW.

Underlying these watermasses is Circumpolar Deep Water (CPDW) and unmodified Antarctic Bottom Water (AABW, mainly originating from the Ross Sea), which enter the southern Tasman Sea via the Tasman and Balleny Fracture Zones (see Chapter 1, Fig. 12 for the location of these fracture zones) (Rodman and Gordon, 1982). The upper layer of CPDW is reported in the Coral Sea whereas the continued northward flow of AABW and lower most CPDW is restricted by the Cato Sill in the northern Tasman Basin (Wyrtki, 1961). Some return flow must occur along the southern margin of the basin, probably along Macquarie Ridge (Osborn et al., 1983), although it is not well documented (Jenkins, 1992). The bottom water in the New Caledonian Basin on the eastern margin of the Lord Howe Rise is significantly different from that in the Tasman Basin and probably enters via the Pacific as Pacific Deep Water or

possibly as flow from the Deep Western Boundary Current (see Chapter 1) (Wyrtki, 1961).

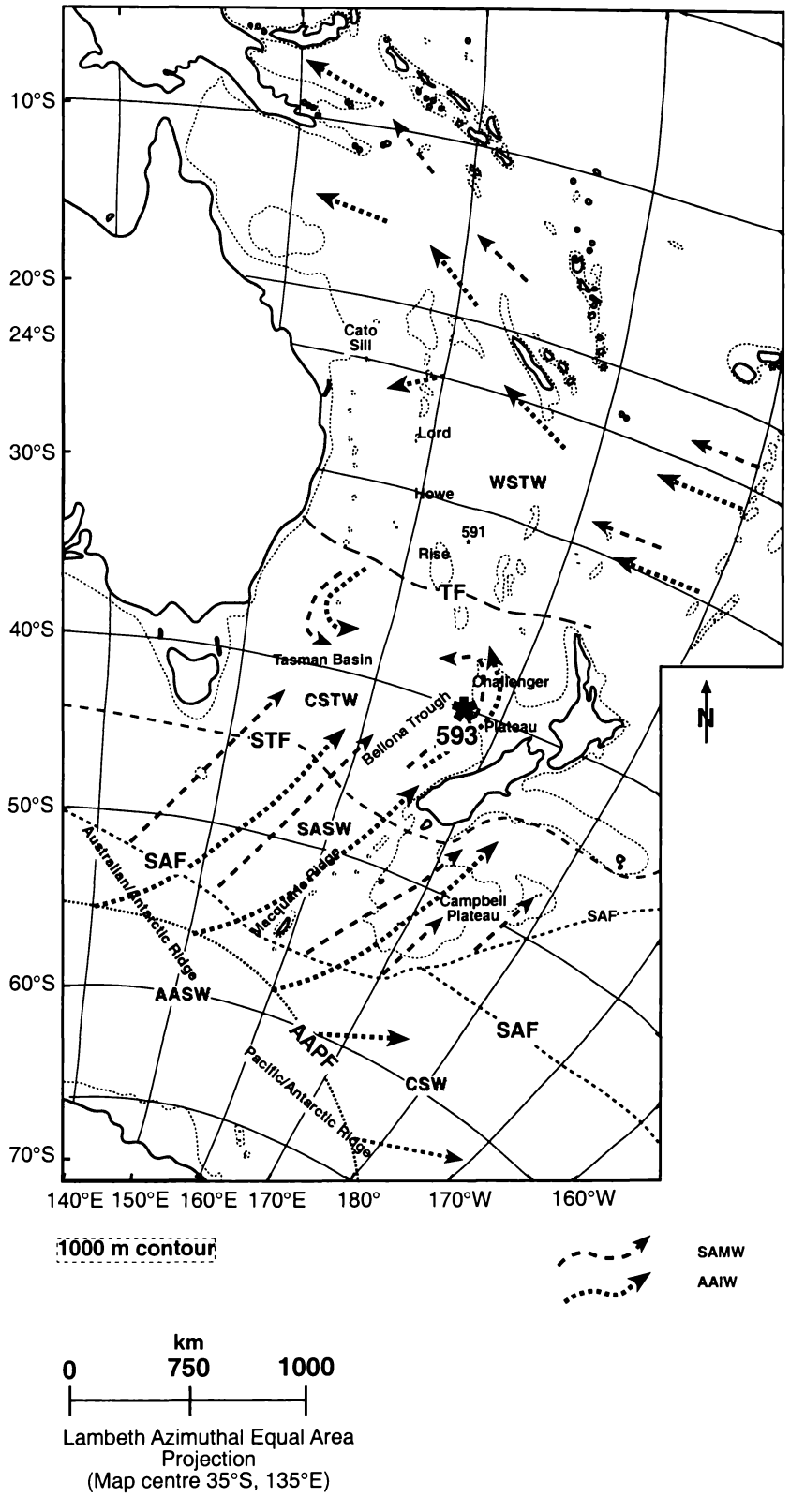


Figure 3 Bathymetry in the Tasman Sea at 1000 m showing Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW) flow pathways. (After Wyrtki, 1961, 1962; Rodman and Gordon, 1982; Drewry, 1983; Heath, 1985).

STRATIGRAPHY

Lithostratigraphy and lithology

Sediments at Site 593 comprise largely undifferentiated latest Eocene to Quaternary nannofossil ooze or foram-bearing nannofossil ooze (Nelson, 1986b) (Fig. 4a). The only non-carbonate unit in the whole core occurs near the base and comprises late Eocene volcanogenic turbidites (Nelson, 1986b). The only really noticeable feature in the carbonate sediments is an early Middle Miocene orange oxidised zone (393.8-418 mbsf; Leg 90 Shipboard Scientific Party, 1986). This zone may be associated with intermediate waters that were sufficiently oxygenated to prevent post-depositional reduction within the sediments (Nelson, 1986b), a suggestion supported by the foraminiferal assemblage (Boersma, 1986). The presence of a thicker than normal (up to 6 m) surficial oxidised zone at the site reflects the presence of northward-flowing, oxygen-rich AAIW at core-top depth (Nelson, 1986b). The presence of this oxidised unit has important bearing on later palaeoceanographic interpretations.

Hole 593 stratigraphic events

This study of the Early to Late Miocene interval uses samples with a spacing of c. 3-20 ky per sample, and which extends through the New Zealand biostratigraphic stages from about top Otaian to basal Opoitian, approximately 19 to 5 Ma (Fig. 4b). The earlier foraminiferal biostratigraphy of Kennett and von der Borch (1986b) has been restudied in detail (Crundwell, in prep.). The ages of some events have been revised, based on the Geopolarity Time Scale (GPTS) of Berggren et al. (1995b) (Table 1). Sedimentation rates generally range from 20-60 m/m.y. (Fig. 5). Noticeably, the 'flattened' interval between c.18-14 Ma corresponds with a condensed section.

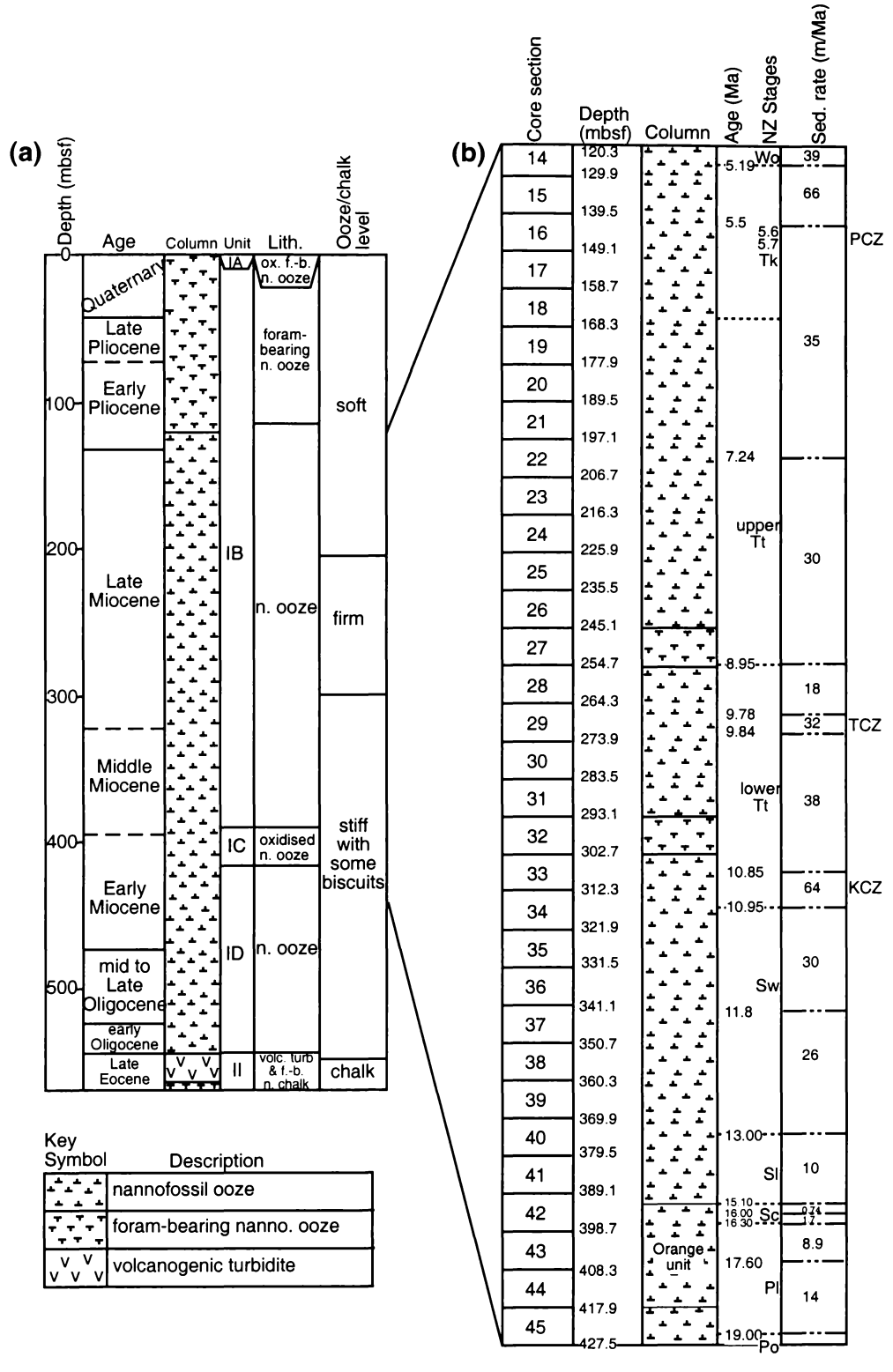


Figure 4 (a) General Site 593 stratigraphy using Leg 90 biostratigraphy, unit IA-D = ooze, unit II = volcanogenic turbidite. After Nelson (1986b). (b) Detailed stratigraphy for the Miocene section used in this study (After Kennett and von der Borch, 1986a) updated using the geopolarity timescale (GPTS) of Berggren et al. (1995b) and biostratigraphy of Crundwell (in prep.). New Zealand stages: Po = Otaian, Pl = Altonian, Sc = Clifdenian, Sl = Lillburnian, Sw = Waiauan, Tt = Tongaporutuan, Tk = Kapitean, Wo = Opoitian. PCZ = Palliser Coiling Zone, TCZ = Tukemokihi Coiling Zone, KCZ = Kaiti Coiling Zone – for detail of the coiling zones, see Chapter 4.

Table 1. Hole 593 stratigraphic tie-points and sedimentation rates used in this study.

Event	Depth (mbsf)	Age (Ma)	approx. Sed. Rate (m/m.y.)
Radiocarbon date [a]	0.07	0.0069	
			39
Radiocarbon date [a]	0.31	0.013	
			19
FAD *Emiliania huxleyi* [a]	5.07	0.268	
			25
LAD *Pseudoemiliania lacunosa* [a]	9.91	0.458	
			20
Brunhes/Matuyama [b]	16.30	0.78	
			20
Top Jaramillo [b]	20.70	0.99	
			35
Base Jaramillo [b]	23.50	1.07	
			14
Top Olduvai[b]	33.33	1.77	
			10
Base Olduvai[b]	35.65	1.95	
			24
Isotope stage 100 [c]	49	2.53	
			21
Isotope stage 104 [c]	50.1	2.58	
			10
Base Gauss [b]	59.9	3.58	
			40
FAD *Globorotalia punticulata* [d]	123.04	5.197	
			66
FAD *Globorotalia sphericomiozea* [d]	143.72	5.511	
			35
FAD *Amorolithus primus* [e]	203.42	7.24	
			30
LO *Globoquidrina dehiscens* [d]	254.38	8.947	
			18
Top Tukemokihi Coiling Zone [d]	269.07	9.782	
			34
Base Tukemokihi Coiling Zone [d]	270.72	9.836	
			38
Top Kaiti Coiling Zone [d]	309.20	10.853	
			64
Base Kaiti Coiling Zone [d]	315.25	10.948	
			30
NN6/NN7 boundary [e]	341.16	11.8	
			26
LO *Fohsella peripheroronda* [f]	372.16	13.0	
			10
FCO *Orbulina suturalis* [f]	393.90	15.1	
			1
FO *Praeorbulina circularis* [f]	394.57	16.0	
			2
FO *Praeorbulina curva* [f]	395.08	16.3	
			9
FO *Globorotalia miozea* [f]	406.65	17.6	
			14
FO *Globorotalia praescitula* [f]	426.10	19	

[a] Determined using Nelson et al. (1986) and Dudley and Nelson (1989)
[b] Palaeomagnetic dates updated after Dudley and Nelson (1989), Berggren et al. (1995a; 1995b)
[c] After Naish (1996) following Shackleton et al. (1995)
[d] Dates determined by Crundwell (in prep.)
[e] After Lohman (1986) and Raffi et al. (1995)
[f] After Elkington (2000) - notice condensed zone
LO = Last occurrence, FCO = First common occurrence, FO = First occurrence, FAD = First appearance datum, LAD = Last appearance datum

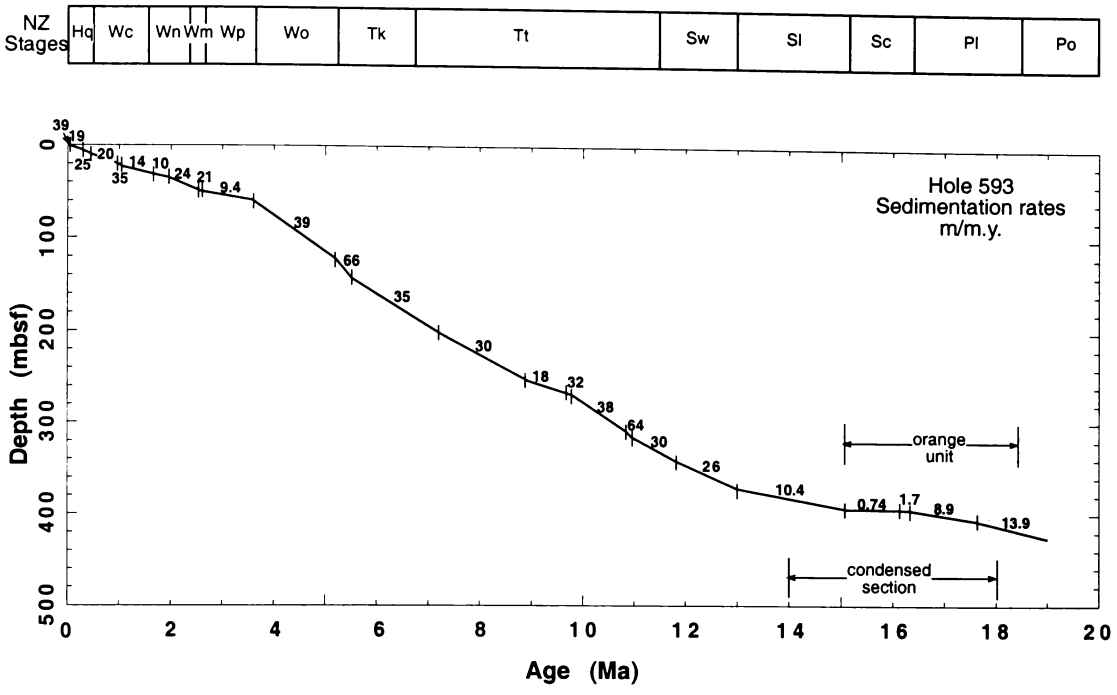


Figure 5 Hole 593 Neogene sedimentation rates calculated using Table 1.

Through the Miocene section of Hole 593, carbonate values are well in excess of 90% (Fig. 6a; Mycke et al., 1986), indicating that the site has always remained well above the CCD and lysocline (Kennett and von der Borch, 1986b). In the modern Tasman Sea the depth of the lysocline is at c. 3600 m below sea level (Martínez, 1994), and there is no indication that the top of the Challenger Plateau has ever sat at such depths (Burns and Andrews, 1973; Wood, 1993). This suggests that any test fragmentation due to dissolution will have made a limited contribution to the fine fraction.

The non-carbonate contribution to the mud consists of clay minerals (Fig. 6b) with minor quartz, feldspar, pyrite and glass shards (Nelson, 1986b; Robert et al., 1986). The non-calcareous fraction probably originated from several sources, including: (a) aeolian dust blown by the prevailing westerlies from Australia; (b) South Island (Southern Alps) derived clays delivered via ocean currents (Thiede, 1979; Robert et al., 1986; Stein and Robert, 1986); and (c) diagenetically altered volcanic ash layers, evident as thin, pale green laminae (Gardner et al., 1986b).

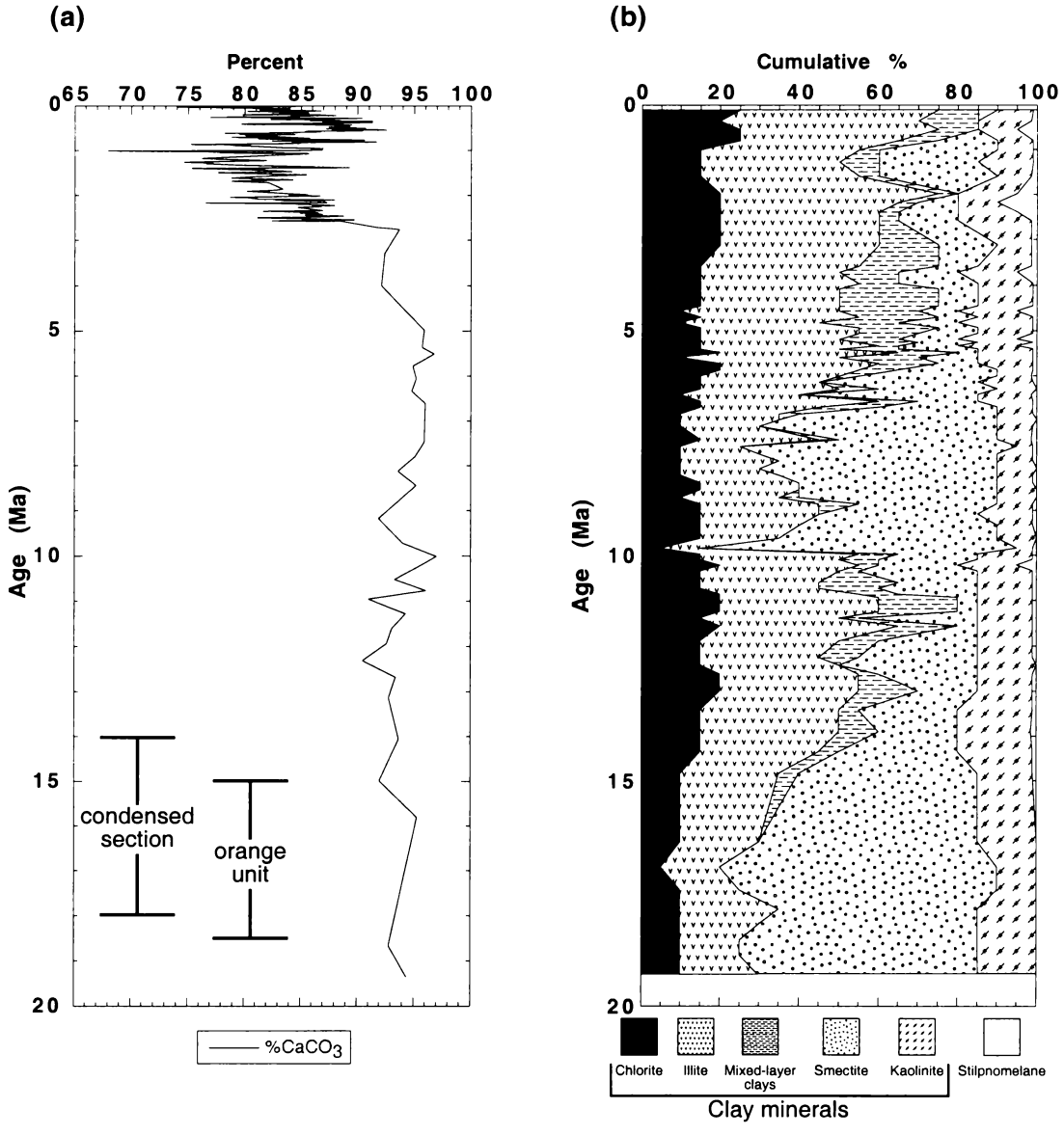


Figure 6 (a) Carbonate content of the Neogene section of Hole 593 sediments. (After Mycke et al., 1986; C. Nelson, unpublished data). (b) Composition of the clay fraction through the Neogene section of Hole 593 where the chemically mature clays (smectite and kaolinite) are considered indicative of chemical weathering on land, and the chemically immature clays (illite and chlorite) of physical weathering. The small amount of stilpnomelane is inferred to originate from the weathering of uplifted, South Island Mesozoic metamorphic terranes containing this micaeous mineral (Robert et al., 1986).

Despite the previous report of radiolarians in the Middle to Late Miocene core intervals (Boersma, 1986), which in fact turned out to be calcareous *Bolboforma* (see Chapter 5), the sediments at Site 593 contain minimal biogenic opal (Caulet, 1986). This is unusual as siliceous organisms would be expected at the latitude of the site. Gardner et al. (1986b) suggested that perhaps the silica-undersaturated AAIW flowing over the site may have dissolved any biogenic silica before it became buried in the sediments.

Bioturbation is uniformly low throughout the core (Nelson, 1986a) with good test preservation of both planktic and benthic foraminifera. Nannofossil preservation in the earlier part of the Late Miocene section is moderate to poor but becomes good in the later part (Nelson, 1986b). There are limited diagenetic overgrowths on grains and minimal evidence of any post-depositional dissolution (Baker, 1986; Hess and Schilling, 1986; Nelson, 1986b).

The coarse and fine sand fractions consist almost entirely of whole foraminifera with minor amounts of pyrite, celestite, ostracods and *Bolboforma*. The bulk of the mud fraction consists of nannofossils and foraminiferal fragments (Nelson, 1986b), with minor amounts of terrigenous material (Robert et al., 1986). It is unlikely that such minor compositional changes would have had any significant affect on the textural character, which effectively reflect the skeletal carbonate components.

METHODOLOGY

About 900 samples were obtained at approximately 10-20 cm intervals between 120 and 427 m below sea floor (mbsf). These were oven dried in foil trays for 24 hours at 35°C, then cooled in a desiccator for at least 1 hour. The samples were weighed and transferred to 50 ml conical flasks with 40 ml of buffer solution (pH c. 9.4; 4g $NaHCO_3$ + 1g Na_2CO_3 in 20*l* distilled water as per Dudley and Nelson (1989)), and left overnight. The samples were washed over a 63 μm sieve and the collected <63 μm mud fraction was allowed to settle then placed into jars with buffer solution for storage. The >63 μm sand fraction was rinsed with distilled water and dried, then sieved into 'fine' sand (63-150 μm) and 'coarse' sand (>150 μm) fractions, weighed and stored. The weight percent of the mud fraction was the difference between the weight of the original bulk sample and the sand fractions (Appendix B). In addition, about 500 samples from previous studies (Elkington, 2000; H. Stone, in prep) were processed using the same methods and are combined, to make the approximately 1400 analyses presented in this study.

Particle size analysis of the mud fraction (<63 μm) alone was undertaken using a Malvern Lasersizer (see Appendix B for details on the function of this machine). This method has previously been used for grain size analysis (e.g., McCave et al., 1986; Singer et al., 1988) with a lens which stopped at 0.5 μm (the 300 lens), and therefore

did not analyse the clay fraction in great detail. The newer lens used in this study (300 RF) extends the size analysis down to 0.05 μm. The size calculations used by the Lasersizer convert the particles to 'equivalent spheres' (Rawle, 1995). The Lasersizer uses microns as its unit of measure and these were converted to equivalent phi values, the standard sedimentological size unit. These data were extracted and sorted into grain size classes between coarse silt and very fine clay (see Appendix B for grain size scale). The Lasersizer data produced a small amount (never greater than 2% of any sample, usually less than 1%) of sand-sized particles. These can be explained as 'long-axis' grains which passed through the sieve or the occasional whole foraminifera which escaped during sample washing. This small amount has been added to the weight percent fine sand determined from sieving. The final grain size classes used are: coarse sand >150 μm; fine sand 63-150 μm; silt 63-4 μm; and clay <4 μm. For the mud (= silt plus clay) fraction, the graphical mean grain size, standard deviation, skewness and kurtosis values were calculated for the Late Miocene section only.

Compositional identification of the sand-sized grains was determined using a binocular microscope. In a few randomly selected samples the <63 μm fraction was washed over a 38 μm sieve to enable identification of the larger grains within the mud fraction. Composition of the <38 μm grains was determined using a scanning electron microscope.

Raw data versus depth is presented in Appendix B. The timescale was calculated assuming linear sedimentation rates between age datums. A 5-point smoothing curve was achieved using the plotting software KaleidaGraph.

RESULTS

Bulk textural properties

Textural records for coarse sand, fine sand, silt and clay fractions were plotted against both depth (in metres below seafloor, mbsf) and age to produce a reference textural stratigraphy for the site (Fig. 7). In the following sections some of the major textural trends and events are briefly noted.

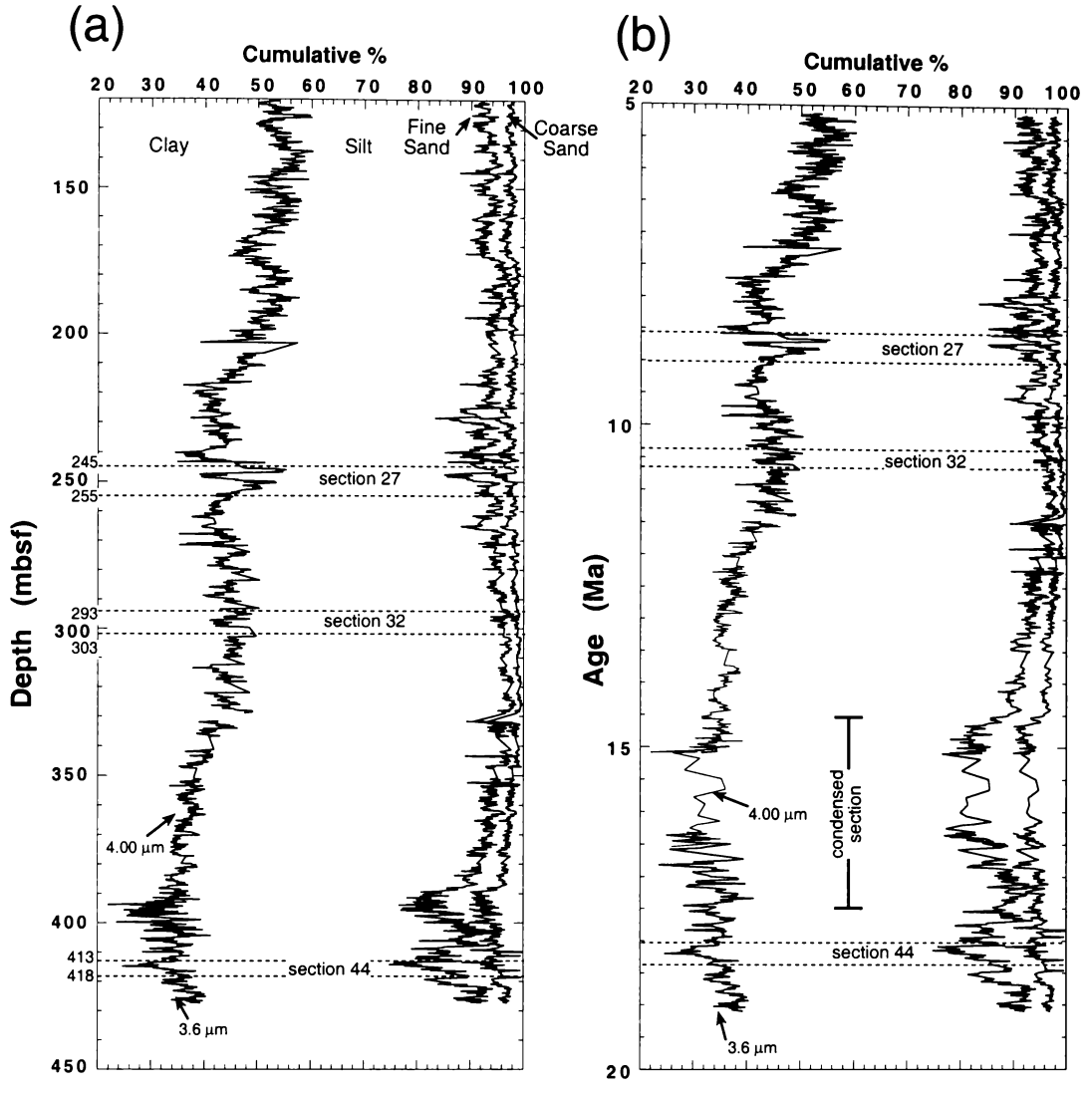


Figure 7 (a) Bulk texture data plotted vs. depth (metres below seafloor) with the three sections logged as foram-bearing nanno ooze marked. (b) Bulk texture vs. age (Ma). Note that the cumulative% axis is shown only as far as 20%, and that for some samples between c. 19-15 Ma, the clay/silt boundary uses 3.6 µm, not the standard 4.0 µm.

Sand

The sand content (coarse and fine) is mainly less than 16% of the bulk samples over the Early to Late Miocene interval (Fig. 7b). Two sections with sand content in excess of 20% occur, between 18.5-18.0 Ma, and 16.5-14.5 Ma. A second zone of high sand content (maximum 16% of bulk sample) occurs between 9-8 Ma. Over the intervals where the sand content increases, both size fractions increase, although the coarse sand content rarely exceeds 10%. Despite the overwhelming predominance of nannofossil ooze in Hole 593 (Fig. 4a), two core sections (27 and 32) were logged as foram-bearing nannofossil ooze, and one section (44) was logged as changing to foram-bearing nannofossil ooze part way along the core (Leg

90 Shipboard Scientific Party, 1986). This change in lithology is evident in the elevated sand content from c. 245-255 mbsf (section 27), and c. 413-418 mbsf (lower half of section 44), but is not so clearly evident from c. 293-303 mbsf (section 32). These sections equate to ages of c. 9-8.5 Ma (section 27), c. 10.7-10.4 Ma (section 32), and c. 18.4-18 Ma (section 44).

Silt and Clay

There is an overall up-core trend of decreasing silt- and increasing clay-size material (Fig. 7). {Note that in several samples from c. 19-15 Ma the clay/silt boundary value used was 3.6 μm rather than the standard 4.00 μm one, a consequence of combining data from different studies.} In the early part of the record the silt content forms typically 45-50 % of the bulk samples, but reduces to around 30% by c. 5 Ma. Noticeable features of this record include: the change in proportion of silt to clay associated with the condensed section from c. 16.5-15 Ma; and a 10% decrease in the silt fraction with a corresponding increase in clay fraction from 9-8.5 Ma, corresponding with the increase in sand content through Section 27.

Silt and clay one phi divisions of mud fraction

To identify which parts of the silt- and clay-sized fractions contribute to textural changes in the mud fraction it has been divided into one phi divisions. This in depth study was undertaken on the Late Miocene (11-5 Ma) interval only.

The silt fraction can be divided into four 1 ϕ divisions, with clay divided into five divisions (Fig. 8). The coarse to medium silt (4-6 ϕ, 63-15.6 μm) size fraction rarely exceeds more than c. 9 % of the total mud fraction. The largest size contributor of silt to the mud fraction is the very fine silt (7-8 ϕ, 7.8-3.9 μm) interval, followed by the fine silt (6-7 ϕ, 15.6-7.8 μm) interval. Therefore the bulk of any changes in the % silt are attributable to changes in the amount of medium to very fine silt (6-8 ϕ, 15.6-3.9 μm) sized particles. Although the Lasersizer 300RF lens extends to 0.05 μm (14.25 ϕ), sizes >12 ϕ (<0.24 μm) have been grouped together as very fine clay, because this size range contains the smallest quantity (c. 2-4%) of clay. The most abundant of the clay divisions is very coarse clay (8-9 ϕ, 3.9-1.95 μm), with the coarse clay (9-10 ϕ, 1.95-0.98 μm), medium clay (10-11 ϕ, 0.98-0.49 μm), and fine clay (11-12 ϕ, 0.49-0.24 μm) divisions each containing similar quantities. The clay divisions exhibit

a significant increase from 9-8.4 Ma, and all clay divisions exhibit an up-core trend of increasing quantities after 8.4 Ma, which indicates either an increase in clay-sized grains, or the removal of silt-size ranges as all plots are proportioned to 100%.

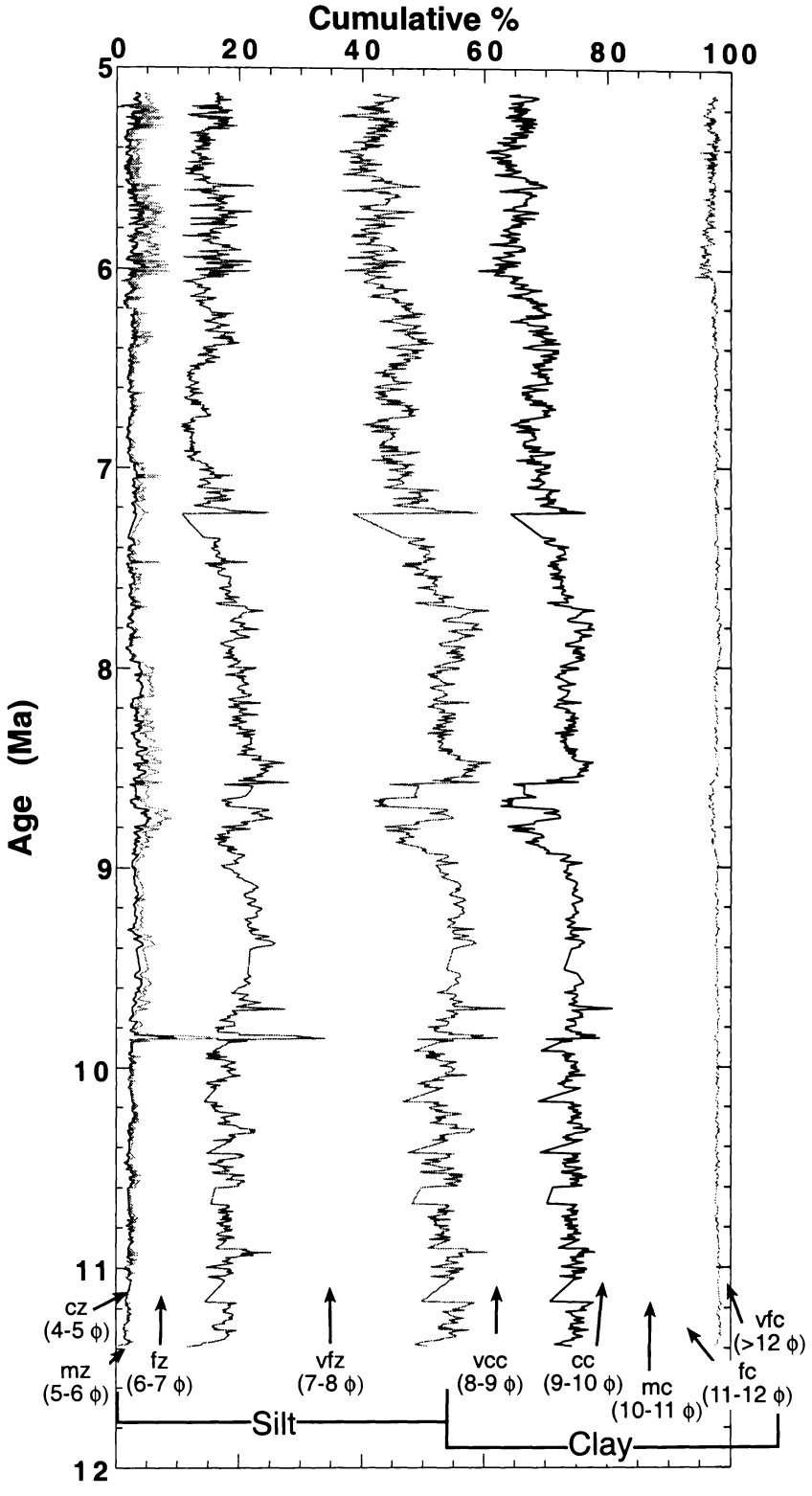


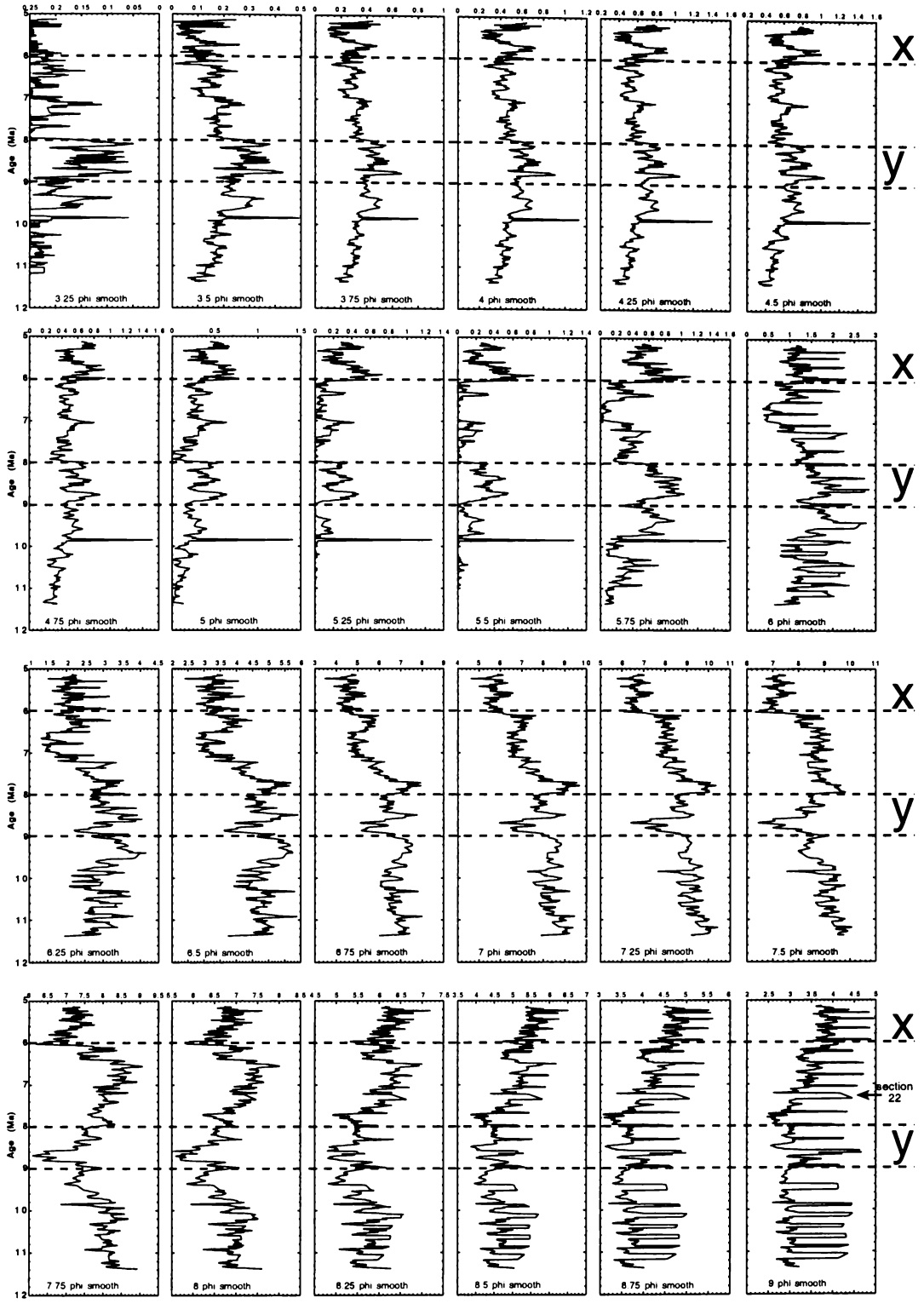
Figure 8 Late Miocene Hole 593 mud fraction divided into 4 silt, and 5 clay, one phi fractions. The largest fraction is the very fine silt (7-8 ϕ, 7.8-3.9 μm).

Silt and clay 0.25 phi divisions of mud fraction

The 0.25 ϕ data is analysed to determine if the noticeable changes in the 1 ϕ data can be narrowed down to particular size ranges, with the intention of determining the composition of those sizes, and to apply grain size statistics. The 1 ϕ data exhibit a noticeable increase in most clay divisions between 9.0-8.4 Ma, so this is one of the sections where the detailed 0.25 ϕ data may be able to provide specifics about the contributing size ranges (Fig. 9). The small amount of 'sand-sized' grains found in the mud fraction make up less than 0.5% of the mud fraction and are not discussed in this section, but 0.25 ϕ plots for 3.25, 3.5, 3.75 ϕ are included in Fig. 9 for completeness. Moreover, particles between 3-5.5 ϕ (125-22 μm) comprise less than 1% of the mud fraction, but are also included here as they exhibit trends which can be linked to other 0.25 ϕ intervals having greater abundance.

Over the intervals 9-8 Ma and 6-5 Ma in the 0.25 ϕ records (zones Y and X, respectively), divisions from 3.25-5.75 ϕ (10.6-18.6 μm) contain more grains than samples which are older or younger (Fig. 9). Then at 6 ϕ this general pattern changes so that these intervals start to include less grains in this size range compared with samples older or younger. The trend reverses again, so that by 8.75 ϕ the proportion of grains in this size range begins to increase through both time intervals. The time frame of zone X reduces to 9-8.5 Ma through the smaller grain size intervals 8.75 to >12 ϕ, corresponding with section 27 (Fig. 7a), but zone X remains at 6-5 Ma.

Through the intervals 6-6.5 ϕ (15.6-11 μm) and 8.25-9.25 ϕ (3.38-1.64 μm), there is an exaggerated grain size change at the top and base of each core section, giving a very jagged shape to the curves. Because this appears to affect only the start and finish of the sections, it is assumed that somehow it is related to drilling disturbance, possibly through compression of the ooze during core recovery. Why all size ranges are not equally affected remains unknown. In addition, at c. 7.3 Ma (c. 206 mbsf), a zone of known drilling disturbance (the end of section 22, Fig. 9 – see 9 ϕ graph), there is an extreme change in percent silt and/or clay. The end of this section was washed out when the drill string got stuck (Kennett and von der Borch, 1986a).


Age (Ma)
3.25 phi smooth
3.5 phi smooth
3.75 phi smooth
4 phi smooth
4.25 phi smooth
4.5 phi smooth
4.75 phi smooth
5 phi smooth
5.25 phi smooth
5.5 phi smooth
5.75 phi smooth
6 phi smooth
6.25 phi smooth
6.5 phi smooth
6.75 phi smooth
7 phi smooth
7.25 phi smooth
7.5 phi smooth
7.75 phi smooth
8 phi smooth
8.25 phi smooth
8.5 phi smooth
8.75 phi smooth
9 phi smooth
x
y
section 22

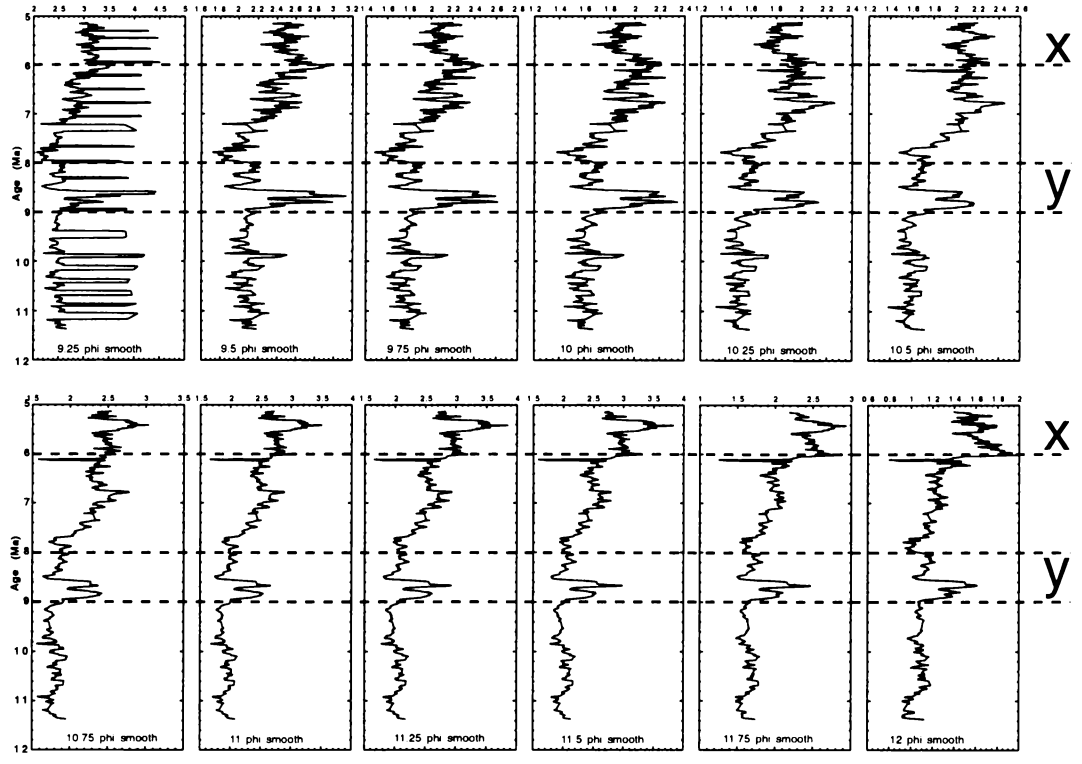


Figure 9 Late Miocene Hole 593 mud fraction divided into 0.25 phi fractions. Data is smoothed using a 5-point running average. Zones X and Y contain a greater mass of grains than samples either side of the zones. A3 version at end of chapter.

Grain size statistics of the mud fraction

Standard Folk and Ward (1957) statistics have been generated by the Lasersizer software for the mud fraction at 0.25 ϕ and are summarised in Table 2.

Table 2. Summary of mud fraction grain size statistics for all samples in comparison with core top sample values.

Mean range (ϕ)	Sorting range (ϕ)	Skewness range	Kurtosis range
This study			
8.33 to 9.67 ϕ coarse to medium clay	1.51 to 2.1 poorly sorted to very poorly sorted	-0.07 to 0.8 near-symmetrical to strongly fine-skewed	0.68 to 1.49 platykurtic to very leptokurtic
Core top samples			
coarse clay	poorly sorted to very poorly sorted	near-symmetrical	mesokurtic to leptokurtic

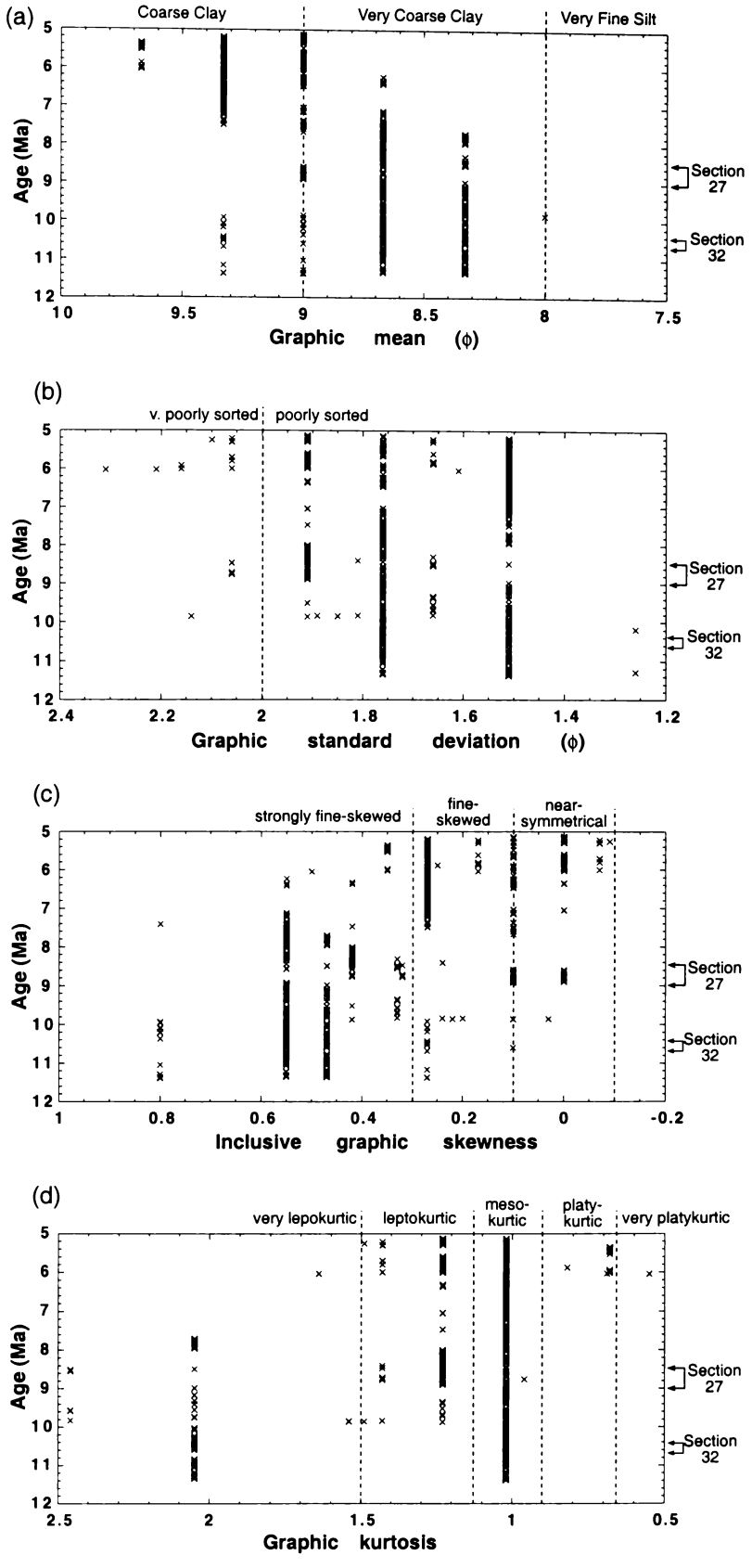


Figure 10 Grain size statistics for the Late Miocene mud fraction from Hole 593: (a) Graphic mean (ϕ); (b) Inclusive graphic standard deviation (ϕ); (c) Inclusive graphic skewness; (d) Graphic kurtosis.

Mean grain size

The mean grain size is calculated as the graphic mean (Folk, 1968). There is a general up-core decrease in mean grain size from very coarse clay (8.33-8.67 ϕ) over the interval 11.4-7.5 Ma, to coarse clay (9-9.33 ϕ) through 7.5-5 Ma (Fig. 10a). The interval 8.9-8.6 Ma, where the mean grain size decreases to 9 ϕ, corresponds with Section 27.

Sorting (standard deviation)

This is calculated as the inclusive graphic standard deviation, the best measure of the distribution of a sample (Folk, 1968). Overall, sorting tends to become poorer up-core, with two zones between c. 9-8 Ma and c. 6-5 Ma where it is noticeably poorer (Fig. 10b).

Skewness

This is also calculated as the inclusive graphic measure and is geometrically independent of the sorting of the sample (Folk, 1968). The majority of samples are fine- to strongly fine-skewed, indicating an excess of fine grains in these samples (Fig. 10c). The general up-core trend is for samples to become less skewed, with many samples between 6-5 Ma being near-symmetrical. The section between c. 9-8 Ma is less finely skewed, and the shift at c. 7.3 Ma marks a general switch from strongly fine-skewed to fine-skewed.

Kurtosis

Graphic kurtosis measures the ratio between the sorting in the tails of a curve and the sorting in the central part (Folk, 1968). Most samples are mesokurtic to leptokurtic (Fig. 10d). This indicates the samples contain a mixture of one dominant grain size population and one subordinate (Folk, 1968). Again, between 9-8 Ma there is a change in grain size description, with one of the grain size populations shifting to leptokurtic from very leptokurtic, and there is a second shift at c. 7.6 Ma towards mesokurtosis. Samples between 6-5 Ma contain a secondary platykurtic population, with the up-core trend from leptokurtic to platykurtic indicates the 'tails' are becoming better sorted.

Visual sediment log vs. textural analysis

The shipboard log for core section 27, foram-bearing nannofossil ooze, shows it to be slightly different to the rest of the Late Miocene section, which is supported by the textural analysis. This section (8.89-8.59 Ma) shows an increase in the amount of sand (Fig. 7a) but a decrease in the mud fraction mean grain size (Fig. 10a). The mud fraction is more poorly sorted than samples above and below it, and is less skewed. It is also less kurtosic, indicating it contains less 'fines' than those sections logged as nannofossil ooze.

Section 32 (c. 10.5 Ma) was also logged as foram-bearing nannofossil ooze, but is not discriminated texturally here.

Modality of mud fraction sizes

Size modes for the mud fraction were derived from 0.25 ϕ data set. These exhibit a consistently trimodal form, with a fine mode between 11.5-11.25 ϕ (0.35-0.4 μm), a medium mode between 7.75-7.25 ϕ (4.7-6.6 μm) and a coarse mode between 4.5-4.25 ϕ (44.2-52.6 μm; Fig. 11).

The modes in some samples were obviously 'double peaked', extending across two size intervals (i.e., were wider than 0.25 ϕ). Three samples exhibited a fourth mode, which is considerably greater than 63 μm, the size of the sieve mesh used in washing the samples. At 2-1.75 ϕ (250-295 μm), this mode lies within the fine to medium sand size range, suggesting it is likely to be due to whole foraminifera which have escaped from the sieve during washing. As this fourth mode comprises only 0.3-0.4 % of these samples, it is not considered further.

The trimodal nature of the samples is a consistent feature through the whole interval from 11-5 Ma (Fig. 11), with the 'dips' in the trimodal plots indicating little or no particles of a given grain size. This is also evident in Fig. 9 where the low % mud values correspond with the dips. A 'dip' occurs from 5-5.5 ϕ, indicating a lack of grains of this size in all samples and may represent a compositional boundary (discussed below). The second 'dip' occurs from 10-10.5 ϕ, where the amount of material contributing to the sediment then declines to around 2% of the total mud fraction (see 10-10.5 ϕ graphs in Fig. 9).

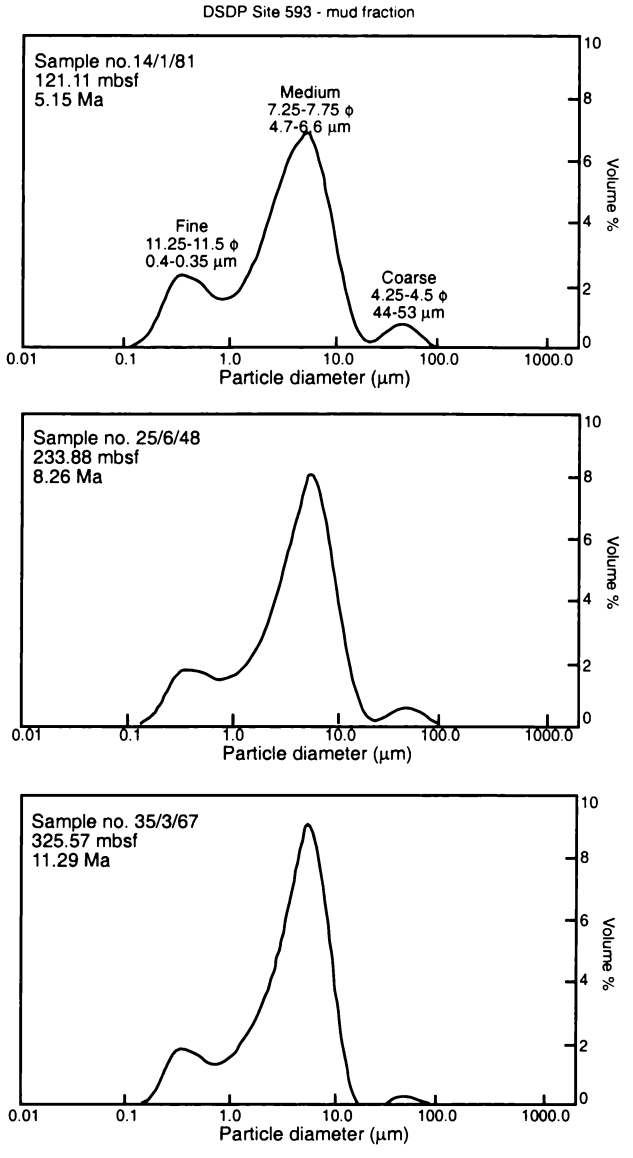


Figure 11 Three samples spaced through the study section illustrating the typical trimodal grain size distribution in the samples and volume % of each mode in the Hole 593 mud fraction.

The three modes

The actual mode values were calculated in both phi and microns and the amount of material at each mode is shown as a proportion of the total mud fraction (Fig. 12).

Coarse mode 4.25-4.75 ϕ (52.56-37.16 μm): Coarse silt

Although in very small quantities (0.3-2%), this mode is consistently present in all samples (Fig. 12a and b). It is double peaked between 11.4-6.0 Ma, after which the spread increases through to 5 Ma. This indicates that the range of grain sizes contributing to this mode increases and includes some slightly smaller sized

material. There is a slight increase in the amount of material within the coarse size mode from 9-8 Ma and again between 6-5 Ma (Fig. 12b), with the older section not exhibiting any change in the modal grain size (Fig. 12a).

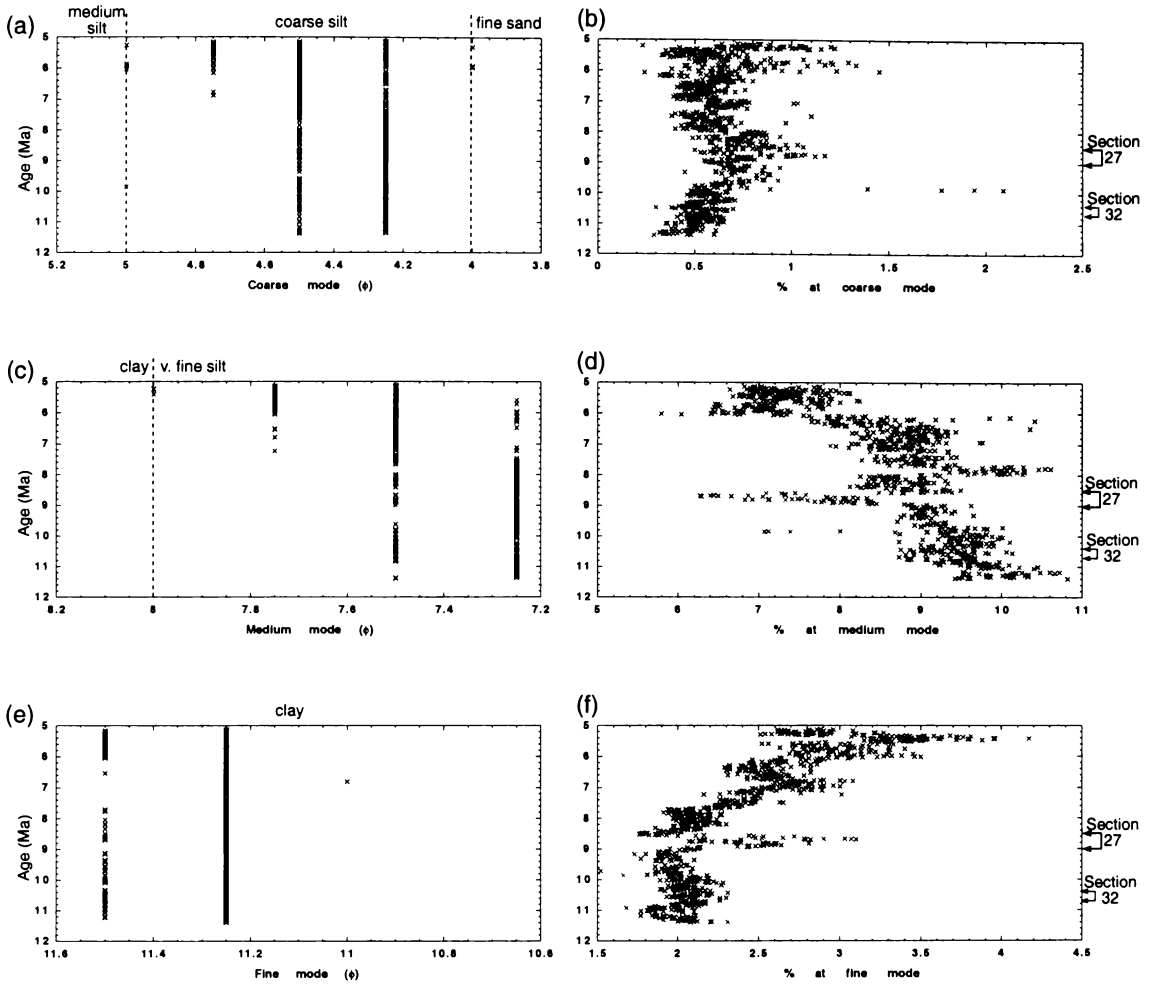


Figure 12 Late Miocene mud fraction size and percentage of grains at each mode: (a-b) coarse mode, (c-d) medium, and (e-f) fine.

Medium mode 7.25-7.75 ϕ (6.57-4.65 μm): Very fine silt

The grain size of this mode gets progressively smaller up-core, with a noticeable size reduction at c. 7.5 Ma (Fig. 12c.). The medium mode is the largest in quantity of the three modes and comprises 6-11 % of the mud fraction (Fig. 12d). There is a general up-core decrease in the amount of the medium size mode from about 10% to about 7%, with a noticeable decrease over the interval c. 8.9-8.5 Ma to 6.2%. The amount of material of this size increases from 8-7.5 Ma, co-incident with the modal size shift, but then decreases again until 6 Ma when there is a further reduction in the amount of material and the modal size decreases.

Fine mode 11.25-11.5 ϕ (0.41-0.35 μm): Very fine clay

The fine size mode exhibits a less variable trend than the other two, with a noticeable gap in the double peak values between 7.5-6 Ma (Fig. 12e). The fairly consistent nature of the double peak spread of this mode suggests that whatever contributes to it is consistently present in all samples. The amount of material in this mode size is relatively consistent between 11.4-7.5 Ma, except for the section between 8.9-8.6 Ma where it increases significantly (Fig. 12f). From 7.5 Ma to 5 Ma there is an up-core increase in material of this grain size, from about 2% to 4% of the total mud fraction.

Section 27 (8.9-8.6 Ma) stands out in all three size mode classes, where the amount of material contributing to the mode changes, but the actual grain size(s) does not.

Grain composition

The grain size ranges correspond to clear (but not exclusive) compositional identities (Table 3). The >63 μm material is composed mostly of foraminiferal tests, with occasional glass shards, quartz grains, celestite crystals and pyrite grains (Kennett and von der Borch, 1986a; this study).

Table 3. Grain size versus composition of the Late Miocene Hole 593 sediments.

Composition	clay >8.5 ϕ (<2.5 μm)	clay-fine silt 8.5-5.5 ϕ (2.5-22 μm)	coarse silt 5.5-4 ϕ (22-63 μm)	sand <4 ϕ (>63 μm)
Detrital (<10%)	clay minerals	?quartz	?glass shards	glass shards
Biologic (>90%)	small coccoliths, coccolith fragments, micrite	coccoliths	juvenile forams, broken test fragments	adult forams, ostracods, bolboforms
Diagenetic	?micrite			pyrite, celestite

Washing the mud fraction over a 38 μm sieve (the smallest size available) showed the 63-38 μm fraction to be composed of juvenile foraminifera with considerable broken test fragments (Fig. 13).

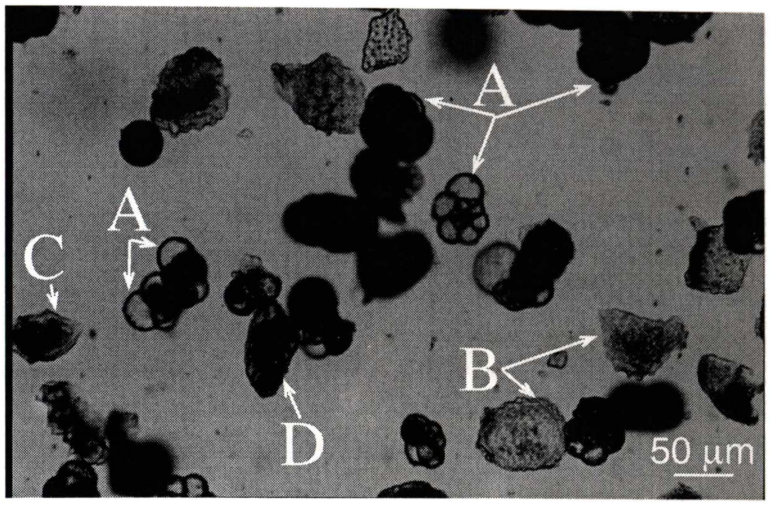


Figure 13 Light microscope image of 63-38 µm fraction showing juvenile foraminifera (A), broken test fragments (B), occasional quartz crystals (C), and juvenile benthic foraminifera (D). The black blobs are juvenile foraminifera which were too dense for light to penetrate.

Most of the <38 µm material comprises nannofossil placoliths, of about 3-6 µm in size (Fig. 14). The smallest material comprises nannofossil placolith 'lathes', broken fragments of placoliths of around 1-0.3 µm in size, and clay minerals (Fig. 15).

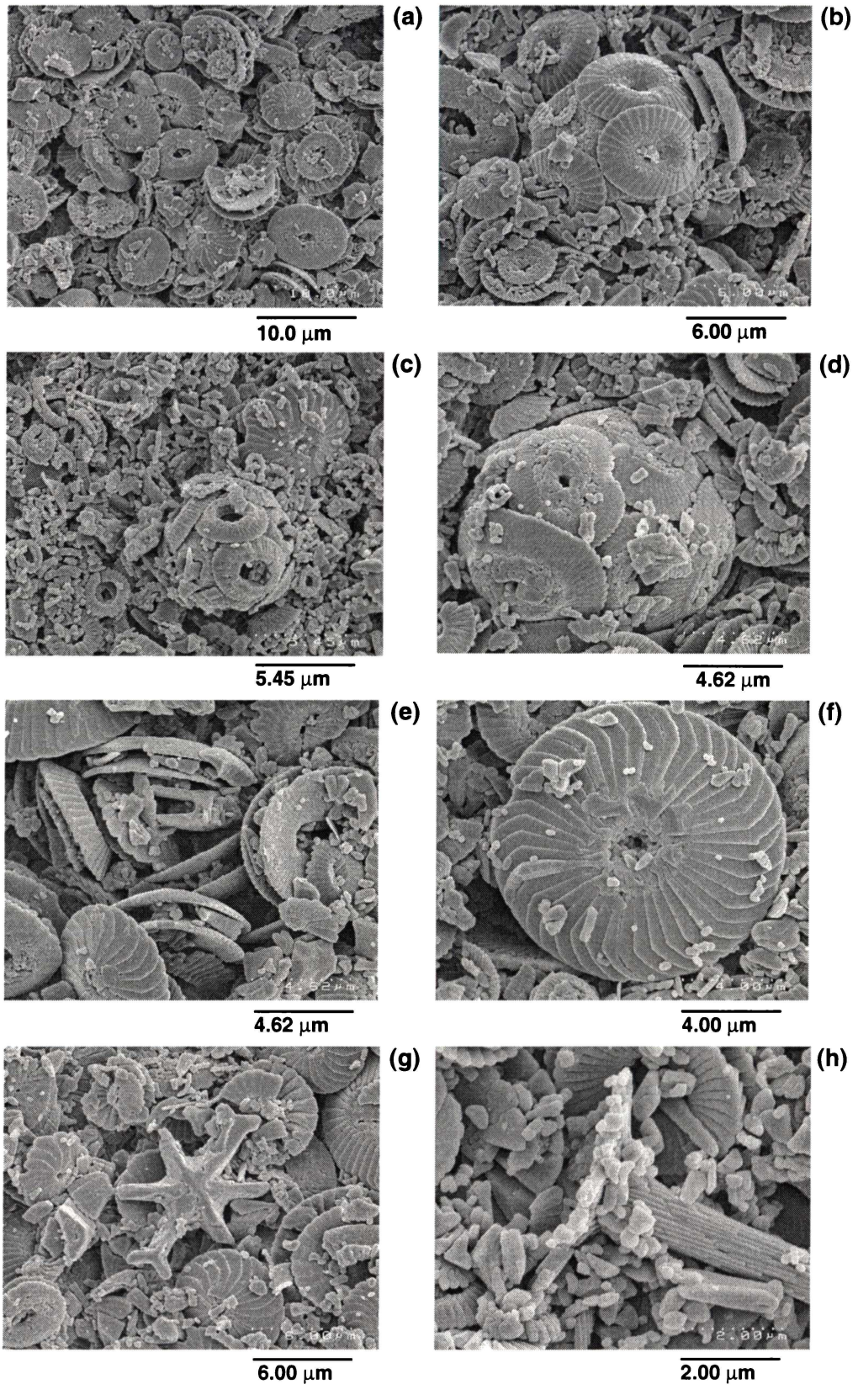


Figure 14 SEM images of the <38 μm fraction showing composition consisting almost entirely of coccolith plates (a, e, f); occasional whole coccolith balls (b-d); occasional discoasters (g) and foraminiferal spines attached to test wall (h).

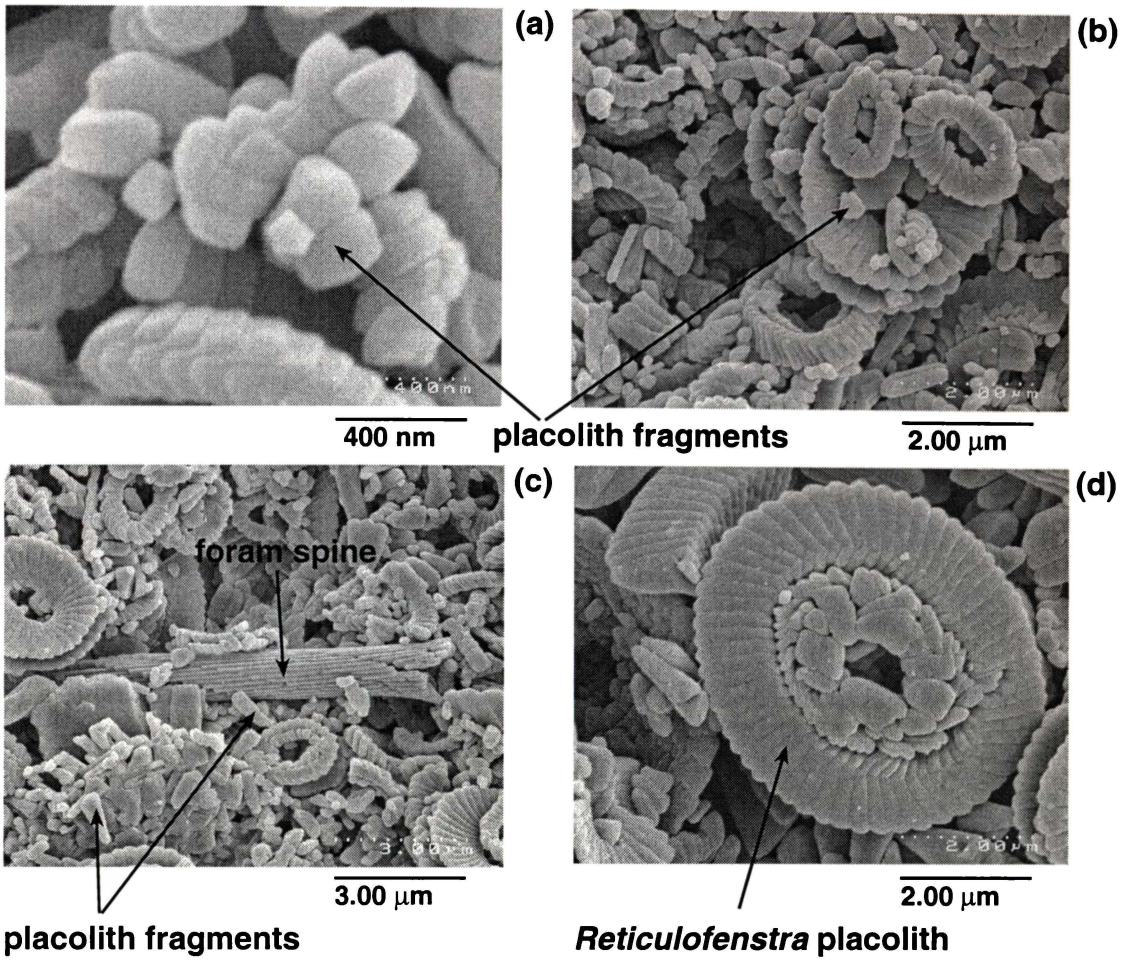


Figure 15 (a-d) Small 'micarb' fragments, many of which are individual placolith lathes.

Within the sand fraction, several samples included large white crystals, identified as authigenic celestite ($SrSO_4$) from SEM and EDAX analysis (Fig. 16).

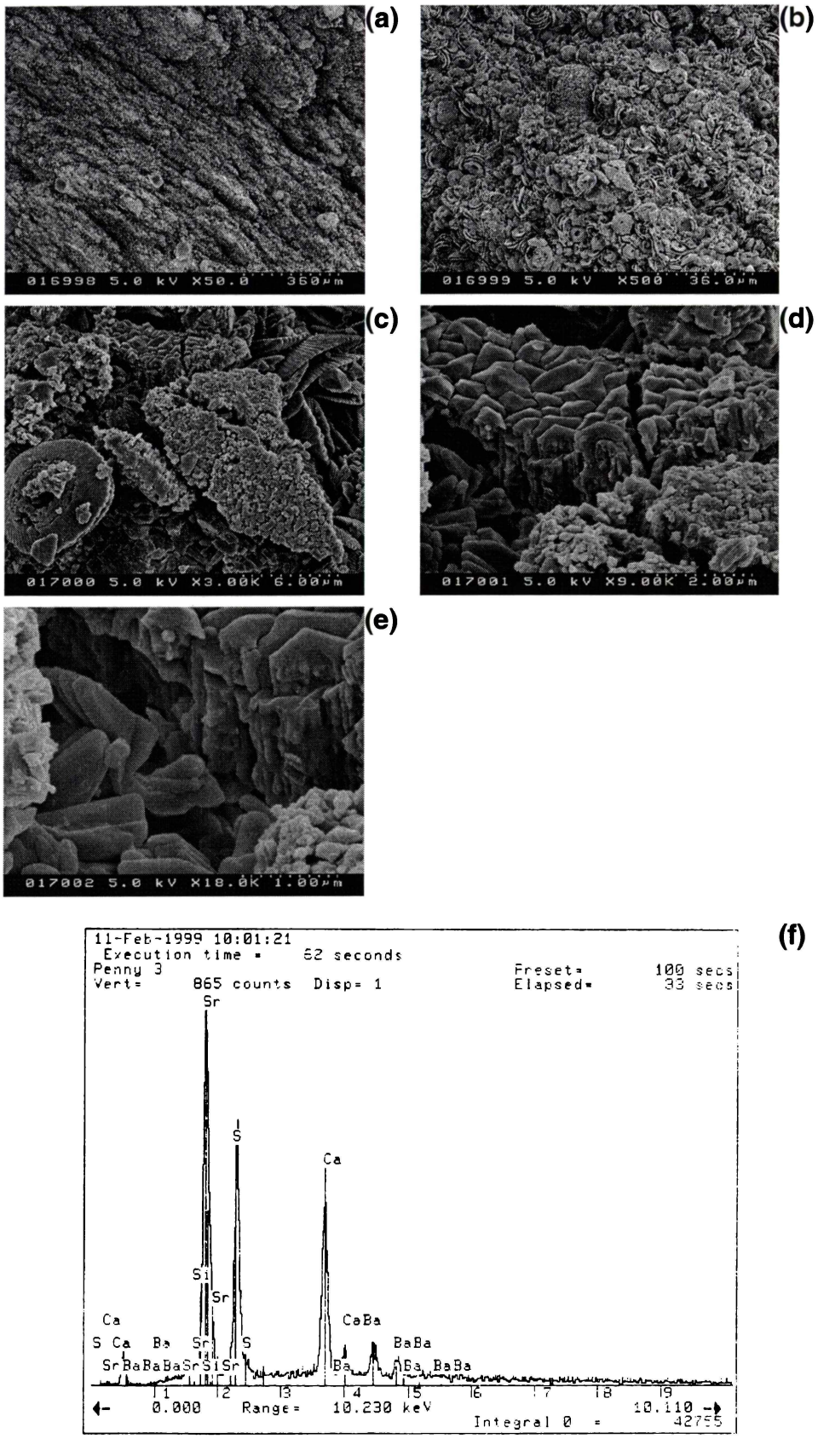


Figure 16 Celestite crystals from the coarse sand fraction in Hole 593 Late Miocene samples: (a-c) crystals with nannofossil placoliths attached; (d-e) high resolution images of the crystals; (f) EDAX analysis of the crystals exhibiting high strontium and sulphur peaks.

DISCUSSION

Controls on sediment texture

Dissolution

In the relatively warm, low pressure thermocline (surface) waters, CO_2 exchanges with the atmosphere result in these waters becoming supersaturated in calcium carbonate, which can be incorporated into the calcitic tests of foraminifera and nannoplankton. Deep waters below the thermocline are undersaturated in calcium carbonate due to the low temperatures and high CO_2 partial pressure (pCO_2), and this results in dissolution of carbonate (Berger, 1970). The CCD occurs at different depths in different parts of the ocean system. For example, in the North Atlantic the CCD occurs at about 5 km depth, whereas in the South Atlantic it is as shallow as 3 km (Berger, 1971). In the Pacific the CCD occurs at 4-4.5 km depth (Peterson, 1966; Berger and Winterer, 1974) well below the depth of Site 593.

The zone between the supersaturated thermocline waters and the CCD is marked by a large increase in the dissolution rate called the lysocline, which separates well preserved from poorly preserved carbonate sediments (Berger, 1970; Berger and Winterer, 1974). The top of the lysocline represents an equilibrium boundary between the supersaturated surface waters, and the slightly calcite undersaturated lower thermocline and intermediate waters (Berger, 1970). The depth of the start of the lysocline varies in different oceans, and in the Tasman Sea occurs at about 3-3.5 km (Martínez, 1994). Dissolution can be discounted as a major influence at Site 593 for a number of reasons. First, the site is located well above both the lysocline and the CCD (Martínez, 1994), and this also applies to its palaeodepth history evident in the high carbonate content through the most of the hole (Fig. 6a). Second, shipboard studies show that foraminifera are well preserved throughout the section studied and that nannofossil preservation is moderate to good (Boersma, 1986; Kennett and von der Borch, 1986b; Nelson, 1986b).

Bioturbation

While bioturbation and vertical mixing of sediment will destroy any stratigraphic changes in grain size, the bioturbation of the Late Miocene section of Hole 593 is uniformly low (Nelson, 1986a). The two most important factors influencing

bioturbation are the sedimentation rate, and organic nutrient supply to the seafloor (Nelson, 1986a). As the Hole 593 sedimentation rate (Fig. 5) is relatively uniform, without any large-scale changes (with the exception of the condensed section), it is unlikely to have dramatically affected the extent of bioturbation. Site 593 is located within an oligotrophic part of the Tasman Sea, lacking major zones of upwelling (Bradford and Roberts, 1978) which could contribute large amounts of organic material to the seafloor, and this may account for the relatively low degree of bioturbation of the sediments.

Diagenesis

Preservation of the dominant nannofossil group can be used as an indicator of the degree of recrystallisation. For example, discoasters generally are the first group to show secondary overgrowths (Nelson, 1986b), and these are not evident on the discoasters imaged in this study (Fig 14g). The lack of welding between nannofossil placoliths (Figs. 14 and 15) also supports the inference that the Hole 593 oozes have not been subjected to significant diagenesis (see Garrison, 1981; Hess and Schilling, 1986). The presence of celestite ($SrSO_4$) crystals in carbonate oozes has been documented as deriving from the dissolution or recrystallisation of calcite during burial, increasing the strontium concentration in pore waters until celestite precipitates (Baker, 1986). Minor amounts of celestite crystals were identified in only a few samples from Hole 593 (Fig. 16), and play an insignificant role in the texture of samples (this study; Baker, 1986; Hess and Schilling, 1986).

Palaeoproductivity

Changes in biological productivity may reflect changes in the dominant organism in the ocean waters. Such changes in pelagic oozes can be used to infer palaeoproductivity changes which in turn may reflect palaeoceanographic changes. The dominant contributions to the Hole 593 sediments come from nannofossils, then foraminifera, then in much smaller quantities, ostracods, bolboforms and clay minerals.

In regions of high primary productivity (e.g., upwelling or close to an oceanographic front) the flux of nannoplankton is going to be high, consequently increasing the proportion of the fine fraction. In the modern setting Site 593 is not located near any

oceanographic front, nor is there any hint that it has done so in the past. To estimate the foraminifera to nannofossil ratio, mass accumulation rate (MAR) data are needed. These are not available for Site 593, but have been calculated for the more northern Tasman Sea Site 591 (Gardner et al., 1986a). Although the Late Miocene sedimentation rates at Site 593 (Fig. 5) are slightly higher (c. 20-60 m/m.y.) than at Site 591 (c. 20 m/m.y.), both sites have similar Late Miocene sand/mud proportions of around 85-90% <63 μm, interpreted as similar palaeoproductivity rates. Early Late Miocene sedimentation rates at Site 591 are relatively typical of those found on carbonate platforms outside regions of high palaeoproductivity, and the MARs are typical of the Southwest Pacific at this time (Gardner et al., 1986a). If the assumption is made that all the coarse fraction (>63 μm) and 10% of the fine fraction (<63 μm) comprises foraminifera and the remaining fine fraction is nannofossils, Site 591 (lacking any mass accumulation rate (MAR) evidence for large changes in palaeoproductivity) has a ratio of foraminifera to nannofossils of 15:85, even though it is close to the high productivity region associated with the Tasman Front (Gardner et al., 1986a). If similar reasoning is applied to Site 593, where the coarse fraction rarely exceeds 10% through the Middle-Late Miocene, and there is a small contribution of juvenile foraminifera (say c. 5%) to the mud fraction, a comparable ratio is determined. In Hole 591 the MARs increase through the latest Miocene into the Pliocene, and are interpreted as the result of increased palaeoproductivity associated with upwelling along the Tasman Front (Gardner et al., 1986a). As there is no corresponding change in the foraminifera to nannofossil ratio in Hole 593, it is inferred that Site 593 has not been subject to large scale flucutations in palaeoproductivity and the changes seen in the Miocene textural record are taken to reflect principally changes in the amount of winnowing of the mud fraction.

Winnowing

The extent of any winnowing depends on sediment composition and water velocity. As seafloor erosional features develop on long time frames, it may be that the threshold current velocity is lower when acting for considerable duration (Jenkins, 1985). For example, winnowing of the mud fraction on ridge crests in the Panama Basin resulted in the concentration of foraminiferal sands which protected the crests from further winnowing (van Andel, 1973). The foram-bearing nannofossil ooze identified in section 27 is interpreted as a zone of winnowing in the Hole 593 record,

resulting from partial removal of the mud-sized fraction. Having discounted other options, the fluctuations in the sand-mud ratio must result from one, or some combination, of the following: (1) fluctuations in the rates of production and accumulation of foraminifera relative to nannofossils; (2) fluctuations in the amount of winnowing of mud from the sediments at the site; and/or (3) fluctuations in the amount of mud-sized sediment deposition, winnowed from up-current.

If Site 593 was a depocentre for mud winnowed from 'up-current, then the <63 μm fraction would dilute the coarser foraminiferal component resulting in an increase in the mud fraction from transported sediment. From the bathymetry (Fig. 2b), Site 593 clearly sits near the top of the eastern slope of the Bellona Trough on the western margin of the Challenger Plateau and, if anything, is likely to be a site of sediment removal rather than one of accumulation of large amounts of sediment derived laterally from other parts of the plateau. Lack of any noticeable hiatuses within the sequence (Kennett and von der Borch, 1986b; Nelson, 1986b) suggests that 'bulk' removal of sediment, for example by slumping or scour, has not occurred. Thus changes in the sand-mud ratio are most likely a result of either changes in palaeoproductivity or winnowing of mud from the bottom sediments. A general up-core increase in the Hole 593 sand content is interpreted as progressive removal of increasing amounts of the mud fraction through the Late Miocene, with extreme winnowing beyond the general trend evident in the increase in sand content between c. 9.5-8 Ma (Fig. 7b). Similarly, the zone of increased sand content between c. 16.5-14.5 Ma (Fig. 7b) is also interpreted as winnowing. This is supported by the biostratigraphy and sedimentation rates over this interval (Fig. 5), which are interpreted as a condensed section (Elkington et al., 2000). Equally, the interval c. 19-17.5 Ma where the sand content increases to c. 25% is also interpreted as due to current winnowing (Fig. 7b).

In Hole 593 the general up-core decrease in fine silt-coarse clay in the c. 6-8 ϕ size range (Fig. 8) through the Late Miocene, and specifically for the size range 6.25-8.25 ϕ (c. 13-3 μm) (Fig. 9), is interpreted as winnowing because it demonstrates the removal of a particular size range by a slight increase in water velocity or perhaps pulsing of the water flow. Up to c. 30% of the mud fraction is finer than 8.5 ϕ (Fig. 8) but is not being removed. The decrease in the amount of material in the medium

mode (Fig. 12) over the interval 8.9-8.5 Ma and at 7.5 Ma also supports winnowing because the modal grain size does not change but the volume at the mode does. This mode comprises nannofossil placoliths, so it must be these components that are being winnowed. If this change in volume was the result of palaeoproductivity changes, all grain size components linked to the nannofossils (including the smaller fragments) would be expected to change, not just the size range specific to the whole placoliths.

As nannofossil placoliths do not develop the cohesive charges typical of fine terrigenous grains, the silt-cohesive boundary at 10 μm identified in terrigenous sediments does not appear to hold for the Site 593 calcareous sediments. From 9-8 Ma the mud fraction is less leptokurtic than before or after this interval (Fig. 10), indicating the removal of a subsidiary grain size population over this interval; it is interpreted as being winnowed out of the sediment. The trend toward mesokurtosis is taken to indicate the persistent loss of the subsidiary grain size population after 7.5 Ma. The subsidiary population is the fine silt-coarse clay 6.25-8.25 ϕ (c. 13-3 μm) size range (Fig. 9). This is supported by the changes in skewness (Fig. 10) where the loss of the fine tail through 9-8 Ma, and after c. 7.5 Ma, also indicates removal of a population of grains. This loss of fines is also evident in the up-core trend to reduced mean grain size, from very coarse clay (8.33 ϕ, c. 3 μm) to coarse clay (9.67 ϕ, c. 1.2μm) (Fig. 10). As the winnowed grains are removed and the grain population size changed, the sorting would be expected to deteriorate. It does indeed, with the grains becoming more poorly sorted over the interval c. 9-8.5 Ma, and again after c. 6.5 Ma (Fig. 10).

Therefore one of the major controls on the sand/mud ratio at Site 593 is the velocity of the watermass bathing the site, and any changes in it. The modern bottom water at the site is Antarctic Intermediate Water (AAIW), and it is likely to have been its equivalent, Southern Component Intermediate Water (SCIW) through the Neogene (Kennett and von der Borch, 1986b; Flower and Kennett, 1995). The velocity of this watermass is poorly known. Mean water velocities at 1000 m depth of 2-4 cm/s are reported from the Tasman Sea north of Site 593 (Reid, 1986), and of 2-8 cm/s at this depth south of the Chatham Rise (Hamilton, 1990). Similar mean values of 3-8 cm/s have been recorded at 1000 m depth along the northern edge of the Antarctic

Circumpolar Current in the Southwest Pacific, but mask considerable variation in mean velocity (Bryden and Heath, 1985). Flow rates in the Crozet Basin (southern Indian Ocean) above 2500 m depth, which would include AAIW, are reported as generally less than 10 cm/s (Park et al., 1993). So a velocity of about 5 cm/s, certainly less than 10 cm/s, is assumed for the AAIW watermass.

Southard et al. (1971) showed that silt-sized foraminiferal tests are eroded by currents in the range 15-35 cm/s. As most of the silt-sized grains at Site 593 are nannofossil placoliths and not foraminiferal tests, it is likely that this slightly overestimates the velocity needed to winnow the placoliths. Using silt-sized particles, Hollister and Heezen (1972, in Ellwood and Ledbetter, 1977) reported that these can be kept in suspension by current velocities greater than 1 cm/sec and eroded by current velocities in the range of 6-15 cm/s. This suggests that changes in quantity of parts of the silt-size range should be sensitive enough to monitor bottom current velocity fluctuations in the Tasman Sea. In non-carbonate sediments, changes in bottom current velocities, below a velocity causing/initiating scour, can be inferred from changes in the percentage of the 63-10 μm fraction (Huang and Watkins, 1977). In some studies (e.g., Robinson and McCave, 1994; Manighetti and McCave, 1995; McCave et al., 1995b) the non-carbonate fine fraction behaviour is dominantly cohesive below 10 μm and non-cohesive above that size, so that the silt fraction finer than 10 μm usually behaves like the clay-sized (<2 μm) fraction (Selley, 1982). However, this silt-cohesive boundary is not recorded in other studies (e.g., Howe and Pudsey, 1999).

Sediment modes and composition

The coarse-sized mode at 44-53 μm is mainly due to whole juvenile foraminifera, rather than foraminiferal test fragments which are unlikely to breakdown to the same sizes in every sample (Fig. 11). The only other components reported from the core sediment which might match this size mode are volcanic glass and aeolian dust (Leg 90 Shipboard Scientific Party, 1986). The presence of pale green laminae (PGLs; Gardner et al., 1986b) argued to form from the breakdown of volcanic glass to clay, and the very rare occurrence of whole volcanic glass shards, make it unlikely that this material contributes to the coarse mode.

An additional component which could contribute to the coarse mode is aeolian dust. During a dust storm in 1928, grains of c. 40 μm size originating from Australia were reported falling over much of the South Island (Marshall and Kidson, 1929). Dust records collected from the Tasman Glacier (South Island) exhibit a bimodal distribution with a peak at c. 40 μm, linked to episodic conditions (i.e., dust storms) overprinting on the background dust levels (Windom, 1969). This transport of aeolian material is reflected in the Quaternary distribution of aeolian dust in Tasman Basin sediments, and is consistent with the modern, predominant westerly wind direction blowing dust across the Tasman Sea from southern Australia (Hesse, 1994). Therefore the coarse-sized mode at Site 593 may contain a very minor contribution from aeolian dust, but the persistency of the coarse mode points to juvenile foraminiferal as the dominant cause (Fig, 13).

The medium size mode (4.7-6.6 μm) is formed by nannofossil placoliths, with the population dominated by the reticulofenestrid group (Lohman, 1986). Small, <4 μm, monospecific populations dominate some samples (D. Waghorn, pers. comm. 1997). This group consists of an elliptical placolith with a central area that is either open or bridged by many small laths that form a reticulum (Fig. 15d), and hence the name (Takayama, 1993). The characteristic feature is the size of the placolith diameter and the central opening, with the group being divided on this basis. Several reports detail the size range of this group. For example, Young (1990) defines 'small' as being <5 μm, whereas Takayama (1993) uses a four stage classification with very large placoliths >7 μm, large from 7-5 μm, small from 5-3 μm and very small <3 μm. The medium size mode falls within the large to small range of Takayama (1993).

The 'dip' between the coarse and medium modes in the texture profiles (Fig. 11) occurs consistently throughout the section, so is inferred to reflect a compositional control on the texture, namely that coarser than 5.5 ϕ (> 22 μm) the grains are juvenile foraminifera, and grains finer than 5.5 ϕ are nannofossils; hence a lack of material contributing to the 5.5 ϕ size class (see Fig. 9). Particles contributing to the fine mode (0.4-0.35 μm) comprise reticulofenestrid-placolith fragments and micarb (micron-sized carbonate material) (Fig. 15). The only other possible contributor to this mode is the very small amount of clay material in the samples. Smectite and

illite are the most common clays in the Late Miocene interval (Robert et al., 1986). While clays are generally not divided into size ranges and the shape of the clay particles may vary greatly, the size ranges reported for illite and smectite generally (Grim, 1968), and specifically in Hole 593 (Robert et al., 1986), may contribute to this mode. The 'dip' between the medium and fine modes between 10-10.5 ϕ (c. 0.8 μm; see Fig. 9) is also inferred to reflect a compositional boundary, with whole placoliths coarser than it and fragments finer than it.

The dominant grain size of the coarse mode shifts at c. 7.5 Ma from 4.25 ϕ (52.6 μm) to 4.5 ϕ (44.2 μm), and shifts again at c. 6 Ma to 4.75 ϕ (37.2 μm), suggesting that either the water velocity increased sufficiently to remove juvenile tests of c. 52 μm size, pushing the mode to a smaller size, or that the production of the tests was somehow changed, and the population test size of the juveniles got smaller. An increase in water velocity sufficient to remove coarse silt (38-63 μm) is likely to remove smaller sizes as well, and to produce sediment scour and hiatuses, for which there is no evidence. Therefore, the coarse mode shift is more likely to result from changes in foraminiferal palaeoproductivity, either a general reduction in the size of the juveniles or a change in the dominant species contributing the juveniles. The position of this modal change at c. 7.5 Ma lies within the dominant shift in the silt/clay ratio (increasing clay) (Fig. 7b). This mode shift also corresponds with a decrease in foraminiferal diversity (M. Crundwell pers. comm., 1999) and is therefore most likely reflects a change in the species contributing to the mode. The mode shift observed in the nannofossils (4.6-6.5 μm section) occurs at the same horizon, which suggests that both shifts may be linked to surface water palaeoproductivity changes. Stabilisation of the position of both the Subtropical and Tasman Fronts, resulting in greater compartmentalisation of the Tasman Sea surface waters, may be a contributing factor.

The medium mode grain size shift occurs near c. 7.5 Ma (Fig. 12), between the FAD *Discoaster quinqueramus/berggrenii* at c. 226.68 mbsf (D. Waghorn, pers. comm., 1999) which is dated at 8.6-8.35 Ma (Berggren et al., 1995b; Raffi and Flores, 1995), and FAD *Amaurolithus primus* at c. 203.42 mbsf (Lohman, 1986) at 7.24 Ma (Berggren et al., 1995b; Raffi and Flores, 1995). The age of FAD *Discoaster quinqueramus/berggrenii* in this study is determined to be c. 8 Ma (at 226.68 mbsf),

but given the limited dating available at this site and the taxonomic problems defining this species it has not been used in establishing the chronostratigraphy. However, as the medium mode is attributed to nannofossils, variation within this group is considered.

Significant changes in the size of reticulofenestrid placoliths (the dominant group at Site 593) during the Middle-Late Miocene have been reported in Atlantic and Mediterranean drill sites, especially an increase in the numbers of 'small placoliths' prior to FAD *Amaurolithus primus* at 7.24 Ma (Flores and Sierro, 1989; Flores et al., 1992). Young (1990) reports something similar at Indian Ocean sites, where the large (>7 μm) reticulofenestrid *Reticulofenestra pseudoumblilicus* disappears, resulting in a 'small *Reticulofenestra* interval' starting in late NN10 (the NN10/11 boundary is now at 8.6 Ma). Between late NN11 to NN15 (top of NN11 at 5.6 Ma) the reticulofenestrid assemblage is strongly skewed towards smaller (<5 μm) placoliths. The *Reticulofenestra pseudoumblilicus* absence interval has also been documented in the equatorial eastern Pacific from 8.85-6.8 Ma (Raffi and Flores, 1995). Clearly there is a biostratigraphic event (the size reduction) on a global scale, but the dating of the event appears to indicate that it may be slightly diachronous between oceans as it ends somewhere between 6.8 and 5.6 Ma. The explanation for this event is uncertain, but suggestions include genotypic with ecological influences (Young, 1990), and/or oceanographic-climatic instability (Rio et al., 1990).

At Site 593 the shift in the medium mode grain size from 7.25 ϕ (6.57 μm) to 7.5 ϕ (5.52 μm) at c. 7.5 Ma (Fig, 12b) reflects a change in the size of the grains (nanno placoliths) contributing to the mode. The second shift at 6 Ma is also inferred to reflect a further reduction in the size of the placoliths. But the size change needs to be distinguished from the effects of winnowing. Winnowing of sediment is inferred because grains sized 6.25-8.25 ϕ have been removed, leaving both larger and smaller grains present in samples. However, if the placolith size reduced this would also result in a similar pattern, as grains of this size range would no longer be contributing to the sediment. Distinguishing between these two options is possible using the grain size of the medium mode (Fig. 11). While the volume of the medium mode reduces, the actual size of this mode does not, indicating that grains

contributing to the mode do not get smaller in size, there are just less of them. Therefore, because the medium mode grain size does not reduce during the time when *Reticulofenestra* placoliths reduce in size, the changes in sediment texture of the bioevent interval are inferred to be due to winnowing and not to the size reduction of the reticulofenestrids. Interestingly, the textural changes over the interval 6-5 Ma, which have been inferred to be due to winnowing, might also have a component of reticulofenestrid placolith size reduction as the mean grain size reduces, along with the medium mode shifting to 7.75 ϕ. Without detailed analysis of the nannofossil assemblage it is not possible to be definitive.

Palaeoceanographic Interpretations

The up-core decrease in mud content, specifically the size range fine silt-very coarse clay (6.25-8.25 ϕ), is inferred to be linked to an increase in flow velocity of the SCIW bottom water (Fig. 17). Therefore the large increases in sand content (and reduction in silt) over the intervals c. 19-17.5, 16.5-14.5 and 9.35-7.9 Ma are taken to indicate especially invigorated SCIW circulation in the southern Tasman Sea. Most of the 0.25 ϕ data exhibit substantive changes from 8.9-8.6 Ma (Section 27) (Figs. 9-11), and the increase in sand content over the interval c. 19-14.5 Ma (Fig. 7b), suggest these times represent accentuated current activity. If a modern velocity of about 5 cm/s is assumed for AAIW, then faster speeds must have characterised the SCIW during stronger winnowing events. However, for the pelagic ooze to accumulate as completely as it has at Site 593 (with the exception of the condensed section), persistently strong SCIW flow can be ruled out. Consequently the subtle changes in the 0.25 ϕ grain size data recorded during the Late Miocene are inferred to monitor an overall increase in SCIW velocity, but that this did not reach as high as 15 cm/s, the velocity at which silt-sized foraminiferal tests are removed (e.g., Southard et al., 1971) because silt-sized foraminifera are still present in approximately the same amounts of 1-5% in the samples.

Conversely, increases in the amount of mud-sized material can be used as a proxy for reduction in SCIW velocity (Fig. 17). The interval c. 14.5-9.5 Ma (Fig. 7b) exhibits some of the highest % mud values of the whole record, and this interval is taken to exhibit a decrease in SCIW velocity. Equally, after c. 8 Ma it is assumed that while the current velocity decreased somewhat, it remained higher than prior to c. 9.5 Ma

because the % mud is less after c. 8 Ma. The core logs for the site show that from c. 5 Ma to the core top, the sediments are logged as foram-bearing nannofossil ooze (Fig. 4a; Leg 90 Shipboard Scientific Party, 1986) this is taken to indicate a continuation of winnowing to the top of the hole.

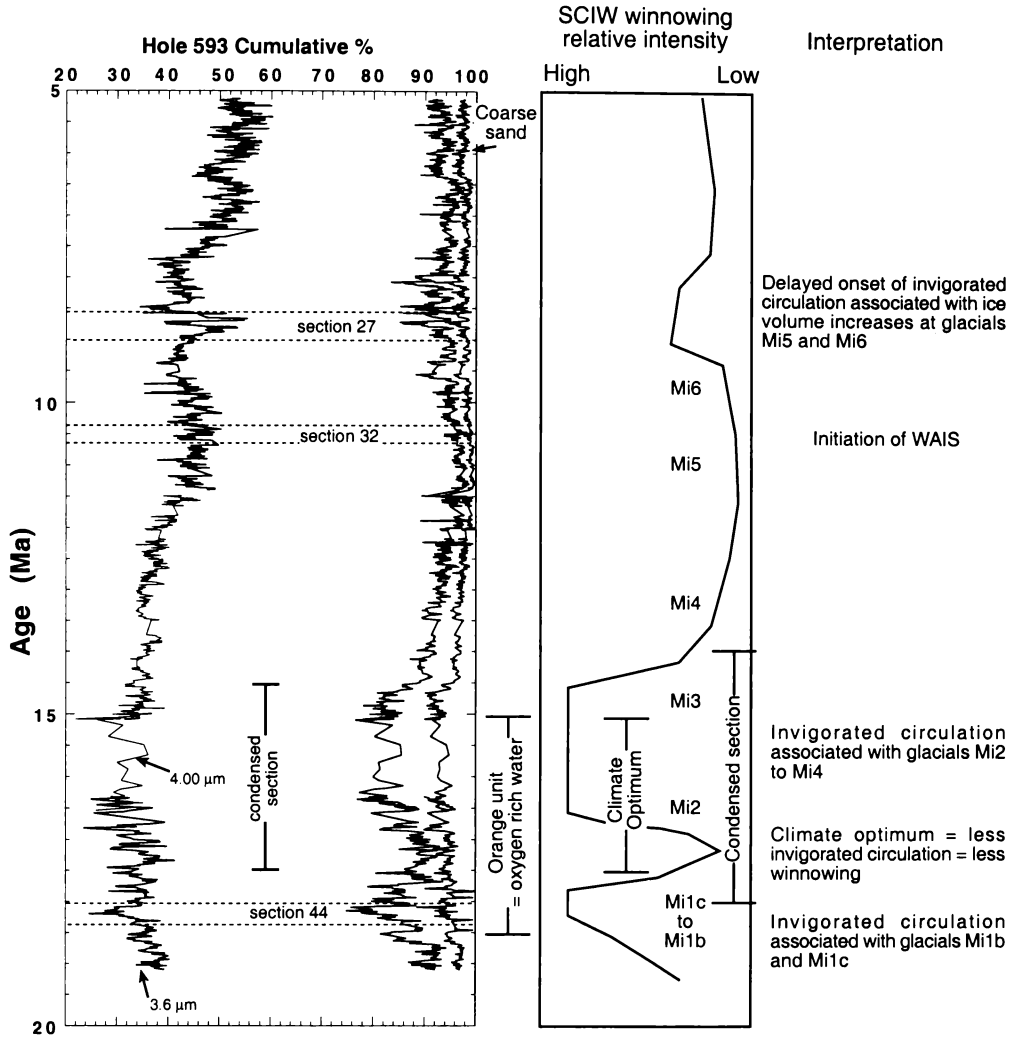


Figure 17 Hole 593 cumulative texture curves versus winnowing intensity of Southern Component Intermediate Water (SCIW) through the Miocene southern Tasman Sea. Greatest winnowing intensity corresponds with the condensed section and core section 27.

The intensification of the current speed of AAIW is linked to the oceanographic front which generates it, namely the AAPF (Fig. 3). The position of the AAPF south of New Zealand is closely linked to the Australian-Pacific ocean spreading ridge (Nelson and Cooke, 2001), and the wind speed of the polar westerlies (Perry and Walker, 1977). The establishment of the West Antarctic Ice Sheet (WAIS) between 10-8 Ma (Ciesielski et al., 1982; Kennett and von der Borch, 1986b) resulted in the meridional thermal gradient increasing, which in turn increased the volume of the Middle to Late Miocene SCIW (Flower and Kennett, 1995). General changes in

Pacific Ocean circulation intensity between 10-8 Ma have been inferred from fluxes in the biogenic opal record which supports intensification in the southern hemisphere trade winds and equatorial upwelling (Leinen, 1979). Tectonic control severely restricting the Indonesian Gateway by c. 16-12 Ma, resulted in intensification of the EAC (Kennett et al., 1985), and also the deep-water closure of the Panama Gateway by c. 10 Ma (Lyle et al., 1995; Collins et al., 1996) initiated close to modern circulation patterns in the Pacific Ocean.

An increase in the >63 μm fraction at about 10 Ma is evident in the sediments from Broken Ridge in the southern Indian Ocean (House et al., 1991). This increase is attributed to an increase in winnowing energy with invigorated SCIW circulation (House et al., 1991). These authors make the suggestion that the isotopic indication for an increase in ice volume at 13 Ma (e.g., Flower and Kennett, 1994; Flower and Kennett, 1995) is manifested in the textural record at Broken Ridge some 3 m.y. after the ice effect. Significant regional cooling in the Southern Ocean at c. 9 Ma is also evident in the increase in ice rafted debris at Kerguelen Plateau sites, associated with more extensive sea ice development (Bohrmann and Ehrmann, 1991; Schlich and Wise, 1992).

If the up to 3 m.y. delay between the ice volume increase and the oceanic changes over Broken Ridge is applied to Hole 593, the winnowing from c. 9.5-8 Ma, could be the delayed consequence of the Middle-Late Miocene isotope events identified in the oxygen isotopic record (Flower and Kennett, 1995; this study Chapter 3). Glacials Mi5 (c. 11.5-11 Ma) and Mi6 (c. 10 Ma) are interpreted as significant ice volume increases contributing to the development of the West Antarctic Ice Sheet (WAIS). Given the proximity of Hole 593 to the Southern Ocean, the oceanic delay may not be at long as 3 m.y., but may be more like 1.5-2 m.y. during the Late Miocene. In Hole 593, significant Miocene glacials (Mi Zones, identified in Chapter 3) occur over the same interval as the Early-Middle Miocene winnowing. Zones Mi1b and Mi1c occur in association with the winnowing from c. 19-17.5 Ma. The decrease in winnowing, and by inference reduction of SCIW velocity from c. 17.5-16.5 Ma in Hole 593 (Fig. 7b), coincides with initiation of the late Early Miocene climate optimum, a period of climate warming and less vigorous oceanic circulation (Woodruff and Savin, 1991; Wright and Miller, 1992). The decrease in mud content

starting at c. 16.5 Ma, interpreted as increasing SCIW velocity, coincides with glacial zone Mi2 (see Chapter 3). Glacials Mi3 and Mi4 (c. 15-13.5 Ma), described as significant ice volume events (Miller et al., 1991; Flower and Kennett, 1995), occur over an interval when the Hole 593 mud content is beginning to increase, but are associated with slight sand spikes. This apparent anomaly is interpreted as a reflection of the ice volume delay, and that the Early-Middle Miocene ice volume/ oceanic effect delay is less than the 2-1.5 m.y. proposed for the Middle-Late Miocene in Hole 593.

In Hole 593 the increased winnowing starting at c. 7.5 Ma, evident as the section with the lowest silt content of the whole record (Fig. 7b), occurs just before the FAD of *Amaurolithus primus* (Lohman, 1986). This bioevent is associated with the well known Chron 6 Messinian carbon shift reported to be isochronous in the Atlantic and Pacific Oceans between 6.1-5.9 Ma (Keigwin and Shackleton, 1980; Vincent et al., 1980; Hodell et al., 1986). The carbon shift occurs at, or immediately after, the FAD of *Amaurolithus* spp. (Haq et al., 1980) dated at 7.24 Ma in the Pacific (Berggren et al., 1995b; Raffi and Flores, 1995), but 7.38 Ma in the Atlantic (Backman and Raffi, 1997). Therefore the updated age of the carbon shift is taken to be slightly younger than 7.24 Ma in Hole 593. The carbon shift is linked to climate cooling and oceanic reorganisation associated with the initiation of the Messinian Salinity Crisis (Shackleton and Kennett, 1975; Elmstrom and Kennett, 1986; Hodell et al., 1986). The Messinian crisis is now thought to have some sea level lowering due to glaciation, in addition to regional tectonic control (Blanc and Duplessy, 1982; Kastens, 1992; Aharon et al., 1993). Glacially-induced changes in the SCIW velocity are again proposed to account for the winnowing episodes in the latest Miocene sediment from Hole 593.

CONCLUSIONS

Hole 593 was drilled on the Challenger Plateau as a re-occupation of an earlier site, Hole 284. In this hole the sediment was interpreted as containing significant palaeoceanographic evidence of Tasman Sea and Southern Ocean climatic changes. Hole 284 bottomed in sediments of latest Miocene age, so the excellent core recovery of Hole 593 provided the opportunity to extend the palaeoceanography of the region, through the earlier part of the Neogene.

Sediments from the Early to Late Miocene of Hole 593 are predominantly nannofossil ooze in which the mud-sized fraction makes up at least 75% of the sediment. The mud fraction (<63 μm) consists mainly of nannofossil placoliths, with c. 5-10% juvenile foraminifera, and typically minor quantities of clay minerals (up to 10%). The sand fraction is dominated by adult foraminifera, with minor quantities of *Bolboforma*, and terrigenous grains. Core sections 27, 32 and 44 were logged as foram-bearing nannofossil ooze, and these are evident in the textural records by either increased sand contents, or % sand spikes.

Current winnowing of Early to Late Miocene sediments on Challenger Plateau is evident in the sediment texture data using a number of parameters: (a) changes in the mud (<63 μm, >4 ϕ) content, specifically through a number of intervals: 19-17.5 Ma, 16.5-14.5 Ma and 9.5-8 Ma; (b) the presence of a condensed section from 18-14 Ma; (c) the removal of fine silt- to coarse clay-sized material (6.5-8.25 ϕ, 11.05-3.28 μm) but not smaller grains; (d) a reduction in the mud fraction mean grain size.

Unlike deep-sea sediments with much larger quantities of terrigenous material, in the pelagic carbonate oozes at Site 593 the grains <10 μm in size do not appear to act cohesively, presumed to reflect the composition of the silt-sized calcitic nannofossil placoliths. Winnowing of pelagic carbonate ooze is more likely reflection of the hydrodynamic properties of nannofossil placoliths and the ease with which they are mobilized by changing water velocity

A trimodal grain size distribution is consistent throughout the Miocene record, and reflects the composition of the sediment: (a) coarse mode (53-44 μm): juvenile foraminifera; (b) medium mode (6.6-4.7 μm): nannofossil placoliths; (c) fine mode (0.35-0.4 μm): placolith laths and clay minerals. Winnowing mainly removes grains contributing to the medium mode (c. 7-4 μm).

The shift in the grain size of the medium mode from 7.25 ϕ (6.6 μm) to 7.75 ϕ (4.7 μm) over the interval c.7.5-6 Ma, is interpreted as the Late Miocene 'small *Reticulofenestra* interval' where nannofossil placoliths record a size reduction. This interval has not been previous reported from the region, and the textural size change provides an independent measure of the placolith size reduction.

Increases in the winnowing potential of Southern Component Intermediate Water, the Miocene equivalent to Antarctic Intermediate Water, are linked to invigorated circulation throughout the Miocene, specifically glacial Mi Zones. These are associated with Antarctic cooling and ice sheet development, where the glacial zones correspond to increased winnowing. Specifically, the East Antarctic Ice Sheet during the winnowing from c. 19-14.5 Ma (Mi1b-Mi3), and the West Antarctic Ice Sheet during the winnowing from c. 9.5-8 Ma (Mi5-6). Delay between the ice volume increase (evident in $\delta^{18}O$ records) and the oceanic effects (invigorated Southern Component Intermediate Water circulation) appears to increase from the Early Miocene where the Mi Zone is coincident with the winnowing, to the Late Miocene where the delay is c. 2 Ma.

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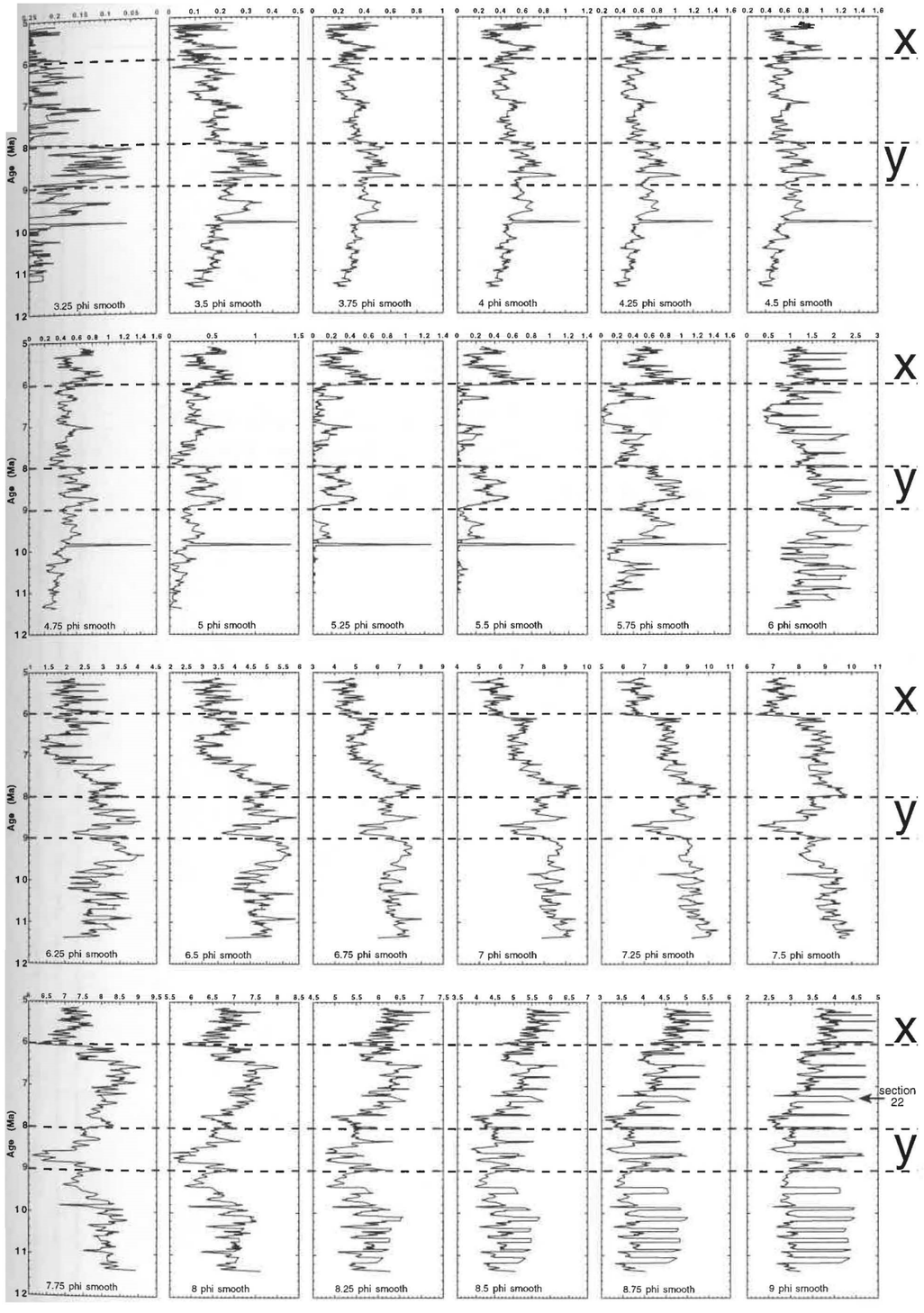
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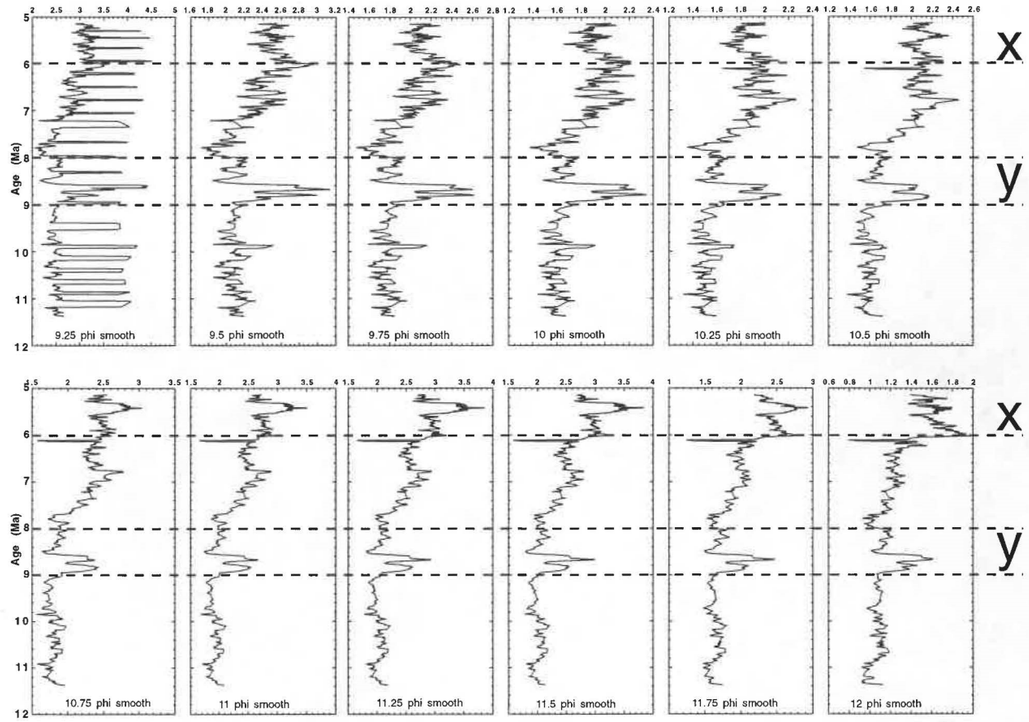
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Chapter 2

Figure 9. Late Miocene Hole 593 mud fraction divided into 0.25 phi fractions. Data are smoothed using a 5-point running average. Zones X and Y contain a greater mass of grains than samples on either side of the zones.

Chapter 3

Stable Isotope Stratigraphy And Watermass Palaeotemperatures For The Miocene (c. 19-5 Ma) At DSDP Site 593, Southern Tasman Sea

May your peak tops be flat,
And may your isotopes be stable

George Scott (1998)

Stable isotope stratigraphy and watermass palaeotemperatures for the Miocene (c. 19-5 Ma) at DSDP Site 593, southern Tasman Sea

ABSTRACT

High-resolution oxygen and carbon isotopic stratigraphies are presented for the late Early Miocene to earliest Pliocene section of DSDP Site 593. These are from the benthic foraminifera *Cibicidoides cenop* and *Cibicidoides* spp., and the planktic foraminifera *Globorotalia miotumida* (sinistral), *Globigerina bulloides*, *Globigerina woodi*, and *Orbulina universa*. The site is bathed by modern Antarctic Intermediate Water and it is likely to have been its Miocene equivalent, Southern Component Intermediate Water (SCIW), which is recorded by the *Cibicidoides* values. The *Globorotalia miotumida* isotope records are interpreted as a mode water signal, specifically Southern Component Mode Water (SCMW), and the *Globigerina bulloides, Globigerina woodi*, and *Orbulina universa* records as surface water signals, equivalent to Cool Subtropical Water (CSTW).

The $\delta^{18}O$ curves of all species exhibit fluctuations interpreted as mainly due to ice volume changes, and the *Cibicidoides* $\delta^{18}O$ record contains the globally recognised extreme glacial episodes, identified as Zones Mi1b-Mi6. These glacial events are also recorded in the planktic records, and it is this covariance that indicates both surface and intermediate waters were responding to global climatic cooling and ice volume increases, and not simply watermass cooling. The Middle Miocene $\delta^{18}O$ Zones (Mi2-Mi5) in the *Cibicidoides* record indicate that the SCIW did not respond to these glacials as 'single point' events, and that over the period 15-11.5 Ma each glacial plateaus before the next one. This is inferred to reflect initial ice volume increase and associated watermass cooling (both resulting in heavier $\delta^{18}O$ values), then the maintenance of the cooler water temperatures at mid-high latitudes prior to the next glacial. However, this was not the case for Mi6 which appears as a 'single point' event. An excursion to the heaviest benthic $\delta^{18}O$ values at 6.4-6.2 Ma is associated with a warming trend in planktic values and is interpreted as significant SCIW cooling of c. 2.3°C, rather than a large ice volume increase. After 6.2 Ma all

records exhibit less extreme fluctuations, interpreted to reflect glacial/interglacial climatic changes, with marked glacials at 5.4 and 5.2 Ma. Overall the SCIW palaeotemperatures range from 9.5-7.5°C, warmer than modern AAIW, but with extremes as low as 5°C. The SCMW palaeotemperatures are mainly warmer than the modern equivalent, and exhibit an upcore cooling trend, with Early-Middle Miocene (Tongaporutuan) values 10-12°C, and Late Miocene (Kapitean) values younger than 6.5 Ma, slightly cooler at 8-11°C.

The $\delta^{13}C$ records clearly indicate separate habitat zones, with *Globigerina bulloides* and *Orbulina universa* inhabiting surface waters (heaviest values), *Globorotalia miotumida* in deeper surface waters (upper permanent thermocline) and *Cibicidoides cenop* (lightest values) the SCIW. Covariance between all records is taken to indicate global carbon-cycle reorganisation. In the Lower-Middle Miocene section of Hole 593, carbon maxima (CM) events CM1-7 are recorded, with CM1-6 occuring during the Monterey Excursion. The $\delta^{13}C$ stratigraphies indicate that the maxima correspond with glacials, in keeping with the consequently lower sea level increasing the organic ^{12}C-rich carbon supply to the ocean from exposed shelf sediments. Mi6 in the Hole 593 record does not follow this trend as its associated with a carbon minima. Identification of the carbon shift associated with the Messinian Salinity Crisis is tentatively placed ending at c. 6.45 Ma, in keeping with other records from the region. The high absolute benthic $\delta^{13}C$ values are linked to thermodynamic tagging of the Antarctic surface water, from which SCIW is derived by subduction.

INTRODUCTION

Much has been written about global climate change through the Neogene, and specifically the Middle Miocene cooling which started around 15 Ma (Shackleton and Kennett, 1975a; Vincent and Berger, 1985; Miller et al., 1991a; Miller et al., 1991b; Wright et al., 1992; Flower and Kennett, 1993a, 1994a; Wright and Miller, 1993). The transition from the cool Middle Miocene to the even cooler Late Miocene was a consequence of continued expansion of the East Antarctic Ice Sheet, development of the West Antarctic Ice Sheet, continuing changes in ocean circulation (Barron and Keller, 1983; Wright et al., 1991; Lyle et al., 1995; Collins et al., 1996), and initial development of glaciers on, and sea ice around, Greenland (Frakes et al., 1992; Larsen et al., 1994; Helland and Holmes, 1997).

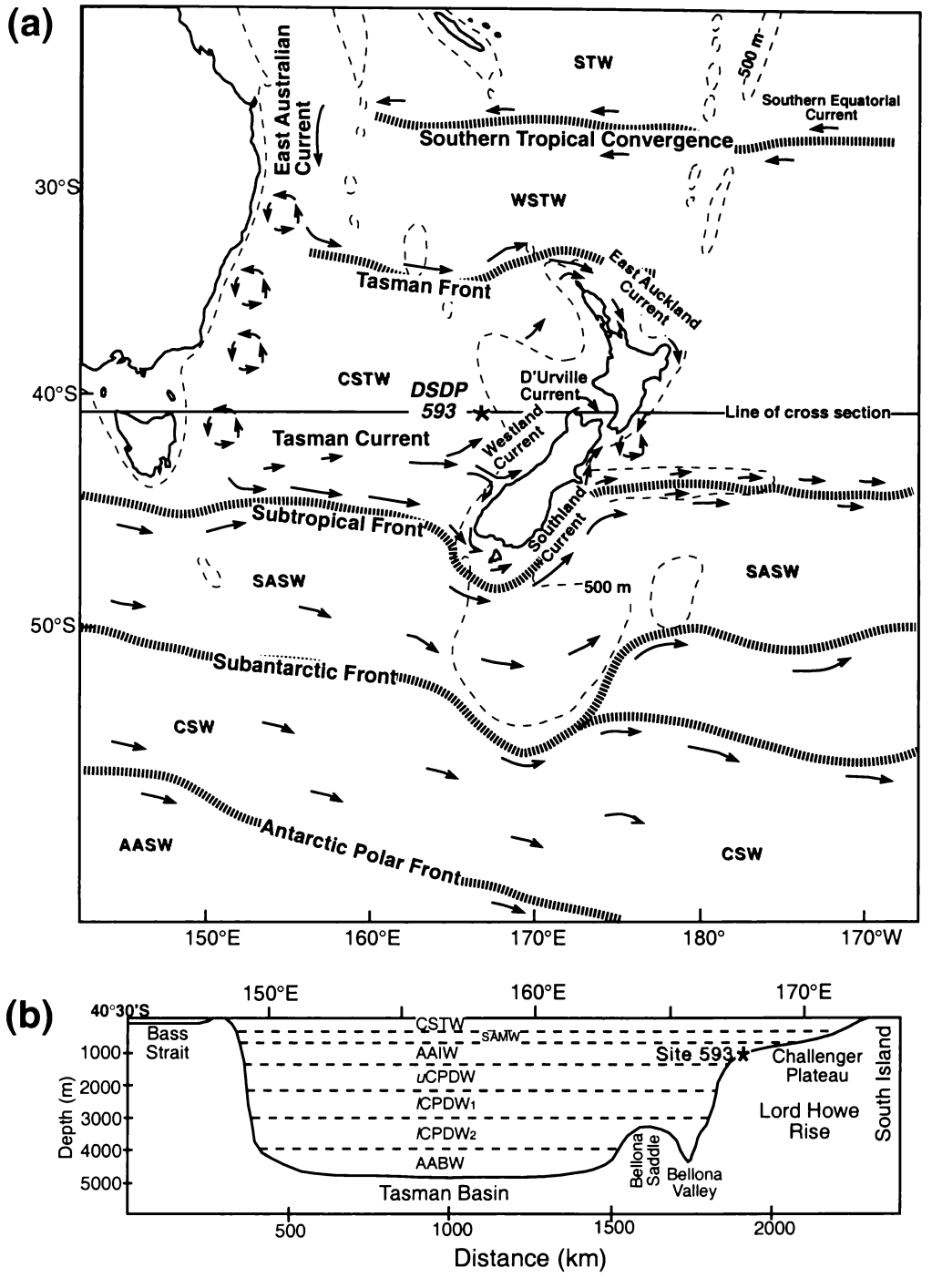
The Middle Miocene 'switch' to biosiliceous sedimentation in the Southern Ocean (Leinen, 1979; Keller and Barron, 1983, 1987), and diatom dissolution in North Atlantic sediments during times of high Northern Component Deep Water (NCDW) production (Wright et al., 1992) have been interpreted as reflecting initial Neogene changes in deep water circulation. Expansion of deep Southern Component Water (SCW) production (Woodruff and Savin, 1989, 1991; Flower and Kennett, 1995), including the production of a high $\delta^{13}C$ Southern Component Intermediate Water (SCIW) between 16-12.5 Ma (Wright et al., 1992) have also been documented. Causes for such circulation changes have been linked to both tectonic restriction of oceanic gateways (e.g., the closure of the Tethys Sea stopped the production of Tethys-derived deep waters and hence reduced the meridional heat transport and cooling Antarctic surface waters; Woodruff and Savin, 1989), and changes in circulation patterns (e.g., the upwelling of NCDW at the Antarctic Divergence which would contribute moisture to accelerated Early to Late Miocene East Antarctic ice sheet growth; Schnitker, 1980). During the Early-Late Miocene the climate cooled sufficiently to result in major glacial events recorded in the marine $\delta^{18}O$ record as events Mi1 to Mi7 (Miller et al., 1991b; Wright and Miller, 1992; Oslick et al., 1994). Associated with the glacials, are carbon maxima events, CM1-7 (Woodruff and Savin, 1985, 1991). Accumulation of organic carbon-rich sediments during the Early-Middle Miocene climate optimum, increased the inorganic carbon isotopic value of foraminieral calcite, culminating in the carbon maxima.

In this study, moderately high-resolution (c. 3-20 ka per sample) oxygen and carbon isotopic records for the Early-Late Miocene interval (c. 19-5 Ma) from DSDP Hole 593 in the southern Tasman Sea are presented. This is one of few Neogene high-resolution studies for the Southwest Pacific, and expands on the data initially published (Kennett and von der Borch, 1986a, b). There are a number of onland New Zealand studies through the Miocene (e.g., Scott, 1970: King et al., 1993; King and Thrasher, 1996), with this study providing the offshore equivalent. Widespread warm-water molluscan genera and large foraminifera through the Early Miocene shallow-water sediments, in conjunction with isolated heads of reef coral north of New Zealand, support considerable warming of New Zealand, culminating in the Neogene climate optimum (Nelson and Cooke, 2001). Subsequently, the Cenozoic climate deterioration is evident in the declining foraminiferal diversity, and extinctions of molluscs (Nelson and Cooke, 2001).

Site location and modern oceanography

Site 593 is located in 1068 m water depth on the southern margin of the Challenger Plateau (Lord Howe Rise) in the southeastern Tasman Sea. The site was at least 4° latitude south of its present position during most of the Miocene, and has migrated northwards with the Australian Plate (Kennett and von der Borch, 1986b). The general circulation pattern of the region is related to the southern Subtropical Gyre in the Pacific Ocean, the western arm of which flows along the coast of Australia as the East Australian Current. The bulk of this current travels across the Tasman Sea as flow along the Tasman Front (Stanton, 1979; 1999, pers. comm.) and enters the Pacific Ocean to the north of New Zealand (Stanton et al., 1997), connecting with the South Pacific Current (Stramma et al., 1995) along the Subtropical Front (Fig. 1a). In the southern Tasman Sea there is a slow anticyclonic gyre with west to east flow as the Tasman Current (Heath, 1985). In the eastern Tasman Sea this current splits, with one part flowing northwards around northern New Zealand to re-join the flow along the Tasman Front (Wyrtki, 1961, 1962; Heath, 1985; Szymanska and Tomczak, 1994; Stramma et al., 1995), and the other southwards around South Island, turning eastwards along the Chatham Rise where it re-joins the South Pacific Current along the Subtropical Front (Tomczak and Godfrey, 1994; Stramma et al., 1995). The bottom watermass which presently bathes the site is Antarctic Intermediate Water (AAIW; Fig. 1b), and the position of this watermass relative to

the permanent thermocline is illustrated in Fig. 1c. As there is no reported evidence for seafloor depth changes of the Lord Howe Rise through the Neogene (see Chapter 2), it is assumed that the site has always been bathed in intermediate water.



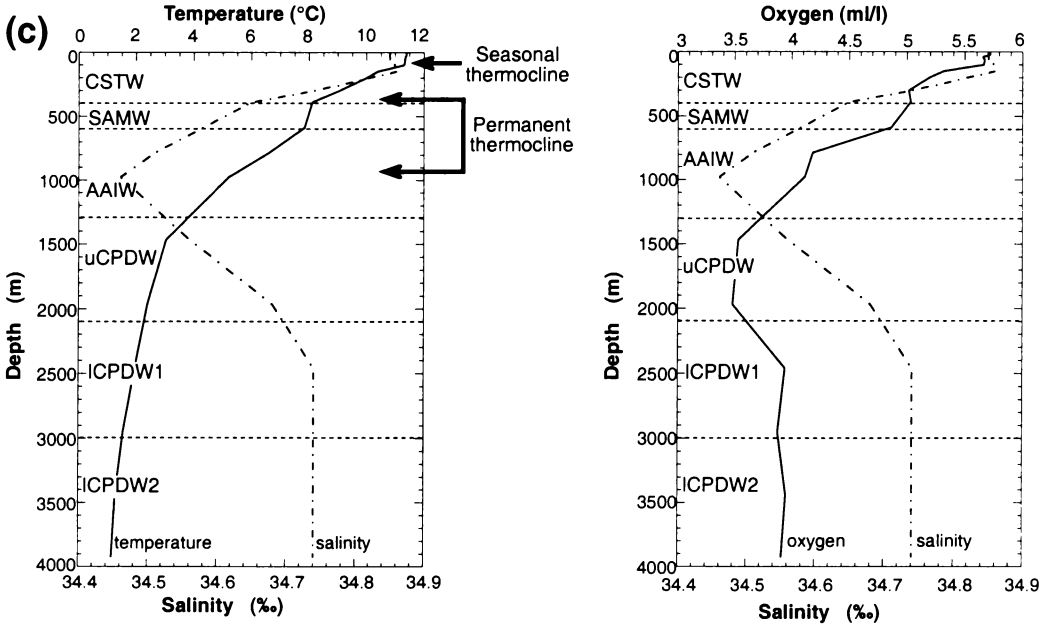


Figure 1 Tasman Sea and Southwest Pacific physical oceanographic setting (a) Oceanic fronts and surface watermasses in the Tasman Sea; (b) cross section through 40°30'S showing watermasses in relation to Site 593 (1068 m water depth); (c) winter salinity, temperature and depth (STD) profile at station Di924, just south of Site 593, defining watermasses in the Tasman Sea; CSTW = Cool Subtropical Water – warm, saline surface watermass; SAMW = Subantarctic Mode Water - subsurface oxygen maximum and thermostad; AAIW = Antarctic Intermediate Water - regional salinity minimum; uCPDW = upper Circumpolar Deep Water - oxygen minimum below salinity minimum; lCPDW1 = lower Circumpolar Deep Water 1 - deep salinity maximum; lCPDW2 = deep oxygen maximum; STD profile is not deep enough to record Antarctic Bottom Water (AABW) corresponding to deep temperature minimum. After Wyrtki (1961; 1962), Garner (1962; 1967), Garner and Ridgway (1965), Drewry (1983), Rodman and Gordon (1982), and Heath (1985).

Core stratigraphy

Hole 593 stratigraphy is presented in Fig. 2a, and expanded for most of the Miocene section in Fig. 2b. The sediments comprise nannofossil and foram-bearing nannofossil ooze, detailed in Chapter 2.

The previous Neogene foraminiferal and nannofossil biostratigraphic framework for Hole 593 (Jenkins and Srinivasan, 1986; Kennett and von der Borch, 1986b; Lohman, 1986) has in this study subsequently been refined (Crundwell et al., 1997a, 1997b) and as far as possible updated following Berggren et al. (1995) (Table 1). Due to a very poor palaeomagnetic record in Hole 593 (Barton and Bloemendal, 1986), it has been necessary to make correlation with other sites which have better age control. To this end, the nearest sites with good palaeomagnetic data are the newly drilled ODP Leg 181 sites to the east of New Zealand (Crundwell, in prep.; Leg 181 Shipboard Scientific Party, 1999).

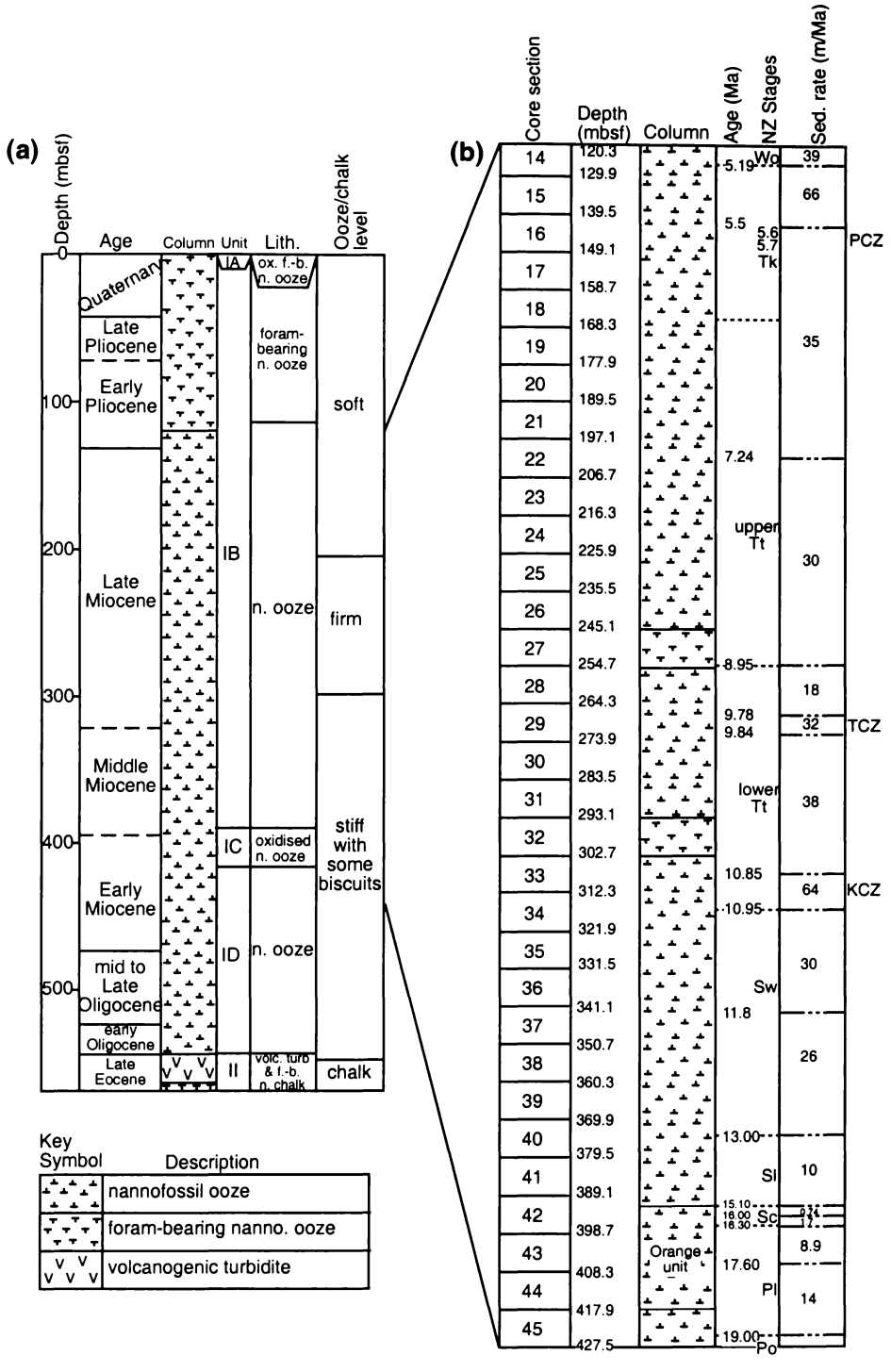


Figure 2 (a) General Site 593 stratigraphy using Leg 90 biostratigraphy, unit IA-D = ooze, unit II = volcanogenic turbidite. After Nelson (1986); (b) detailed stratigraphy for the Miocene section used in this study (After Kennett and von der Borch, 1986a) updated using the geopolarity timescale (GPTS) of Berggren et al. (1995) and biostratigraphy of Crundwell (in prep.). New Zealand stages: Po = Otaian, Pl = Altonian, Sc = Clifdenian, Sl = Lillburnian, Sw = Waiauan, Tt = Tongaporutuan, Tk = Kapitean, Wo = Opoitian. PCZ, TCZ, and KCZ represent *Globorotalia miotumida* coiling zones which are discussed in Chapter 4.

Table 1. Biostratigraphic events used to derive Miocene sedimentation rates for Hole 593. The NN6/7 boundary and (N) are nannofossil events, the remainder are foraminiferal events. Coiling zones are discussed in Chapter 4.

Event	Depth (mbsf)	Approx. Age (Ma)
First occurrence *Globorotalia puncticulata*	126.04	5.20
First occurrence *Globorotalia sphericomiozea*	143.72	5.51
Top Palliser Coiling Zone	153.97	5.81
Base Palliser Coiling Zone	158.10	5.93
First occurrence *Amorolithus primus* (N)	203.42	7.24
Last occurrence *Globoquidrina dehiscens*	254.38	8.95
Top Tukemokihi Coiling Zone	269.07	9.78
Base Tukemokihi Coiling Zone	270.82	9.84
Top Kaiti Coiling Zone	309.20	10.85
Base Kaiti Coiling Zone	315.25	10.95
NN6/7 boundary	341.16	11.80
Last occurrence *Fohsella peripheroronda* s.l.	372.16	13.00
First common occurrence *Orbulina suturalis*	393.90	15.10
First common occurrence *Praeorbulina circularis*	394.57	16.00
First occurrence *Praeorbulina glomerosa*	395.08	16.30
First occurrence *Globorotalia miozea*	406.65	17.60
First occurrence *Globorotalia praescitula*	426.10	19.00

CONTROLS ON ISOTOPIC VALUES

Using the $\delta^{18}O$ and $\delta^{13}C$ stable isotopic values of foraminiferal shell calcite as proxies, it is possible to derive palaeoclimate information. The mean $\delta^{18}O$ of ocean water varies with the quantity of isotopically-light ice stored on the continents, with seawater temperature controlling the fractionation of oxygen isotopes between seawater and calcite. Consequently, the $\delta^{18}O$ record from foraminiferal calcite is a blend of global (ice volume) and local (temperature) components (Emiliani, 1955; Kennett, 1986) (Table 2). Planktic foraminiferal $\delta^{18}O$ values may also be affected by surface watermass salinity, the changing seasonal growth and depth habitats of species, and nutrient availability. Deep water benthic foraminifera are less subject to changes in water temperature and salinity on seasonal and annual bases, and therefore they provide a less complicated record of global ice volume and watermass palaeotemperatures (Chappell and Shackleton, 1986).

Table 2. Major controls on $\delta^{18}O$ values from open ocean benthic and planktic foraminifera. Assumes foraminiferal species do not change their depth habitat (after Gasperi and Kennett, 1993).

No net change in $\delta^{18}O$
Warm surface and bottom waters equal to the increase in ice volume effect
Cool surface and bottom waters equal to decrease in ice volume effect
Increase $\delta^{18}O$
Cool the watermasses
Increase ice volume
Cool watermasses and increase ice volume
Cool watermasses more than the decrease in ice volume
Warm watermasses by less than the ice volume increase
Decrease $\delta^{18}O$
Warm the watermasses
Decrease ice volume
Warm the watermasses and decrease ice volume
Cool watermasses by more than the ice volume increase

By comparing $\delta^{18}O$ compositions of shells from species which are known to inhabit the surface mixed layer (e.g., *Orbulina universa* and *Globigerina bulloides*) with extinct species where depth preference is unknown (e.g., *Globorotalia (Globoconella) miotumida* and *Globigerina woodi*) it is possible to infer changes in depth by the systematic departures in isotopic values from species of known depth habitat (Norris et al., 1993, 1994). The difference between the benthic and planktic $\delta^{18}O$ values from the same sample provides a measure of the vertical temperature gradient in the ocean in the absence of measurable temperature records (Table 3). For summary diagram see Fig. 14 in Chapter 1.

Table 3. Combinations of possible climatic events that can produce observed changes in vertical thermal gradients (after Gasperi and Kennett, 1993).

No net change
Entire water volume warmed equally
Entire water volume cooled equally
Change ice volume
Strengthen vertical thermal gradients
Warm surface waters more than deep waters
Cool deep waters more than surface waters
Warm surface waters and cool deep waters
Weaken vertical thermal gradients
Warm deep waters more than surface waters
Cool surface waters more than deep waters
Warm deep waters and cool surface waters

Carbon isotopic values are related to the cycling of ^{12}C due to biological activity. The overall dissolved carbon dioxide (ΣCO_2) gradient in the ocean is a function of the productivity of the surface waters. Because ^{12}C is taken up preferentially by marine phytoplankton and incorporated into their organic material, this results in surface waters becoming enriched in ^{13}C. The inorganic shell calcite incorporates the ^{13}C, so that changes in $\delta^{13}C$ of foraminiferal calcite can provide information on palaeoproductivity. Planktic foraminiferal calcite $\delta^{13}C$ is highest in shallow-dwelling species and slightly less enriched in deep-dwelling planktic foraminifera. Regions of high surface water productivity exhibit well developed vertical gradients of ΣCO_2, with surface waters containing relatively low levels of ΣCO_2 because of the high carbon utilisation (Kroopnick, 1985). In areas of low productivity and a well developed thermocline, the carbon isotopic gradients are smaller and therefore planktic foraminifera living at deeper depths exhibit only small $\delta^{13}C$ differences from those of surface dwelling species (Berger et al., 1978). Conversely, areas of upwelling and therefore reduced thermal depth gradient have higher carbon isotopic depth gradients.

Deeper waters contain increasingly higher concentrations of ΣCO_2 due to the oxidation and decomposition of organic carbon (rich in ^{12}C) which 'rains' down onto the seafloor, a process which starts within the water column and continues in seafloor sediments. The decomposition recycles ^{12}C-rich CO_2 back into the water via respiration, and results in benthic foraminiferal calcite containing more ^{12}C, and therefore showing a depleted $\delta^{13}C$ signal compared with planktic foraminifera. This assumes that no active fractionation (the 'vital effect') occurs during calcite secretion, or if it does that it can be corrected for (Grossman, 1987; Spero et al., 1991).

The planktic foraminifera *Globigerina bulloides* used in this study has been shown experimentally to actively fractionate carbon isotopes by an amount which can be corrected for using the following equations (Spero and Lea, 1996):

$$\delta^{13}C_{\Sigma CO_2}(@16°C) = 000012x^2 - 0.011x + 3.97 \quad (1)$$

$$\delta^{13}C_{\Sigma CO_2}(@22°C) = 000014x^2 - 0.014x + 5.65 \quad (2)$$

where 'x' equals the mean shell size (296 μm) of an 11 chambered shell and $\delta^{13}C_{\Sigma CO_2}$ is the seawater dissolved inorganic carbon value. Using equation (1) and 11 chambers as standard, the correction factor for $\delta^{13}C$ for *Globigerina bulloides* in the southern Tasman Sea (sea surface temperatures, SSTs, <20°C) is +1.76‰, and this has been applied to all $\delta^{13}C$ data for this species.

As well as palaeoproductivity, the benthic $\delta^{13}C$ signal can be used to indicate the mixing of watermasses and the time since each watermass was in contact with the atmosphere. This provides an 'ageing' or ventilation signal, so that the longer the watermass is isolated from the atmosphere the more depleted it will become in ^{13}C as more ^{12}C is added (Berger, 1981; Berger and Vincent, 1986). At high-latitudes the ocean-atmosphere exchange of CO_2 enriches surface waters in $\delta^{13}C$ relative to the atmosphere and isotopic fractionation (during gas exchange) increases with decreasing temperature (Charles and Fairbanks, 1990; Charles et al., 1993). Ocean-atmosphere equilibration at 0°C would result in seawater $\delta^{13}C$ about 3‰ higher than equilibration at 25°C (Mook et al., 1974), but oceanic mixing is fast enough that complete equilibration is never reached (Charles et al., 1993). However, there is about 1‰ enrichment in surface water $\delta^{13}C$ at the Antarctic Polar Front suggesting that persistently high gas exchange occurs there resulting in partial equilibrium with the atmosphere (Charles and Fairbanks, 1990). This has been termed 'thermodynamic tagging' by Charles and Fairbanks (1990) and any watermasses which contain 'tagged' surface water will reflect this enrichment in ^{13}C (Charles et al., 1993). Climate modelling demonstrates that the tagging imprint increases in colder waters and, as a result, southern-sourced glacial intermediate waters would have a greater thermodynamic signal than during interglacials (Mackensen et al., 1996).

Early to Middle Miocene benthic $\delta^{13}C$ values have been used to track deep watermasses between oceans. During this time interval North Atlantic values (Hole 563) are higher than equatorial Pacific values (Hole 289), and Southern Ocean values (Hole 704) lie between these two (Wright et al., 1992). In order for the Southern Ocean to have higher $\delta^{13}C$ values than the Pacific, the deep water source must be either from the Atlantic or the Indian Ocean (Wright et al., 1992). At c. 21 Ma the Pacific and Southern Oceans had similar $\delta^{13}C$ values, and as they start to

diverge at c. 19.5 Ma, a high $\delta^{13}C$ source (probably Northern Component Water) is inferred to have entered the region (Wright et al., 1992). Middle Miocene benthic $\delta^{13}C$ values from Hole 593 are heavier (Flower and Kennett, 1995; Elkington et al., 2000) than those from the Atlantic, and this has been explained by the site being bathed by SCIW which contained large volumes of 'tagged' surface water, resulting in the benthic calcite exhibiting an enriched $\delta^{13}C$ signal.

Hence, planktic foraminifera which lived and secreted calcite in surface waters would be expected (vital effects aside) to exhibit light $\delta^{18}O$ and heavy $\delta^{13}C$ calcite values. Conversely, benthic specimens should exhibit the opposite, with the heavy $\delta^{18}O$ reflecting the colder bottom waters in which they lived and the light $\delta^{13}C$ the release of ^{12}C-rich CO_2 by oxidation and respiration. For a summary diagram, see Fig. 15 in Chapter 1.

MONTEREY EXCURSION AND MESSINIAN CARBON SHIFT

The Monterey Excursion recognised in many records as a substantial Early-Middle Miocene $\delta^{13}C$ shift toward heavier values, referred to by Vincent and Berger (1985) and Vincent et al. (1985) as the Chron 16 Carbon Shift. It has been identified in numerous marine records from different oceans (e.g., Corfield and Cartlidge, 1993; Flower and Kennett, 1993b, 1995; Smart and Murray, 1994; Rea et al., 1998). By updating the timescales of these records in light of the GPTS of Berggren et al. (1995), the Monterey Excursion started c. 18 Ma and ended c. 14 Ma. Dramatic increases of organic carbon accumulation in Pacific-rim sediments (e.g., the Monterey Formation) are linked to invigorated coastal and equatorial upwelling by not only the high carbon content, but also by the phosphorus content and phytoplankton abundance changes (Vincent and Berger, 1985; Vincent and Killingley, 1985). Carbon cycle-adjustments have been proposed that necessitated CO_2 equilibrium changes between the ocean and atmosphere, and resulted in 'greenhouse cooling' lowering global temperatures (Vincent and Berger, 1985). Burial of ^{12}C-rich organic material resulted in a net $\delta^{13}C$ increase in foraminiferal calcite. Extreme carbon maxima (and therefore extreme carbon accumulation) within the Monterey Excursion have been labelled CM1-6 (Woodruff and Savin, 1991; Hodell and Woodruff, 1994), with CM7 occurring after the excursion. The resultant global cooling is evident in the increase in $\delta^{18}O$, starting about 15 Ma and

culminating in the major glacial Zone Mi3 of Wright et al. (1992) (Fig. 3). Increased nutrient supply as a result of chemical weathering of continental rock has also been linked to this event (Raymo et al., 1988; Raymo, 1992, 1997; Ruddiman et al., 1997). As upwelling increased, with its consequent increased nutrient supply to surface waters, the phytoplanktic biomass increased and hence the organic carbon contribution to the sea floor sediments can be linked to weathering products. In addition, chemical weathering is linked to CO_2 draw-down (Raymo, 1994; Harrison, 2000).

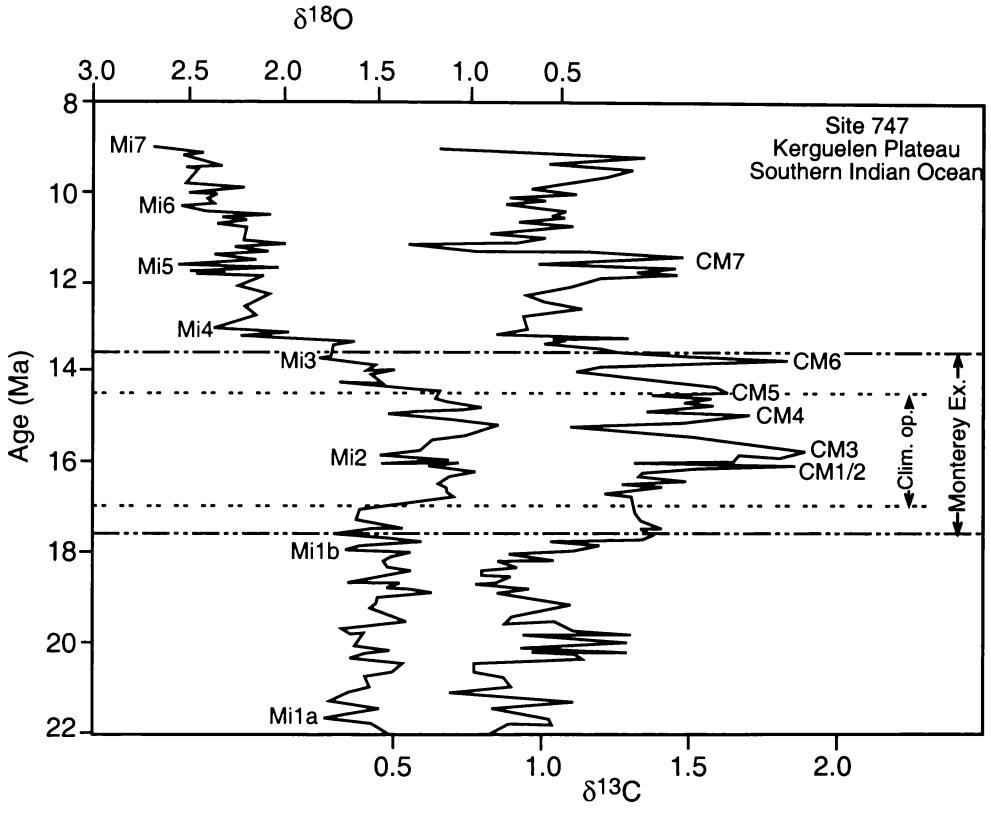


Figure 3 Isotope stratigraphy from Southern Ocean Site 747, Kerguelen Plateau, in which both glacial Mi Zones, and CM carbon events have been identified. Clim. op. = climate optimum; Monterey Ex. = Monterey Excursion. After Wright and Miller (1992) and Woodruff & Savin (1991) with ages adjusted according to Hodell and Woodruff (1994).

A distinct $\delta^{13}C$ shift toward lighter values is evident in many deep sea records at c. 6.5 Ma (Shackleton and Kennett, 1975a; Bender and Keigwin, 1979; Keigwin and Shackleton, 1980; Vincent et al., 1985; Elmstrom and Kennett, 1986; Benson, 1995) and was described as the Chron 6 Carbon Shift by Vincent et al. (1980), now referred to as the Messinian Carbon Shift (MSC). This shift is the opposite of the Monterey Excursion, and has been attributed to the addition of ^{12}C-rich organic carbon to the ocean system. This was due of exposure of continental shelves, rich

in organic carbon, by glacioeustatic sea level lowering (Keigwin and Shackleton, 1980; Vincent et al., 1980). In addition, palaeocirculation changes brought about by restriction of flow between the Mediterranean Sea and the North Atlantic, instigating a 'salinity crisis' have also been linked to this carbon shift (Hsü et al., 1977; Hodell et al., 1986; Hodell et al., 2001). In the original description, the above authors noted a lack of conspicuous $\delta^{18}O$ change associated with the carbon shift (as would be required if ice volume change was involved), but rather a change in the pattern of the $\delta^{18}O$ record from comparatively smooth before the carbon shift, to marked fluctuations after it (Vincent et al., 1980). However, subsequent studies have identified $\delta^{18}O$ change indicating sea level lowering associated with the carbon shift (e.g., Kennett, 1986; Kastens, 1992; Aharon et al., 1993).

Sediment accumulation in Hole 593 is considered to be relatively complete (Leg 90 Shipboard Scientific Party, 1986), so as this study encompasses the age interval 19-5 Ma, both the Monterey Excursion and Messinian Carbon Shift $\delta^{13}C$ events should be present, as well as the Mi glacial Zones. Three of the latter (Mi1b, Mi1c, and Mi2) have previously been identified in the Hole 593 $\delta^{18}O$ record (Scott et al., 1994).

FORAMINIFERAL SPECIES SELECTION

The benthic foraminiferal genus *Cibicidoides* was chosen for analysis (Fig. 4), specifically *Cibicidoides cenop*, *Cibicidoides wuellerstorfi,* and *Cibicidoides kullenbergi*, but if not present in sufficient quantities, a mixed *Cibicidoides* sample was used, including *Cibicidoides subhaidingerii, Cibicidoides kuglerii,* and *Cibicidoides rugosa*. This genus has been shown to secrete calcite offset from oxygen equilibrium by c. 0.64 ‰ when compared with the commonly used *Uvigerina peregrina* (Shackleton and Opdyke, 1973; Shackleton et al., 1984). Some recent studies however, have indicated *Cibicidoides* spp. values may be closer to equilibrium, and that *Uvigerina* sp. usually considered to be at equilibrium, are relatively enriched in $\delta^{18}O$ (Bemis et al., 1998). The *Cibicidoides* genus is epibenthic (Lutze and Thiel, 1989; Linke and Lutze, 1993), and its test calcite records mean ambient $\delta^{13}C$ of dissolved inorganic carbon in bottom waters (Graham et al., 1981; Vincent et al., 1981; Grossman, 1987; Duplessy et al., 1988). Between 3-10 tests were analysed per sample. Selected SEM images are provided in Appendix C.

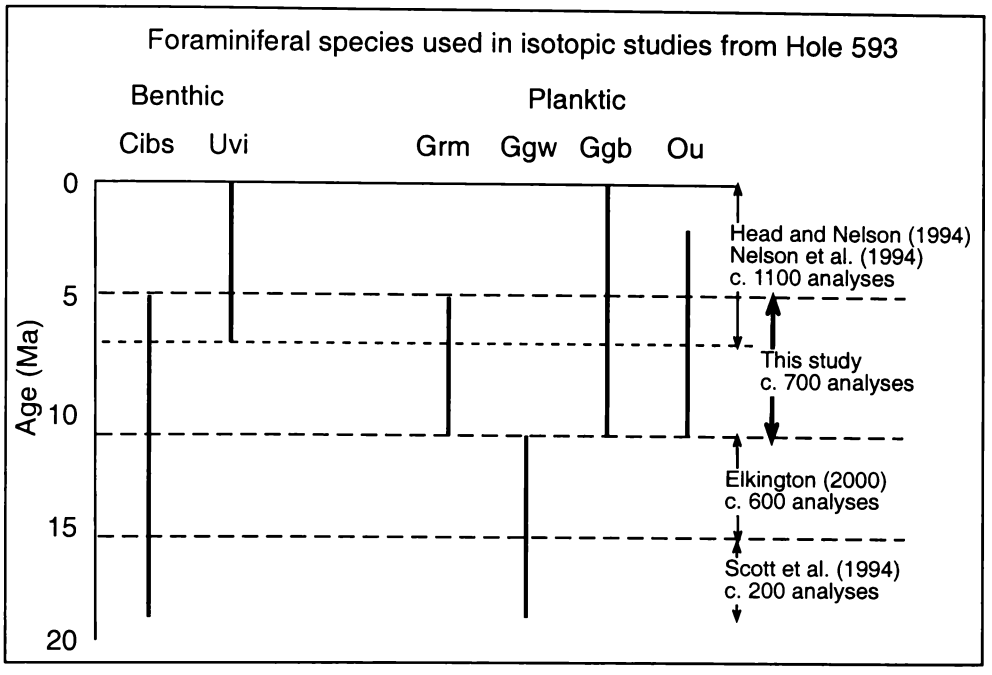


Figure 4 Summary of foraminiferal species used in isotopic studies from Hole 593. Cibs = *Cibicidoides* spp., Uvi = *Uvigerina peregrina*, Grm = *Globorotalia miotumida*, Ggw = *Globigerina woodi*, Ggb = *Globigerina bulloides*, Ou = *Orbulina universa*. Number of analyses in each study are noted. SEM images of selected species are provided in Appendix C.

Four planktic species were analysed, *Globorotalia (Globoconella) miotumida* (sinistral), *Orbulina universa*, *Globigerina woodi,* and *Globigerina bulloides* (Fig. 4). As a general rule, the oxygen isotopic composition of planktic foraminiferal calcite reflects the major growing season of the species (Spero and Lea, 1996).

Globorotalia (Globoconella) miotumida is not often used in isotopic studies as it is not found in sediments younger than Late Miocene (Scott et al., 1990). The only living species of the *Globoconella* subgenus is *Globorotalia (Globoconella) inflata* in which the $\delta^{18}O$ calcite values correspond with winter sea surface temperatures (Ganssen and Sarnthein, 1981), and it reproduces at depths of c. 400 m (Hemleben et al., 1989) within the upper part of the permanent thermocline. Calcite secretion in *Globorotalia inflata* has been linked to seawater density, specifically to the 26.8 σ_t isopycnal, the result of which is that individual tests may record a wide range of temperatures and salinities (Curry and Matthews, 1981). Whether these assumptions can be applied to *Globorotalia miotumida* is debatable, but Norris et al. (1994) did conclude that the globoconellids lived within the main thermocline and hence give a deep-dwelling planktic signal. Where possible 20 tests per sample were used for analysis.

Orbulina universa is a shallow-dwelling planktic species which maintains algal symbionts that may contribute to the $\delta^{13}C$ value of secreted shell calcite (Spero, 1992). However, it can be used reliably for isotope studies provided sufficient numbers and large test sizes are available (Schiffelbein and Hills, 1984). In the modern ocean this species appears to calcify in oxygen equilibrium with seawater during its maximum productivity phase in winter (Sautter and Thunell, 1991). Its preferred thermal range is c. 13-17°C (Bradshaw, 1959; Sautter and Thunell, 1991) and individuals descend to the deep mixed layer as surface temperatures and solar irradiance increase in spring (Sautter and Thunell, 1991). The $\delta^{13}C$ of *Orbulina universa* test calcite has been linked experimentally to $\delta^{13}C_{\Sigma CO_2}$ of surface waters in low light conditions during winter (Spero, 1992). These ecological preferences are assumed to hold for the Late Miocene specimens. In this study 10-30 tests, mainly about 20, were picked from the >150 µm fraction.

Globigerina bulloides is a spinose, non-symbiont-bearing species commonly associated with areas of upwelling (Fairbanks et al., 1982; Kroon and Darling, 1995; Weaver et al., 1997). It is generally considered to be a shallow-dwelling (0-100 m) species (Hemleben et al., 1989). It has been found living below the seasonal thermocline and follows upwelling water to the surface (Ganssen and Sarnthein, 1981; Fairbanks et al., 1982), maintaining a thermal preference for the 10°C isotherm (Sautter and Thunell, 1991). This species secretes its shell out of equilibrium with seawater with respect to both carbon and oxygen due to the incorporation of metabolic CO_2 prior to full isotopic equilibration with seawater (Sautter and Thunell, 1991). Despite this, seasonal variations in the $\delta^{18}O$ signal respond systematically to changes in water temperature at which the individuals calcified (Curry and Matthews, 1981; Sautter and Thunell, 1991), specifically recording winter temperatures in the Southwest Pacific region (Weaver et al., 1997). Carbon fractionation can be corrected for using equations (1) or (2) noted earlier. Oxygen isotope correction equations have been experimentally calculated (Spero and Lea, 1996), but when these are applied to modern southern Tasman Sea calcite values, they result in *Globigerina bulloides* $\delta^{18}O$ values that are heavier than benthic values, and so they have not been used. Although size differences were noted, and in several samples were picked, big tests were not available in all samples resulting in a patchy record. Curry and Matthews (1981) reported that smaller individuals

appear to calcify closer to oxygen isotopic equilibrium than do larger ones. Where possible about 20 small tests per sample analysis were used.

Globigerina (Zeaglobigerina) woodi is another extinct species, disappearing in the Late Pliocene, and has been linked to temperate to warm subtropical waters (Kennett and Srinivasan, 1983). This species was analysed over the lower to middle Miocene sections of the hole (Fig. 4), mainly because it was available in large numbers, but also because *Globigerina bulloides* did not evolve until the Middle Miocene. The only living ancestor is *Globigerina (Zeaglobigerina) rubenscens,* a tropical to subtropical species that is rarely used in isotopic studies, which limits any consideration of its vital effect on isotopic values.

METHODS

Sample processing is detailed in Chapter 2. Only whole, well preserved foraminiferal tests were selected for analysis from the sand fraction (63-150 μm) and, where possible, similar numbers and sizes were used. For identification, the taxonomic schemes of Kennett and Srinivasan (1983) and Scott (1990) have been followed here. All tests were picked from the >150 μm fraction, ultrasonicated in methanol to remove any adhering sediment, roasted at 300°C for one hour, and cooled under vacuum. Samples were reacted in 100% orthophosphoric acid at 70°C for 20 minutes. Isotopic analyses were conducted using a number of machines: a VG602 with a manual reaction line (University of Waikato); Europa 20/20 mass spectrometers fitted with CAPS ovens (Universities of Waikato and Southampton); and on a Finnigan Mat with a Kiel III oven (NIWA), all using single sample acid reaction. Values are given in delta notation as per mille deviation of the $^{18}O/^{16}O$ or $^{13}C/^{12}C$ ratio of the sample relative to the VPDB standard by repeated analyses of international standards NBS-19 and/or TSS. Instrument precision is ± 0.05 ‰ for both $\delta^{18}O$ and $\delta^{13}C$, and analytical precision is ± 0.05 to 0.2‰.

While the same planktic and very similar benthic species were used for the intervals c. 19-16.5 Ma and c. 16.5-11.5 Ma, they were analysed on different mass spectrometers, and corrections have been applied to the some of the data to account for instrument offset. These corrections were calculated using overlapping samples from the same sub-bottom depth in the core. Specifically over the interval

c. 19-16.5 Ma, +0.3‰ has been added to the planktic *Globigerina (Zeaglobigerina) woodi* $\delta^{18}O$ values, and +0.24‰ to the benthic *Cibicidoides* $\delta^{13}C$ values. It is possible that the benthic offset could be attributed to a vital effect difference between the original *Cibicidoides kullenbergi*, and the *Cibicidoides rugosa/wuellerstorfi* used in the overlap samples, but without further analysis this cannot be certain. As the planktic samples prior to and after 16.5 Ma both used *Globigerina (Zeaglobigerina) woodi*, it makes intrument offset a more likely explanation than vital effect.

RESULTS

The isotope data is listed in Appendix C. All data are provided against depth in the core (metres below sea floor, mbsf), and have been converted to age (Ma) using the age model (Table 1), and detailed in Chapter 2. In the Early to Late Miocene section of the hole about 1600 samples were analysed, and the data have been smoothed in many instances (always noted on graphs) to facilitate easier interpretation. Smoothing using a 5-point running average was undertaken using the plotting software KaleidaGraph.

Benthic foraminifera

The benthic $\delta^{18}O$ data range from c. 0 to 3‰, and are generally lighter than 2‰ (Fig. 5). The modern, core top, benthic $\delta^{18}O$ value of 2.55‰ (*Uvigerina* = 3.19‰), obtained in an earlier study (Nelson et al., 1994), is exceeded only at c. 9.8 Ma and 6.5-6 Ma. The proportions of the $\delta^{18}O$ values separately attributable to palaeotemperature changes and to ice volume are discussed later. There is a general upcore trend to heavier values, with the heaviest at c. 6.5 Ma. Several enrichment events have been previously identified, namely glacial Zones Mi1b, Mi1c and Mi2 by Scott et al. (1994). Additional events include: a shift of 0.3‰ to enriched values at c. 14.75 Ma; a second shift of 0.25‰ at c. 13.5 Ma; a third shift of c. 0.4‰ by c. 11 Ma; a spike of 0.5‰ to heavier values at c. 9.8 Ma; a second spike of c. 0.6‰ at c. 6.3 Ma within a general trend to heavier values from 6.6-6.2 Ma. After this time, the record gets slightly lighter, by 0.6‰, with noticeable enrichment spikes at c. 5.4 and 5.2 Ma. Amplitude changes of c. 1‰ are associated with some enrichment events.

The benthic $\delta^{13}C$ record exhibits a general upcore enrichment from 19-16.5 Ma, followed by overall general depletion through to 5 Ma (Fig. 6). A noticeable enrichment spike occurs at 17.5-17 Ma to c. 2.15‰, reaching a maximum of c. 2.8‰ (Fig. 6). From 16.5-14.5 Ma values fluctuate between 1.6-2.4‰, then decrease to c. 1‰ between 14.5-12.5 Ma. Values enrich by 0.8‰ between 12-11.5 Ma, then deplete again to reach 0.8‰ by c. 9.8 Ma. The lower resolution data between c. 8.3-7 Ma exhibits enrichment to 1.9‰ after which the data gets lighter, with the lightest values of the whole record, c. 0.4‰, from 6.5-6 Ma. From 6-5.5 Ma values fluctuate between 0.6-1.2‰, with a slight upcore enrichment, then at c. 5.5 Ma there is a shift of about 0.5‰ to heavier values.

Planktic foraminifera

The planktic $\delta^{18}O$ records exhibit a general upcore trend to heavier values (Fig. 5), noting the shift of 0.4‰ at 11.5-11 Ma occurs between the records from *Globigerina woodi* (older section), and *Globigerina bulloides* and *Orbulina universa* (younger section). This may be attributable to vital effect-differences between these planktic species. However, as the benthic $\delta^{18}O$ record also exhibits a shift to heavier values over this interval, it is inferred that at least part of the planktic shift is genuine. The planktic record also contains enrichment spikes previously attributed by Scott et al. (1994) to the glacials Mi1b, Mi1c, and Mi2. The enrichment in all three planktic records at c. 9.8 Ma lags the benthic slightly. The modern *Globigerina bulloides* $\delta^{18}O$ value of 0.9‰ is only reached or exceeded after 11 Ma. The partitioning of the $\delta^{18}O$ values according to temperature changes or to ice volume changes is discussed later.

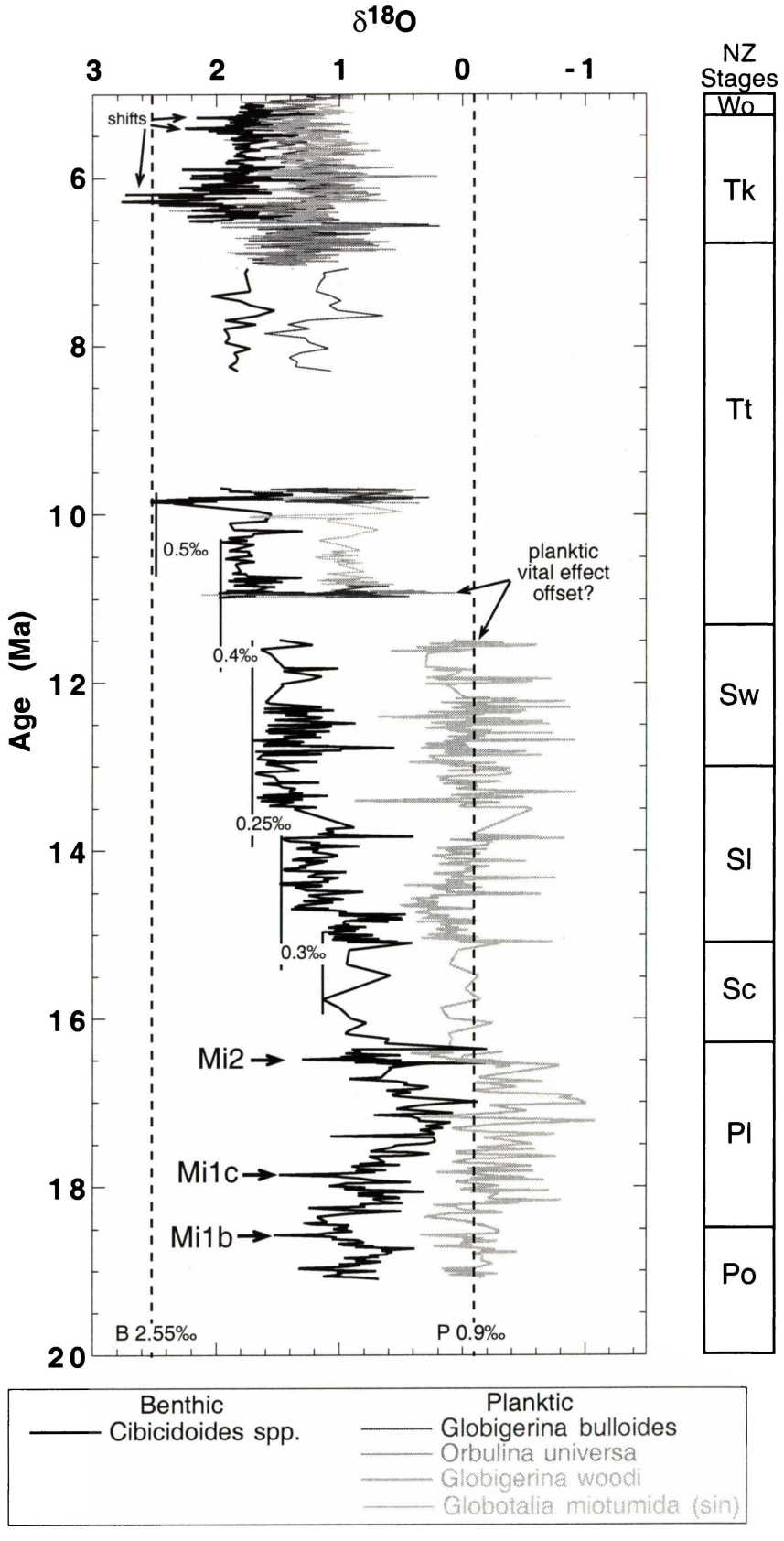


Figure 5 Early to Late Miocene benthic and planktic $\delta^{18}O$ records from Hole 593. Glacial Zones Mi1b, Mi1c, and Mi2 after Scott et al. (1994). Holocene benthic (2.55‰) and planktic (0.9‰) values are included for comparison (after Nelson et al., 1994). For NZ Stages see Fig. 2. An A3 version is provided at the end of the chapter.

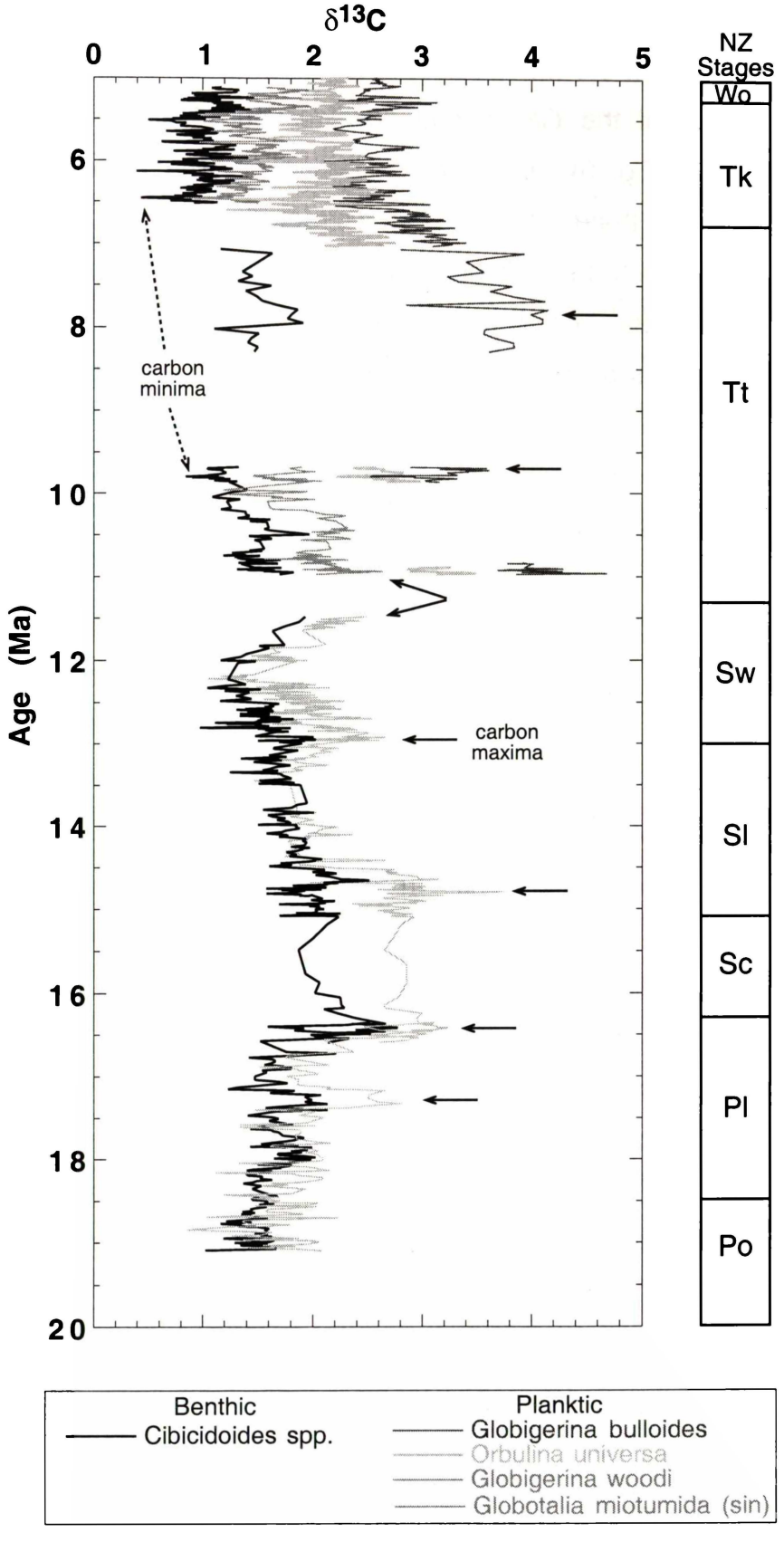


Figure 6 Early to Late Miocene benthic and planktic $\delta^{13}C$ records from Hole 593. Significant enrichment spikes evident in both benthic and planktic data are marked with arrows. For NZ Stages see Fig. 2. An A3 version is provided at the end of the chapter.

In addition to the general trends, the *Globorotalia miotumida* (sinistral) $\delta^{18}O$ record exhibits extreme enrichment events at c. 6.45 (1.65‰), c. 6-5.9 Ma (1.65‰), and c. 5.4 Ma (1.75‰). At c. 5.3 Ma the record shifts to lighter values (1.3-0.8‰). The intermittent nature of the *Globigerina bulloides* and *Orbulina universa* records between 11-9 Ma (Fig. 6) reflects the targeting of certain events, described in Chapter 4. Generally the planktic and benthic records exhibit good covariance from 19-15 Ma, after which they diverge until 13.5 Ma, and then again return to reasonable covariance. The enriched planktic $\delta^{18}O$ values at c. 6.4 Ma occur just before the enrichment spike in the benthic record at c. 6.2 Ma. At the 6.2 Ma enrichment in the benthic record, the heaviest values of the whole section 19-5 Ma, the planktic records exhibit depletion (the benthic and planktic records go in opposite directions over this interval). After c. 6.1 Ma the records again covary.

The *Globigerina woodi* $\delta^{13}C$ record exhibits upcore enrichment, reaching a maximum of 3.8‰ at 14.75 Ma (Fig. 6). This record includes noticeable spikes at 17.5-17 Ma (2.8‰), c. 16.5 Ma (3.2‰), and c. 13 Ma (2.6‰), all of which correspond to spikes in the benthic record, and there is generally good covariance between the two records. Depletion to c. 1‰ at 12.25 Ma, followed by enrichment to 2.4‰ at 11.5 Ma, again follows the benthic trend. From c. 19-17.5 Ma and 14.5-11.5 Ma, the *Globigerina woodi* $\delta^{13}C$ absolute values are very similar to the *Cibicidoides* record, but from 17.5-17 Ma and 16.5-14.5 Ma they are offset by up to c. 1‰.

The planktic $\delta^{13}C$ records from 11 Ma exhibit a general upcore trend to depleted values. The *Globigerina bulloides* does exhibit noticeable enrichment between 9.8 Ma and 8.5 Ma, and from 8.5-5 Ma there is considerable depletion of c. 1.5‰. Where all three planktic records co-exist, they exhibit good covariance.

Overall, the $\delta^{18}O$ isotope stratigraphy indicates that the benthic foraminifera *Cibicidoides* secretes isotopically heavier calcite than the planktic foraminifera. The difference in $\delta^{18}O$ between *Cibicidoides* and *Globorotalia miotumida* (sin) reflects the variation in vertical temperature gradient between intermediate and permanent thermocline waters (i.e., mode water). The difference between *Cibicidoides* and *Globigerina bulloides, Orbulina universa,* and *Globigerina woodi* reflects the gradient between intermediate and near-surface waters. The *Cibicidoides* $\delta^{13}C$

record is lighter than the planktic records indicative of its deeper water habitat, and the gradient between the benthic and planktic $\delta^{13}C$ records indicates planktic-depth stratification between intermediate and surface waters.

DISCUSSION

Foraminiferal depth stratigraphy

Both the planktic $\delta^{18}O$ and $\delta^{13}C$ results (Figs. 5 and 6) confirm the assumption that the extinct *Globorotalia miotumida* (sin) had a deeper dwelling habitat preference than *Orbulina universa*, a surface mixed-layer species. The *Globigerina bulloides* $\delta^{18}O$ record provides a less definitive depth habitat preference as it exhibits large fluctuations, but most of the record suggests these species lived in surface waters, while the carbon record supports some upwelling. Modern *Globigerina bulloides* follow upwelling waters to the surface (Spero and Lea, 1996; Weaver et al., 1997), which would explain the light $\delta^{13}C$ values in this study. However, if upwelling was occurring bringing cold deep water to the surface, the $\delta^{18}O$ records from all the planktic species would be expected to exhibit heavier values. As the *Globigerina bulloides* $\delta^{18}O$ values are similar to those of *Globorotalia miotumida* (sin) and *Orbulina universa,* the case for deep water upwelling is not convincing. Equally, upwelled, ^{12}C-rich water is not evident in the *Orbulina universa* record. The overall pattern of very separate carbon curves is interpreted as indicating relatively little vertical watermass mixing in the southern Tasman Sea, particularly during the Late Miocene.

If *Globorotalia miotumida* had changed its depth habitat preference over time this might account for its isotopic changes and affect the interpretation of it being a deep-dwelling planktic species. Some members of the globoconellid clade (to which *Globorotalia miotumida* belongs) have exhibited increases in $\delta^{18}O$ over time, interpreted as progressive occupation of cooler habitats, either by increasing depth or seasonality, rather than changes in water temperature or ice volume (Schneider and Kennett, 1996). However, Norris et al. (1994) proposed that the high vertical temperature gradient in the South Pacific (the modern Southwest Pacific thermocline is steeper by c. 3°C compared with the South Atlantic) magnified small isotopic differences and that the $\delta^{18}O$ changes actually reflected very little change

in depth habitat. These authors concluded that the globoconellids evolved entirely within the main thermocline, with an inferred minimum depth of reproduction of c. 400 m, similar to modern *Globorotalia inflata* (Fig. 7).

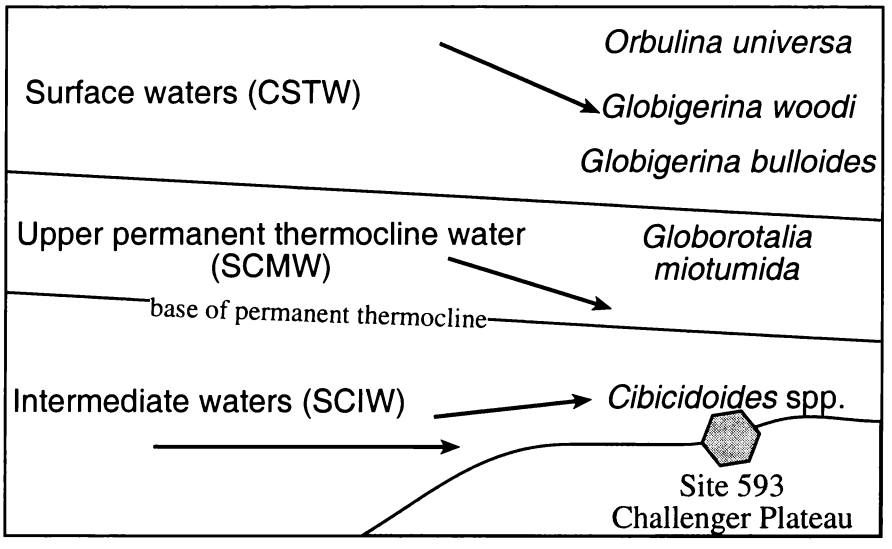


Figure 7 Foraminiferal depth stratification based on the Hole 593 stable isotopic data. Arrows indicate watermass flow directions from south (left) to north (right).

The $\delta^{18}O$ offset between *Cibicidoides* and *Globigerina woodi* reflects the expected benthic/planktic differences. However, the similarity of the absolute *Cibicidoides* and *Globigerina woodi* $\delta^{13}C$ values, when some offset might be expected, hints at 'vital effects' playing a role in the *Globigerina woodi* values. Equally, the absolute values of the *Globigerina woodi* $\delta^{13}C$ record are considerably depleted compared with the (admittedly younger) *Orbulina universa* record, a known surface dweller. The *Globigerina bulloides* records have a $\delta^{13}C$ correction of +1.76‰ added, based on experimental evidence for vital effect offset (Spero and Lea, 1996). Without additional data from deep-upwelling planktic species over the interval 19-11.5 Ma, the *Globigerina woodi* data cannot realistically be assessed for $\delta^{13}C$ offset. However, when surface-dwelling planktic $\delta^{13}C$ values are the same or similar to those of benthic species, and the $\delta^{18}O$ data do not indicate upwelling, then some vital effect is a plausible explanation.

The relatively enriched benthic $\delta^{13}C$ absolute values over the entire Miocene record are interpreted as reflecting considerable ocean-atmosphere ventilation of the intermediate water and/or expanded mode water, rather than any contribution of high ^{13}C carbon to the region around Site 593, or shallowing water depth above the

site. Relatively enriched absolute $\delta^{13}C$ values have also been reported at other Southern Ocean sites by Woodruff and Savin (1989) and Wright et al. (1992) who suggested they reflect well-ventilated, southern-sourced intermediate waters. Additional evidence for Site 593 being closer to the sources of relatively 'young' intermediate water is the presence of an 'orange unit' from c. 18.4-15.1 Ma (418-394 mbsf) (Kennett and von der Borch, 1986a; Flower and Kennett, 1995). This was interpreted as the result of unusually high oxidation of sediments which reflect increased production of oxygen-rich SCIW associated with East Antarctic Ice Sheet growth (Kennett and von der Borch, 1986b). See also Chapter 2.

Miocene oxygen and carbon isotope events in Hole 593

A number of the globally recognised $\delta^{18}O$ events (= Mi Zones) have been identified in the Miocene section of Hole 593 (Elkington et al., 2000) using the criteria of Miller et al. (1991b). The original definition of the Mi Zones used the maximum $\delta^{18}O$ value at a specified depth in a specific core, and the recognition of the zones from multiple sites, so that they are inferred to be globally correlatable and synchronous (Miller et al., 1991b). The original sequence has been followed here, in accordance with the international stratigraphic guide recognising that these events are chronostratigraphic, i.e., in themselves they do not provide absolute ages (Hedberg, 1976; Murphy and Salvador, 1999). The Early to Late Miocene Zones Mi1-7 (Fig. 3) have been linked to the GPTS and the ages for the events revised accordingly (Table 4).

Table 4. Miocene oxygen isotope Zones, noting their original definitions and ages (Miller et al., 1991b; Wright and Miller, 1992; Wright et al., 1992) and their revised ages following the GPTS of Oslick et al. (1994) and Berggren et al. (1995), and recent amendments of Billups et al. (2002). Also shown are the estimated ages of the events in Hole 593.

Zone	Original definition and age	GPTS	Age (Ma)	593 age (Ma)
Mi7	base C4Ar (8.5 Ma)	base C4Ar.1n	9.31	
Mi6	near middle C5n (9.6 Ma)	mid C5n.2n	10.4	9.8-10
Mi5	near base C5r (11.3 Ma)	base C5r.2r	11.48	11-11.5
Mi4	C5AAn/C5An transition (c. 12.6 Ma)	base C5AAn	13.14	13.5-12.2
Mi3	base C5ABr (starts in C5AD; 14.9-13.6 Ma)	base C5ABr	13.7	14.7-13.8
Mi2	C5n / C5Br boundary (16.5-16 Ma)	top C5Cn.1n	16.2	16.5
Mi1b	C5Dr (C6Dr appears to be typing error)	mid C5Dr	18.0	18.6
Mi1a	C6Ar (21.8 Ma)	C6Ar	21.32-21.77	
Mi1	C6Cn2-C6Cn3 (24.5-23.5 Ma)		23.9	

In Hole 593 the Zones Mi1b-Mi4 are consistently older by c. 1-0.3 Ma than the calibrated dates (Table 4). Event Mi5, tentatively identified in an earlier study (Elkington, 2000; Elkington et al., 2000) and definitely recognised in this study, is dated at c. 11.5-11 Ma, consistent with the calibrated GPTS age. However, the age of Mi6 at c. 9.9 Ma is reasonably well constrained in Hole 593, but the GPTS age is slightly older. The age disparities are inferred to partly reflect the limited dating available in the Early-Middle Miocene interval of the hole, but also more importantly the plateau-like nature of several of the Mi Zones in Hole 593 compared with the single-point Zones in other records (Fig. 3). In the Hole 593 $\delta^{18}O$ record Zones Mi3, Mi4, and Mi5 appear to step down to heavier values and, although fluctuating, maintain the heavier values. This is unlike Zones Mi1b, Mi1c, and Mi2 which are recognised as 'point' values (Fig. 8). The ages of 'type' Zones Mi3, Mi4, and Mi5 fall more or less within the age range determined for the Hole 593 zones. While the Middle Miocene cooling occurs in two steps, namely Mi3 and Mi4) (Miller et al., 1991b), the plateau-like nature of the intermediate water record from Hole 593 record is not evident in the deep water benthic records. However, a stepwise cooling pattern in deep water has been noted from the middle Eocene-Oligocene Maud Rise $\delta^{18}O$ record (Stott et al., 1990). The plateaued nature of the Hole 593 SCIW $\delta^{18}O$ Mi Zones is interpreted as ice volume increases with stabilisation of cooler SCIW temperatures after the initial glacial event.

Zones Mi2, Mi3, Mi5, and Mi6 have been identified in both benthic and planktic records and this synchoroneity is interpreted as reflecting ice volume changes (Miller et al., 1991b). In previous studies the absence of low latitude planktic records prevented concise identification of Zone Mi4 as a glacial ice volume increase. Hole 593 does have a planktic record covering this zone, and while this event is evident in the *Globigerina woodi* data, it is not as large as the other zones (Fig. 8). The lack of a clear shift in some Middle Miocene planktic records (i.e., Mi3 and Mi4) has been explained by the ice volume increase being partially compensated for by warming of surface waters (Vincent et al., 1985).

In the younger section of the Hole 593 benthic record the $\delta^{18}O$ enrichment event of about 0.8‰ between 6.5-6.0 Ma, does not appear to represent a large glacial event because the planktic $\delta^{18}O$ records all exhibit upcore depletion over this interval (Fig.

9). Rather the event is inferred to indicate c. 3°C cooling (0.24‰/1°C) of the SCIW. After 6.2 Ma, the records covary and exhibit further significant glacials at c. 5.9 Ma, c. 5.42 Ma, and c. 5.27 Ma.

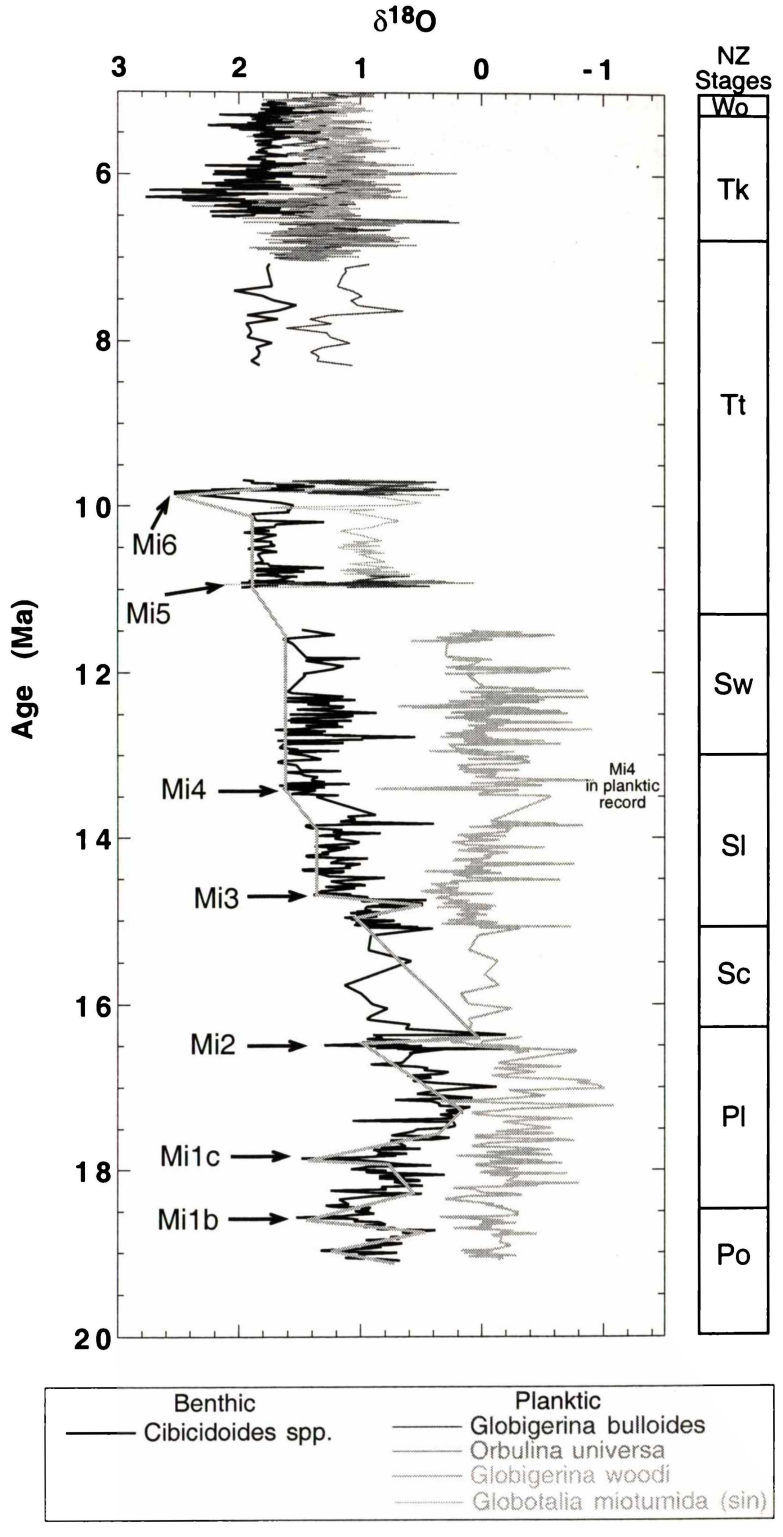


Figure 8 Identified Early-Late Miocene $\delta^{18}O$ isotope Mi Zones in Hole 593. Compare with Fig. 9. Zones Mi1b-Mi2 were previously established by Scott et al. (1994). Note that Zones Mi3-Mi5 exhibit a stepwise increase in $\delta^{18}O$ as indicated by the line. For NZ Stages see Fig. 2.

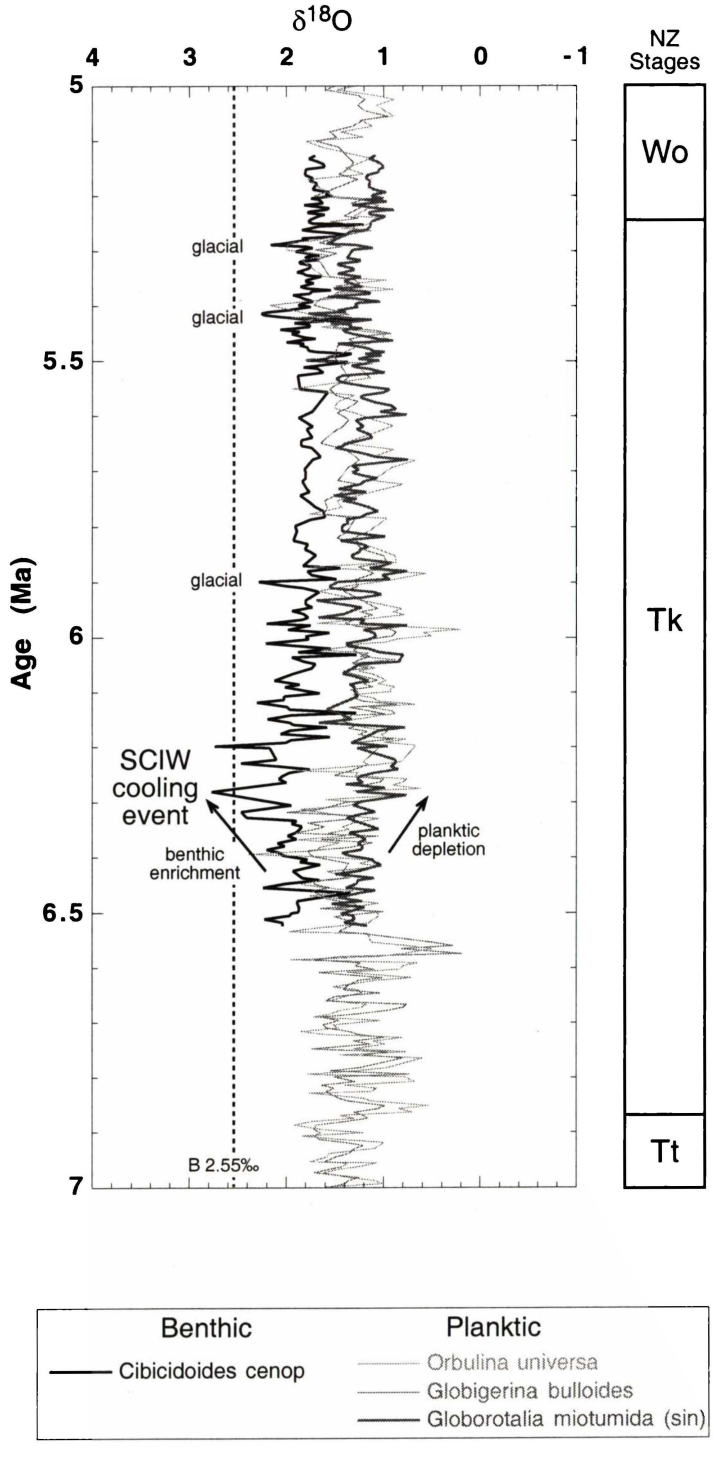


Figure 9 Expanded $\delta^{18}O$ record for the latest Miocene interval from Hole 593 to illustrate the SCIW cooling event associated with intermediate water cooling and surface water warming, indicating that the event is thermally controlled, with a small component of ice volume. The modern *Cibicidoides* (equivalent) $\delta^{18}O$ value of 2.55 ‰ is noted for comparison.

Palaeotemperature calculations

Relative water temperatures can be estimated from $\delta^{18}O$ data using the calculations of Epstein et al. (1951; 1953). These assume no significant salinity change or ice volume effects (Kennett, 1986), and indicate that a 1‰ change in $\delta^{18}O$ equates to a c. 4°C change in temperature. Absolute palaeotemperatures were initially calculated from marine calcite using mollusc shells (Epstein et al., 1953; O'Neil et al., 1969), and this equation was subsequently modified (Craig, 1965):

$$T°C = 16.9-4.2(\delta^{18}O_c-\delta^{18}O_w)+0.13(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (3a)$$

where $\delta^{18}O_c$ = foraminiferal calcite$_{(VPDB)}$ and $\delta^{18}O_w$ = seawater$_{(VSMOW)}$. The equation was again modified (3b) to accommodate cold (0-7°C), deep water benthic foraminiferal calcite (Shackleton and Kennett, 1975b):

$$T°C = 16.9-4.38(\delta^{18}O_c-\delta^{18}O_w)+0.1(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (3b).$$

Equation 3b is commonly used to calculate bottom water palaeotemperatures (BWPTs), but when it is applied using Holocene *Uvigerina* $\delta^{18}O$ values {this species is generally considered to be in equlibrium with sea water and therefore provides a realistic palaeotemperature, comparible with measured temperature}, from Hole 593 of 3.19‰ (Nelson et al., 1994) and modern measured AAIW $\delta^{18}O_w$ of -0.3‰$_{VSMOW}$ (Bigg and Rohling, 2000), it results in a BWPT of 2.83°C. This is colder than modern measured AAIW temperatures of 3.5-7.5°C in the southern Tasman Sea (Garner, 1962, 1967; Garner and Ridgway, 1965). When (3a) is used the calculated BWPT is 3.83°C, within the modern range (*Cibicidoides* BWPT = 5.99°C). A possible explanation is that (3b) is suitable for deep water palaeotemperatures, but overcompensates BWPTs for intermediate depth waters. Therefore this study uses equation (3a).

Sea surface palaeotemperatures (SSPTs) can be calculated using a slightly modified version of the palaeotemperature equation (4), following Erez and Luz (1983) and Zachos et al. (1994):

$$T°C = 16.998-4.52(\delta^{18}O_c-\delta^{18}O_w)+0.028(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (4).$$

Equation (4) generates a SSPT of 14.75°C using Holocene Hole 593 planktic foraminiferal calcite (*Globigerina bulloides*) $\delta^{18}O$ of 0.9‰ (Nelson et al., 1993), and measured surface $\delta^{18}O_w$ = 0.39‰$_{VSMOW}$ from CSTW east of North Island (Schmidt et al., 1999), as there are no $\delta^{18}O_w$ surface water measurements available for the Tasman Sea. A similar $\delta^{18}O_w$ value (of 0.4‰) was obtained from surface waters around the Galápagos Islands in slightly warmer water, but with similar salinity to the southern Tasman Sea (Wellington et al., 1996). Modern measured CSTW temperatures are 10-17°C in southern Tasman Sea, so the calculated SSPT near 15°C is realistic as *Globigerina bulloides* calcite usually gives winter temperatures (Weaver et al., 1997).

Mean seawater $\delta^{18}O_w$ estimates

For any time other than the Holocene, palaeotemperature calculations are critically dependent on estimating the mean isotopic composition of seawater ($\delta^{18}O_w$), which cannot be measured directly (Feary et al., 1991). One approach is to consider estimating mean $\delta^{18}O_w$ using modern, regional average salinity values (5) (Craig and Gordon, 1965; Savin et al., 1985):

$$\delta^{18}O_w = 0.687*S - 23.74_{VSMOW} \quad (5)$$

where S = salinity. This results in a calculated Tasman Sea AAIW $\delta^{18}O_w$ value of -0.25‰$_{VSMOW}$ and CSTW $\delta^{18}O_w$ value of 0‰$_{VSMOW}$. These are different to the measured values (see above).

With the exception of average modern and ice free values of c. -0.28‰ and -1.2‰$_{VPDB}$ respectively, or c. 0‰ and c. -0.93‰$_{VSMOW}$ (using the correction between these two standards of -0.27‰, see Hut, 1987), there are no absolute controls on $\delta^{18}O_w$ estimates. Proximity to glacial meltwater and/or areas of precipitation can produce large local variations in $\delta^{18}O_w$. Comparing $\delta^{18}O_c$ from low-mid latitude planktic and benthic foraminifera from open ocean sites reduces potential variability in estimating mean ocean $\delta^{18}O_w$ (Feary et al., 1991). Hence, one of the most difficult aspects of calculating the ice volume contribution to the oxygen isotope values is to know the ice budget during the Miocene, and its isotopic composition. Ice volume changes will affect both the calcite and seawater $\delta^{18}O$

values. Many attempts have either used modern $\delta^{18}O_w$ values (which will overestimate Miocene ice and underestimate the water temperature), or the ice free value (which will do the opposite). As a compromise, global mean estimates of $\delta^{18}O_w$ values have been determined for time slices through the Miocene-Holocene based on the time intervals of Feary et al. (1991), and the modern $\delta^{18}O_w$ values for the Tasman Sea as end points, rather than the modern average global values (Table 5). These $\delta^{18}O_w$ values are used here in the palaeotemperature calculations and therefore incorporate some ice volume contribution. During glacials, this calculation will slightly overestimate the watermass cooling, as no additional correction to the $\delta^{18}O_w$ value is included to account for ice volume increases. On the other hand, during interglacials this calculation will slightly underestimate the watermass warming as any ice melting is not adjusted for in the $\delta^{18}O_w$ value.

Table 5. Estimated $\delta^{18}O_w$ values since the Early Miocene that have been used in palaeotemperature calculations (after Feary et al., 1991). Modern measured $\delta^{18}O_w$ values provide the youngest values and the other $\delta^{18}O_w$ values are spaced equidistance between the time slices.

Time interval (Ma)	$\delta^{18}O_{wVSMOW}$	$\delta^{18}O_{wVPDB}$
Benthic – intermediate water		
22-16	-0.83	-1.1
16-12	-0.63	-0.9
12-5.2	-0.43	-0.7
5.2-4.3	-0.37	-0.64
4.3-0	-0.3	-0.57
Planktic – cool subtropical surface waters		
22-16	-0.83	-1.1
16-12	-0.63	-0.9
12-6.2	-0.43	-0.7
6.2-4.3	-0.225	-0.495
4.3-3.4	-0.02	-0.29
3.4-1.6	0.185	-0.008
1.6-0	0.39	0.12

An interesting approach to the independent determination of $\delta^{18}O_w$ for surface waters is to use the $\delta^{18}O$ of both cetacean and fish bone phosphate (Yoshida and Miyazaki, 1991; Barrick et al., 1992; Barrick and Fischer, 1993). This technique assumes that the phosphate is in equilibrium with sea water and generates a range of average surface $\delta^{18}O_w$ values from c. 1.7 to -1.0‰$_{VMSOW}$, mainly 1.5 to -0.5‰ $_{VMSOW}$ through the Miocene (corrected for phosphorous/water fractionation)

(Barrick and Fischer, 1993). However, as ice free mean ocean $\delta^{18}O_w$ is calculated to be -1.2‰$_{VPDB}$ or -1.0‰$_{VSMOW}$, and modern mean ocean is taken as 0‰$_{VSMOW}$ (Miller et al., 1991b), the cetacean and fish $\delta^{18}O_w$ values of up to 1.7‰ appear much to high.

Global ice volume estimates

One approach to estimating ice volume, and therefore the proportion of $\delta^{18}O$ change which can be ascribed to ice rather than temperature, is to assume that the western equatorial regions have been thermally stable through the mid-late Cenozoic. The assumption then is that all changes in $\delta^{18}O$ of tropical surface-dwelling planktic foraminiferal shell calcite reflect ice volume (Matthews and Poore, 1980; Prentice and Matthews, 1988). This approach is supported by some non-foraminiferal biota studies (e.g. Adams et al., 1990), but recent analysis of Quaternary isotopes from the equatorial Pacific indicates cooling of tropical surface waters by c. 3°C or more during the Last Glacial Maximum (Patrick and Thunell, 1997; McCulloch et al., 1999; Lea et al., 2000), so it may prove to be less reliable than previously thought.

Alternatively, deep water benthic calcite $\delta^{18}O$ values can be used to estimate ice volume independently of seawater $\delta^{18}O_w$ (Miller et al., 1987, 1991b). If the assumption is made that deep water temperatures did not fall below 1-4°C (i.e., modern values) during the Palaeogene, when essentially ice-free conditions existed, the equilibrium $\delta^{18}O$ value from *Cibicidoides* would provide a lower limit on ice volume. Using the maximum deep water temperature of 4°C the equilibrium calcite $\delta^{18}O$ value is c. 2.4‰$_{VPDB}$. Therefore, any benthic foraminiferal $\delta^{18}O$ value which exceeds this equilibrium value must reflect ice-volume changes, because if change in water temperature is inferred the deep waters would have to have been colder than modern but without as much ice. For example, modern $\delta^{18}O$ deep water equilibrium values of 3.5-3.2‰ (2.86-2.56‰ *Cibicidoides* values) at any time since ice began accumulating on Antarctica would require ice volumes as great as modern conditions, assuming mean isotopic composition of continental ice was similar to today at -50 to -45‰$_{VSMOW}$ (Shackleton and Kennett, 1975b), or that deep waters were colder than modern. In order to reach 'ice free' conditions, the modern mean ocean $\delta^{18}O_w$ value (-0.28‰$_{VPDB}$) is deducted from the ice free ocean $\delta^{18}O_w$ (-1.2$_{VPDB}$). This leaves a value of c. 0.9‰, which is directly attributable to the

modern ice volume (Miller et al., 1991b). Therefore, if 0.9‰ of the mean Holocene North Atlantic Deep Water *Cibicidoides* $\delta^{18}O$ value of 2.7‰ equates to modern ice, the $\delta^{18}O$ remaining after deducting 0.9‰, in this case 1.8‰, must relate to water temperature. Hence Cenozoic *Cibicidoides* $\delta^{18}O$ values >1.8‰ equate to periods when ice was actively accumulating on Antarctica in addition to any watermass cooling (Miller et al., 1991b) (Fig. 10). These authors were unsure if periods where the $\delta^{18}O$ values were <1.8 ‰ equated to static ice sheets (and watermass temperature changes) or active reduction in ice volume. It should be noted that if ice free conditions on Antarctica are assumed when *Cibicidoides* values are >1.8‰, then both deep water and high latitude surface water would need to be colder than modern values, which is at odds with an ice free world where both are assumed to be warmer. However, if deep water temperatures were warmer, then large volumes of ice could exist when *Cibicidoides* $\delta^{18}O$ values were <1.8‰ (Zachos et al., 1993, 1994).

Global circulation by the early Neogene is likely to have begun to resemble modern, with cold, high latitude Bottom and Intermediate Waters flowing northwards from Antarctica (Kennett and Stott, 1990). However, a residual Tethys Deep Water (warm and high salinity) is evident in the Southwest Pacific as late as Middle Miocene, but only on the eastern side of the Lord Howe Rise, not at Site 593 (Flower and Kennett, 1995). Although this lower latitude deep water (warmer and more saline than deep water from high latitudes at the same time) would produce heavier benthic $\delta^{18}O$ values (Prentice and Matthews, 1988; Woodruff and Savin, 1989), the deep water salinities needed to achieve $\delta^{18}O_c$ >1.8‰ are considered unrealistic (Miller et al., 1991b), and there is good evidence for high latitude deep water production during the Oligocene-Miocene (Kennett and Stott, 1990).

To generate an equivalent *Cibicidoides* $\delta^{18}O$ ice volume 'constraint value' for intermediate waters at Site 593, the modern (Holocene) benthic $\delta^{18}O$ value is needed along with the assumption that SCIW palaeotemperatures could not be colder than modern AAIW with the same ice volume as the present day. The Holocene *Uvigerina* $\delta^{18}O$ value is 3.19‰ (Nelson et al., 1994) which equates to a *Cibicidoides* value of 2.55‰ using a species correction factor of 0.64‰ (Shackleton et al., 1984). When the modern ice volume component of 0.9‰ is deducted from

the Hole 593 Holocene *Cibicidoides* $\delta^{18}O$ of 2.55‰ (K. Miller, pers. comm., 2000), a constraint value of 1.65‰ for intermediate water depth *Cibicidoides* calcite is established. Hence, during the Late Miocene when intermediate depth *Cibicidoides* $\delta^{18}O$ is >1.65‰, it is likely there was ice volume increase on Antarctica. While the intermediate water has some capacity for cooling to increase the $\delta^{18}O$ value because it is warmer than the deep waters, the Hole 593 SCIW follows similar trends to those from deep water. This covariance indicates the changes are more likely due to ice volume changes.

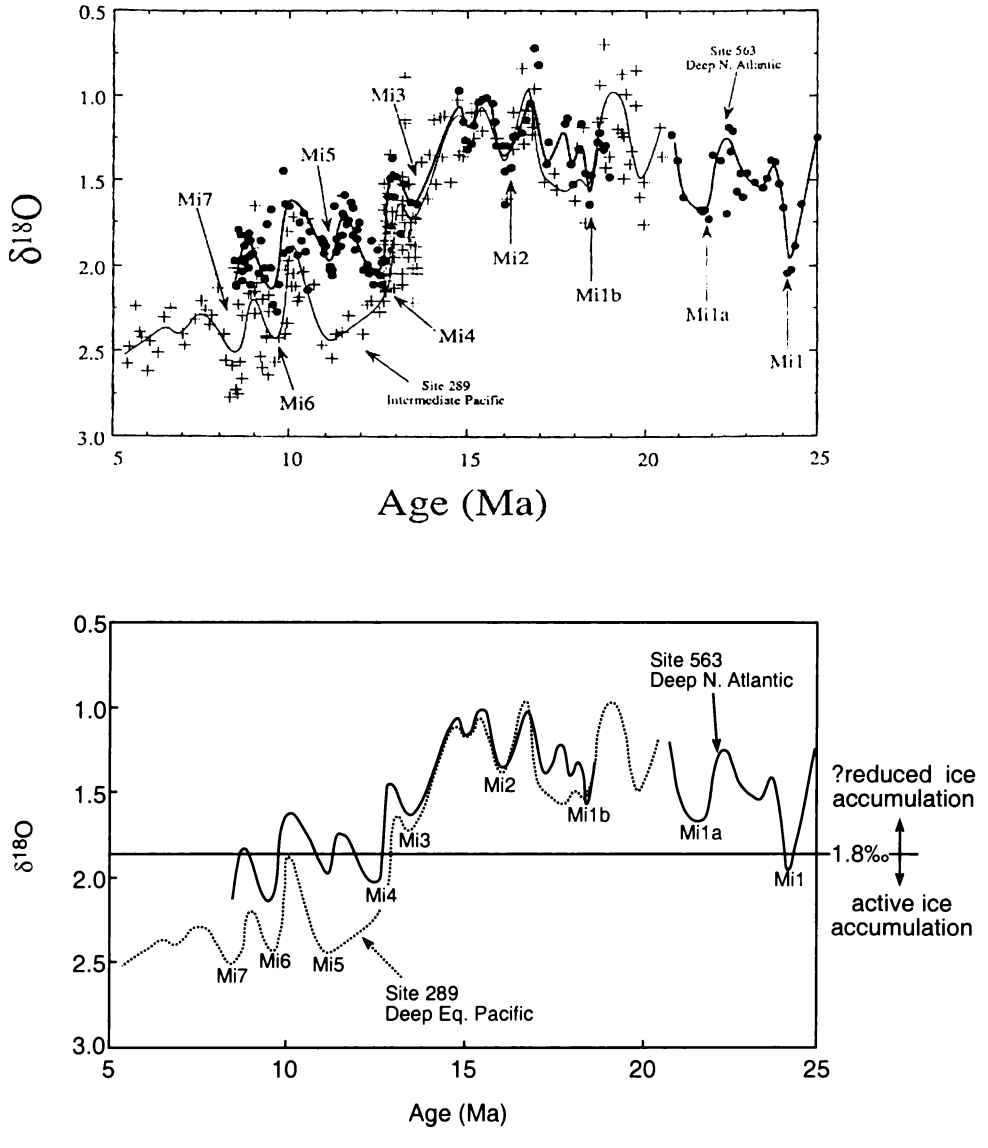


Figure 10 (a) *Cibicidoides* $\delta^{18}O$ records illustrating the Mi Zones of Wright and Miller (1992); (b) smoothed data illustrating the general trends, the 1.8‰ line represents ice volume increases when deep water *Cibicidoides* values are heavier.

The Hole 593 SCIW $\delta^{18}O$ record starts to reach $\delta^{18}O$ values >1.65‰ during glacial event Mi4, and definitely between events Mi4-Mi5 (Fig. 11). Prior to Mi4 fluctuations

in the $\delta^{18}O$ values are attributed to decreasing SCIW temperature in addition to small ice volume changes. A similar pattern is evident using the deep water records from the North Atlantic (Wright et al., 1992) and the deep water 1.8‰ benthic constraint value (Fig. 10). The first glacial event to include values >1.8‰ is Mi4, and events younger than Mi4 are consistently heavier than 1.8‰. Although Site 289 (Ontong-Java Plateau) was originally labelled 'intermediate', the site lies under 2206 m of water indicating it is bathed by deep waters and certainly not SCIW/AAIW (see Chapter 1), so that the 1.8‰ value is appropriate.

Links between some of the Oligocene and Miocene glacials (Oi and Mi Zones, respectively) and sea level lowering have been proposed (Miller et al., 1991b). The Miocene was a time of major deep water circulation changes and phases of ice cap growth, in particular during the early Middle Miocene there was intensified accumulation of the East Antarctic Ice Sheet (EAIS) (Shackleton and Kennett, 1975b; Kennett, 1986; Kennett and von der Borch, 1986b; Flower and Kennett, 1994a). After this the thermal structure of the ocean started to assume modern characteristics (Woodruff, 1985; Woodruff and Savin, 1989). The EAIS accumulation is evident as Zones Mi1-4, while Zones Mi5-6 (and Mi7, present in the Kerguelen Plateau Site 747A record (Fig. 3) but not in the Hole 593 data) are associated with the ice volume accumulation on the western part of Antarctica through the Middle Miocene, resulting in the establishment of the West Antarctic Ice Sheet (WAIS) between about 10 and 7 Ma (Denton et al., 1990; Kennett, 1995).

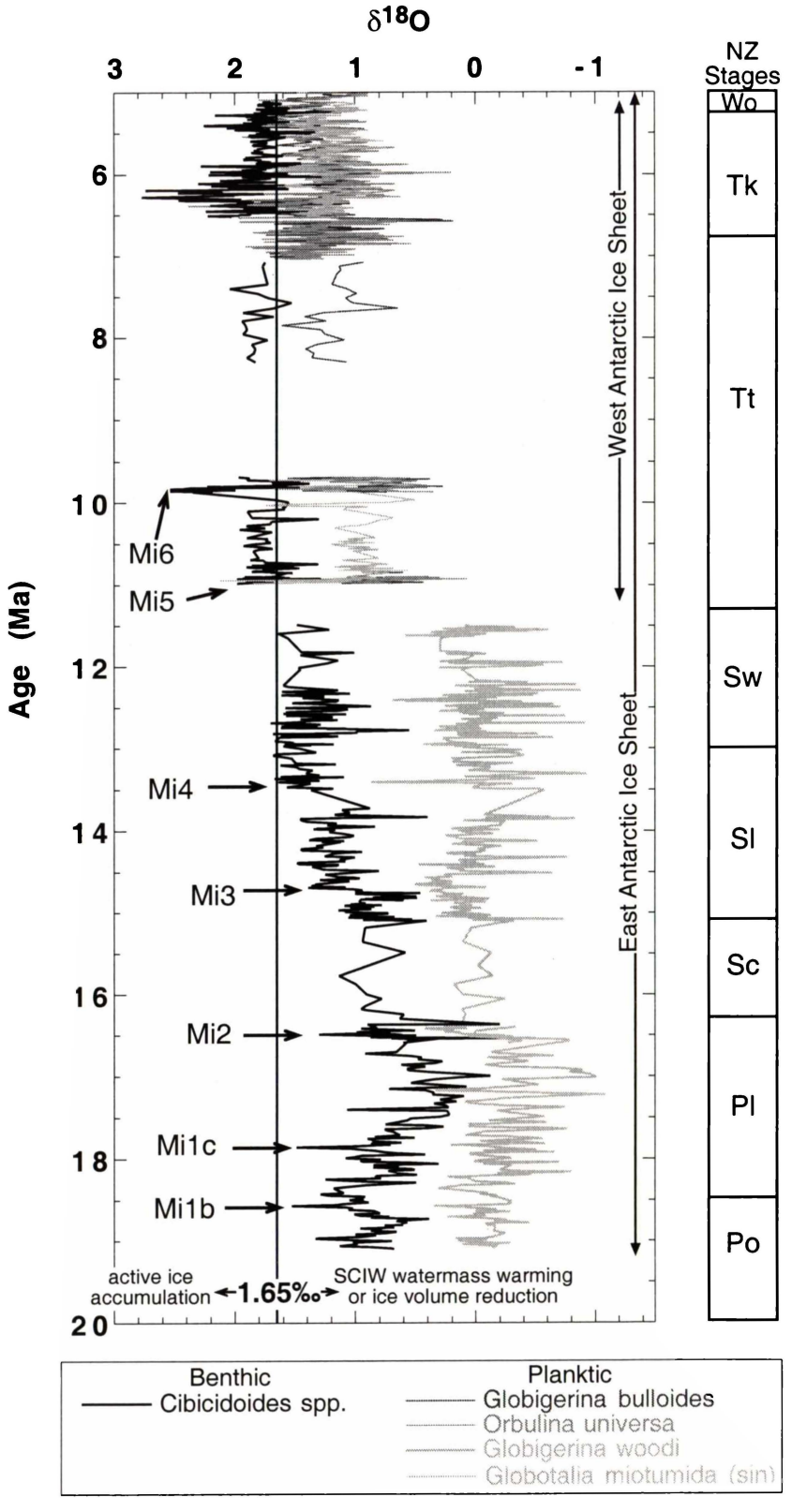


Figure 11 Hole 593 *Cibicidoides* $\delta^{18}O$ record with the 1.65‰ constraint line and Mi Zones, where values heavier than this line are inferred to reflect ice volume increases, whereas lighter values are more likely due to warming of SCIW and not necessarily to ice volume decreases. For NZ Stages see Fig. 2.

Palaeotemperature estimates for Site 593

The *Cibicidoides* palaeotemperature record, interpreted as associated with SCIW, exhibits the expected increase in BWPT at c. 17.5 Ma leading into the late Early-Middle Miocene climate optimum (see Fig. 3). If the *Cibicidoides* $\delta^{18}O_c$ is assumed to be offset from equilibrium by -0.64‰ (Shackleton, et al., 1984), then the SCIW palaeotemperatures will be to warm by 2.6°C (0.24‰/1°C, Kennett, 1986). However, if recent analysis is correct and *Cibicidoides* $\delta^{18}O_c$ is close to equilibrium (Bemis, et al., 1998), the palaeotemperatures will not significantly overestimate water temperature, and this has been assumed here. In Hole 593 the climate optimum warming is evident in the SCIW change from c. 8.5-12°C, to BWPTs consistently warmer than 10°C (Fig. 12). The jump in the data at 16 Ma occurs at the point when the $\delta^{18}O_w$ value changes (Table 5). It may be that the $\delta^{18}O_w$ change should occur slightly closer to Mi2 (16.5 Ma in this study) as this zone is interpreted as a glacial, when the $\delta^{18}O_w$ would be heavier anyway. Mi3 represents the transition out of the climate optimum, and BWPTs cool to c. 9-11°C, with several maxima reaching c. 14°C. Through Mi4 BWPTs again cool slightly to 8-10°C, and through Mi5 to just before Mi6 to 9.5-7.5°C. During Mi6 BWPTs reach 5.5°C, the first time during the Miocene that SCIW cools to modern AAIW temperatures (3.5-7.5°C).

The Late Miocene (early Kapitean) SCIW record remains warmer than modern until 6.5-6 Ma, where it cools to a minimum of c. 4.5 °C (similar to the coldest modern AAIW records from southern Tasman Sea, see Appendix A), and represents SCIW cooling of c. 3°C. However, as the benthic $\delta^{18}O$ values during this event are heavier than modern by c. 0.3‰, equivalent to 1.2°C, this suggests that 0.3‰ can be attributed to ice volume changes and that the SCIW cooling was in the order of 2.3°C. Interestingly, a slightly older (c. 7.2 Ma) benthic $\delta^{18}O$ enrichment has been re-interpreted by Hodell et al. (2001) as reflecting cooling of bottom waters rather than ice volume increase from a site on the Rockall Plateau in the North Atlantic, where it was attributed to salinity and water budget changes associated with initial restriction on flow into the Mediterranean. The interval c. 7-6 Ma covers the initiation of the Messinian Salinity Crisis (Hodell et al., 1986, 1994; Aharon et al., 1993), and the SCIW cooling event may contain a component of $\delta^{18}O_w$ connected to the salinity changes, rather than palaeotemperature.

The planktic $\delta^{18}O$ record of *Globorotalia miotumida* is used to record permanent thermocline palaeotemperatures, and so is most likely to record SSPTs for the watermass above the SCIW, namely Subantarctic Mode Water (SAMW). The modern SAMW temperature in the southern Tasman Sea is 8-9°C (see Chapter 1), so the Late Miocene record indicates Southern Component Mode Water (SCMW) palaeotemperatures were up to a few degrees warmer than modern, from c. 9-12°C during the Tongaporutuan, decreasing to 8-10°C during the Kapitean (Fig. 13). Several of the cooling episodes noted in the SCIW record are also present in the SCMW curve, including at c. 11 Ma corresponding to Mi5 (cooling to c. 8°C), at c. 9.8 Ma during Mi6 (cooling to 9°C), and the events at c. 5.4 Ma (cooling to c. 8°C) and 5.2 Ma (cooling to 8.5°C). As these cooling episodes covary with the SCIW record it is inferred that they represent relatively extreme glacial events. The SCMW curve exhibits an additional cooling event to c. 8.5°C, at c. 6.15 Ma. After 6.15 Ma the records exhibit good covariance, interpreted as glacial/interglacial cycles.

In order to cool both intermediate and mode waters, substantial cooling of their source areas is inferred. The modern AAIW is generated at the Antarctic Polar Front (AAPF) from the sinking of Antarctic Surface Waters (AASW). SAMW is generated from Subantarctic Surface Water (SASW) sinking between the Subantarctic Front (SAF) and the Subtropical Front (STF). All three of these fronts are inferred to have existed to the south of the Tasman Sea during the Miocene (Nelson and Cooke, 2001). Therefore the cooling of SCIW at 6.4-6.2 Ma is interpreted as cooling of Miocene AASW, and the cooling of SCMW at 6.15 Ma requires the cooling of SASW. The palaeotemperature divergence between the mode and intermediate waters of up to about 6°C from 6.4-6.2 Ma, indicates cooling of one area of the Southern Ocean surface waters, but warming of another. This suggests that palaeoclimatic changes did not necessarily affect the whole of the Miocene Southern Ocean to the same degree at the same time. Hence, it may be possible that the SCIW and SCMW watermass signals are somehow offset (as the data comes from the same samples there is no sample offset). If the cooling signal of the SCMW was delayed by c. 50,000 years then the curves would in fact covary and the 6.4-6.2 Ma event could be interpreted as an extreme glacial.

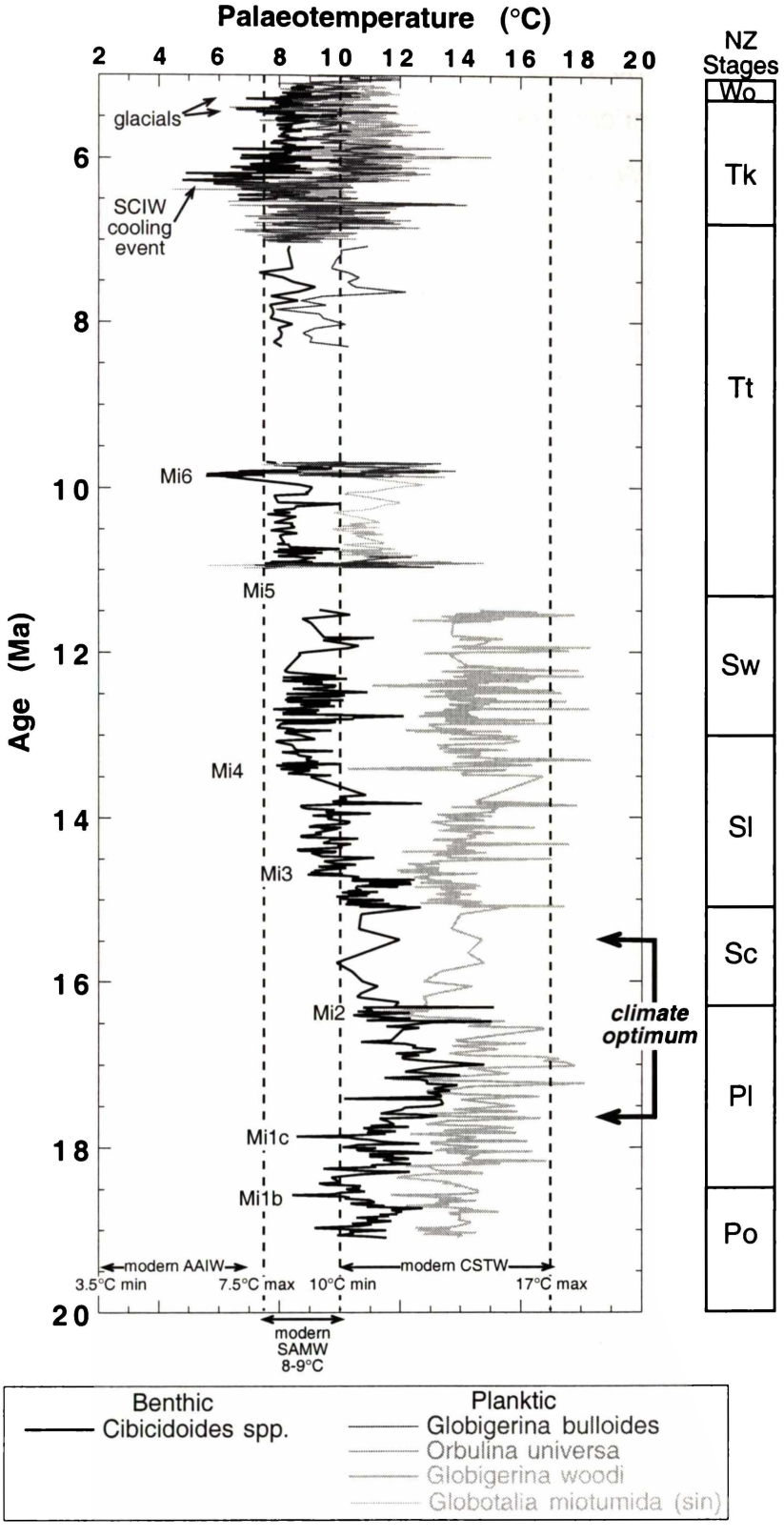


Figure 12 Hole 593 Early-Late Miocene calculated palaeotemperature records. Dotted lines mark: 10°C and 17°C = minimum (winter) and maximum (summer) modern CSTW SST in southern Tasman Sea; 7.5°C = maximum modern AAIW BWT in southern Tasman Sea. For NZ Stages see Fig. 2. An A3 version is provided at the end of the chapter.

A possible mechanism for cooling antarctic surface waters would be the development and expansion of sea ice in the Ross Sea region as part of the Late Miocene evolution of the West Antarctic Ice Sheet. If most of this sea ice melted each summer, the enrichment of the surface water $\delta^{18}O$ value, which when subducted formed SCIW, would reflect thermal changes and surface water cooling, and not large ice volume accumulation (C. Hendy, pers. comm., 2001). As ice volume increased, and surface watermass temperature decreased, the net change in $\delta^{18}O$ would reduce (see Table 3), and benthic and planktic records would exhibit covariance as climate fluctuated between glacial and interglacial. If the cooling occurred closer to the Antarctic continent, then those surface waters subducted to form SCIW would be colder than the subantarctic surface waters which were subducted to form SCMW. This differential cooling might explain the 50,000 year delay between the SCIW and SCMW records.

Interpretation of the SSPTs for the surface waters of the Miocene southern Tasman Sea is somewhat experimental. The palaeotemperature equation used for *Globigerina bulloides* and *Orbulina universa* is applied to the *Globigerina woodi* record, but with caution as this record lacks an additional planktic species with which to compare. The *Globigerina woodi* record exhibits a sharp warming into the climate optimum, of c. 2°C, from SSPTs of 12.5°C to 14.5°C (Fig. 12). Over the optimum, this record exhibits large amplitude fluctuations of >4°C, reaching maximum values of c. 18°C. Interestingly, the *Globigerina woodi* record remains (to within c. 2°C) within the modern southern Tasman Sea SSTs (10-17°C), interpreted as relative stability in the surface waters of the region and an absence of upwelling. Mi2 is particularly evident in the *Globigerina woodi* record of SSPTs as a time of rapid cooling by >2°C. Mi3 is also evident as a 1°C cooling event, followed by surface water warming to c. 15°C at 13.75 Ma. As already discussed, Mi4 is evident in the *Globigerina woodi* record as a general decrease of 1°C from 13.5-13 Ma, with a single point extreme at c. 11°C, but this Zone is not as 'clear-cut' as some of the others. The remaining *Globigerina woodi* record from 13-11.5 Ma exhibits SSPTs of 13-18°C, again with several large 4°C amplitude fluctuations.

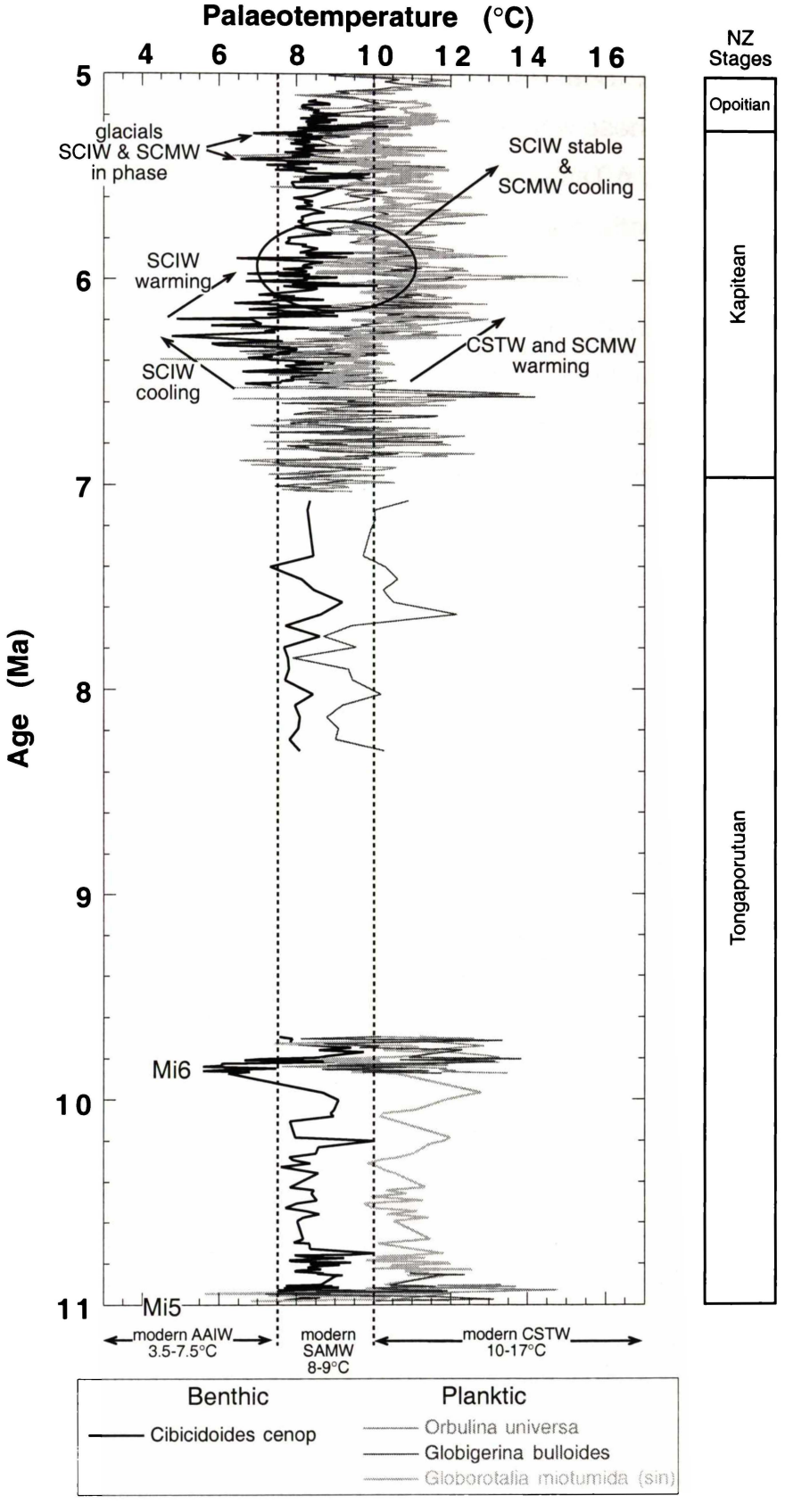


Figure 13 Hole 593 expanded Late Miocene calculated palaeotemperature records. Dotted lines mark: 10°C = minimum (winter) modern CSTW SST; 7.5°C = maximum modern AAIW BWT in southern Tasman Sea. An A3 version is provided at the end of the chapter.

The Middle Miocene (Tongaporutuan) SSPTs from the *Globigerina bulloides* and *Orbulina universa* records both exhibit cooling during Mi5 to 8°C and 11°C, respectively (Fig. 13). Both records warm after Mi5 to reach maxima of 12°C and 14°C, respectively. These warmer SSPTs are within the modern CSTW range of 10-17°C from the southern Tasman Sea and, as for *Globigerina woodi*, are interpreted to indicate relative water column stability without upwelling. During Mi6 both the surface water records cool to c. 8°C, then warm to c. 11-13°C after this extreme glacial. The *Globigerina bulloides* record cools over the interval c. 8.5-7 Ma to 8-11°C, and with *Orbulina universa* fluctuates around this range until c. 6.6 Ma where it warms considerably to reach c. 14°C. Both records then cool rapidly, by >4°C, then along with the *Globorotalia miotumida* record the surface planktic records warm over the interval 6.4-6.2 Ma, from c. 8°C to c. 12°C, interpreted as warming through the water column to mode water depths. After 6.2 Ma until 5 Ma, the surface water SSPTs fluctuate around 9-12°C.

In a previous study (Nelson et al., 1994) it was noted that the planktic $\delta^{18}O$ record from several Tasman Sea cores, including Hole 593, over the LGM to Holocene climate transition did not exhibit any cooling/warming and only changed by the ice volume amount of 1.2‰ (Chappell et al., 1996). This was interpreted as indicating an influx of warm water into the Tasman Sea during LGM as a result of restriction from lowered sea level through the Indonesian gateway to the north. The backed up warm tropical waters were fed into the Tasman Sea via the East Australian Current and maintained relatively constant SSTs during LGM, and may account for the warm subtropical planktic foraminifera reported from LGM sediments east of Tasmania (Martínez, 1994) . As sea level rose during interglacial warming, the flow through the gateway increased, less tropical water entered the Tasman Sea, and the planktic $\delta^{18}O$ values changed by ice volume only. The benthic Tasman Sea $\delta^{18}O$ data indicate that during the LGM the bottom waters remained warmer than those to the east of New Zealand (Nelson et al., 1994). This was inferred to be due to the Tasman's somewhat restricted circulation, with the change between glacial and interglacial conditions not 'flushing' out the deeper waters as fast as eastern areas in the Pacific Ocean

The New Zealand onland evidence indicates significant cooling at the LGM, with glaciers covering much of the South Island and estimated air temperatures up to 5°C cooler than modern (McGlone et al., 1993), so it appears likely that had the warm water influx not occurred the Tasman SSPTs would have cooled during LGM. Hence, it may be possible that the apparent warming of SCMW over the interval 6.4-6.2 Ma is an artefact of glacial restriction on flow through the Indonesian gateway. Warm tropical surface waters entering the southern Tasman Sea could have been subducted into the SCMW at the STF. Such overwhelming of the glacially-cooled subantarctic surface waters contributing to SCMW would lead to an apparent warming of this watermass (see Table 2). As the glacial ended, the tropical water contribution would decrease and the subantarctic surface water would again dominate SCMW, reflected in the cooling event at 6.15 Ma and the overall decrease in SCMW palaeotemperatures through the Kapitean.

Miocene carbon events

Covariance between planktic and benthic carbon records generally reflects changes in mean ocean $\delta^{13}C$ by reservoir transfer (Vincent and Berger, 1985), because the main global control on $\delta^{13}C$ in the oceans is related to organic carbon burial (Flower and Kennett, 1993b, 1994b), and the rate of chemical weathering (Raymo, 1992; Raymo and Ruddiman, 1992). Using many ocean sediment drill sites, Woodruff and Savin (1991) identified a number of heavy $\delta^{13}C$ spikes (carbon maxima = CM) in foraminiferal calcite records (Table 6). They postulated that these CM events represented rapid, organic ^{12}C-rich carbon burial and noted that they coincided with glacial events; hence they made the link between rapid organic carbon generation, upwelling, CO_2 draw down and glaciation. Further support for CO_2 draw down leading to reduced atmospheric CO_2 comes from the sediments associated with the CM events. The carbonate sediments are generally better preserved, which would be expected if the carbon was being buried rather than dissolving into the deep waters of the ocean where it would increase the pCO_2 and dissolve any carbonate (Woodruff and Savin, 1991).

Carbon maxima (CM)

Several of the globally recognised CM events (Woodruff and Savin, 1991) have been identified in the Hole 593 data (Fig. 14). Following the original definitions, some of the CM events are associated with Mi Zones (Table 6).

Table 6. Miocene carbon maxima (CM) events, listing the original definition (Woodruff and Savin, 1991), any age updates, and associated glacial (Mi) events from Table 4. Estimated ages of the events in Hole 593 are noted.

Carbon maxima	Original Age (Ma)	Original definition and any age update	Associated Mi Zone	Hole 593 age (Ma)
CM7	11.5	high $\delta^{13}C$ values after Monterey Excursion	Mi5 (11.5 Ma)	11.5
CM6	14.0-14.2	0.3‰ heavier than CM3	Mi3 (13.7 Ma)	14.6
CM5	14.6	N9/N10 boundary (now 14.8 Ma)		14.9
CM4	15.1	precedes start of major increase in $\delta^{18}O$		nd[2]
CM3	15.5	large CM event (now 16.4-15.65 Ma)	Mi2 (16.2 Ma)	16.45
CM2	15.8	2nd Cmax after beginning of Mon. Ex.[1] and within N8		16.75
CM1	16.4	1st Cmax = beginning of Mon. Ex.[1]		17.3

[1]Mon. Ex. = Monterey Excursion (Middle Miocene period of high $\delta^{13}C$ values).
[2] nd = not identified

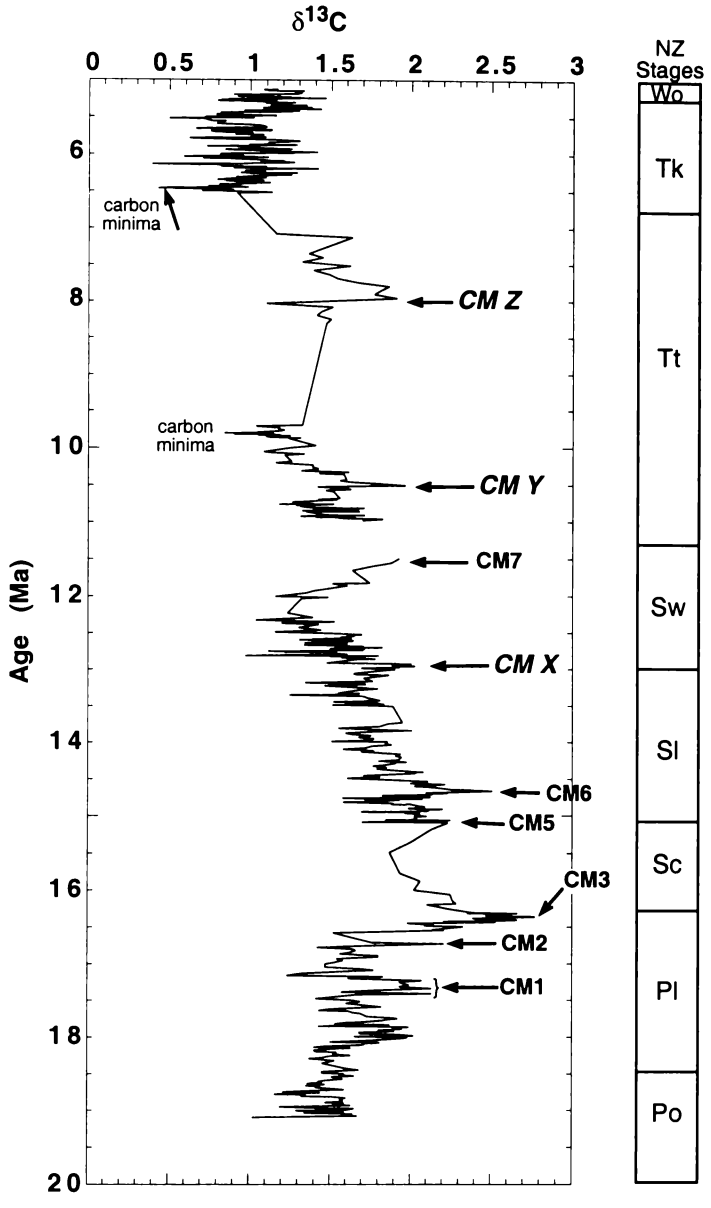


Figure 14 Early-Late Miocene benthic $\delta^{13}C$ isotope CM (carbon maxima) events in Hole 593; CM1-7 identified using the criteria of Woodruff and Savin (1991); CM events X, Y, and Z are additional carbon maxima, not previously reported.

Monterey Excursion and carbon maxima

The Monterey Excursion is clearly evident in the Hole 593 benthic $\delta^{13}C$ record as a shift of up to 1‰ by 17.5 Ma (Fig. 15). The $\delta^{13}C$ values through this excursion are the heaviest of the whole Miocene section and include CM1-6 (Fig. 15). The absolute $\delta^{13}C$ values are considerably heavier than most other benthic records, and reach those of some planktic records (Woodruff and Savin, 1991). The most likely explanation is two-fold: 1) the Hole 593 benthic record is for intermediate water and will therefore be expected to have slightly heavier $\delta^{13}C$ values compared with deep

waters; and 2) the ventilation of the surface waters contributing to the SCIW is high – see discussion below.

Despite the slight age discrepancies, the correlation of CM3, CM6 and CM7 with Mi Zones, follows the original definitions. Interestingly, Zone Mi4 corresponds with a carbon maxima (CMX) in the Hole 593 records (Fig. 15), a situation not previously recognised in deep water records. CMY and Z do not however, correspond with obvious glacial events, which may in part be due to the limited Hole 593 data set.

Messinian Carbon Shift

Identification of the Messinian Carbon Shift (MSC) in the Site 593 benthic $\delta^{13}C$ record is unfortunately limited due to a gap in the data over the interval c. 7.1-6.5 Ma, and a lack of core recovery due to drilling disturbance and loss of sections from core 22 over the interval 7.35-7.23 Ma. A number of stratigraphic events have been used previously (Table 7) to identify the MCS in oceanic sediments.

Table 7. Summary of palaeomagnetic chrons and bio-events linked to the Late Miocene Carbon shift, now referred to as the Messinian Carbon Shift (MCS), and updated using the GPTS. FAD *Globorotalia conomiozea* datum at Blind River (6.2 Ma using Roberts et al. (1994) magnetostratigraphy updated according to Berggren et al. (1995)) may be diachronous with Mediterranean datum of 7.12 Ma and possibly should not be used).

EVENT	AGE (Ma) - prior to:	- after: Berggren et al. (1995)	Type of event
C3AN/C3AR	5.89 (top Chron 6)	6.567 (C3An.2n/C3Ar)	
FAD *Nitzschia miocenica*	6.1	>6.567	D
FAD *Globorotalia conomiozea*	6.1	7.12 - (6.2)	P
Top Carbon shift	5.9-6.0		
Base Carbon shift	6.37-6.58		
FAD *Stichocorys peregrina*	6.3	6.69	R
FAD *Solenosphaera omnitubus*	>6.3	7.13	R
FAD *Amaurolithus primus*	6.25 (6.50)	7.24	N
C3AR/C4N	6.70 (base Chron 6)	7.432 (C3Br.3r/C4n.1n)	

Date of Top and Base Carbon shift from Müller et al. (1991). D = diatom datum (Vincent et al., 1980; Berger and Vincent, 1986; Berggren et al., 1995); P = planktic foram datum (Loutit and Kennett, 1979; Loutit, 1981; Elmstrom and Kennett, 1986; Berggren et al., 1995); R = radiolarian datum (Vincent et al., 1980; Berger and Vincent, 1986; Moore, 1995); N = nannofossil datum (Berggren et al., 1995; Backman and Raffi, 1997).

The only event listed in Table 7 which is present in the Hole 593 record, is the first occurrence of the nannofossil *Amorolithus primus* at 203.42 mbsf (Table 1 and Chapter 2) (Lohman, 1986), dated at 7.24 Ma in the Pacific Ocean (Backman and

Raffi, 1997), which has been reported just prior to the carbon shift in many sites (Haq et al., 1980; Benson et al., 1991). This helps constrain identification of the MCS in Hole 593 since it must occur after this bioevent. The difference in $\delta^{13}C$ values in Hole 593 prior to the gap (>7.1 Ma) compared to after it (<6.5 Ma) represents a shift of about 1.2‰ over the gap interval (Fig. 15). This is inferred to correspond to the position of the MCS. Reported ages for the carbon shift (c. 6.58-5.9 Ma) at other Southwest Pacific sites, e.g., Site 588 (Hodell et al., 1986), and Nuie atoll (Aharon et al., 1993) are generally younger than the Hole 593 age of c. 7.15-6.45 Ma. However, when correction is made for GPTS timescale changes the carbon shift at other sites occurs between the base of palaeomagnetic chron C3Br.3r (7.43 Ma) and the top of 3Ar (6.57 Ma, i.e., the 'old' Chron 6), thus including the Site 593 age.

In addition to Table 7, a significant change in the dominant coiling direction of the planktic foraminifera *Neogloboquadrina pachyderma* in the Late Miocene of Site 284 occurs just above the carbon shift (Shackleton and Kennett, 1975a; Hodell et al., 1986). A switch in the coiling of *Neogloboquadrina acostaensis* was reported in the Equatorial Pacific core RC12-66 just after the carbon shift (Keigwin and Shackleton, 1980) and is correlated with a dextral shift in the coiling of *Neogloboquadrina pachyderma* at Site 590 (Elmstrom and Kennett, 1986). This dextral coiling shift is evident in the Site 593 data (Crundwell, in prep.) and occurs between 130-127 mbsf. Using the age model developed here for Hole 593, a date for this coiling event of c. 5.3-5.26 Ma is established which is in keeping with it being younger than the MCS in Hole 593 (196-180 mbsf, 7.0-6.56 Ma).

The magnitude of the MCS at Site 593 (>1.0‰) is slightly more than the Tasman Sea Site 588 shift of c. 0.7-1‰ (Hodell et al., 1986), and certainly more than the global shift of c. 0.8‰ (Berger and Vincent, 1986). This may reflect coincident local input of ^{12}C-rich organic matter into the Tasman Basin. West coast South Island sources for the organic matter include: Late Eocene Greymouth coal measures, inverted during a compressional phase as a result of uplift along the Alpine Fault, between 12 and 7 Ma (Kamp et al., 1999); Late Tongaporutuan Blue Bottom Group (calcareous mudstones) south of Greymouth, uplifted by initiation of the Kotuku Anticline (Suggate and Waight, 1999). These sediments contain traces of oil and gas originating from either the Cretaceous-Eocene coal measures or the Early

Miocene Niagara Sandstone (submarine fan sediments) (Suggate and Waight, 1999). The erosion of any/all of these organic ^{12}C-containing sediments, transported via either the Hokitika or Haast Submarine Canyons (or both) into the southern Tasman Sea, could contribute to the greater-than global carbon shift at Site 593 by incorporation into the SCIW.

Ventilation and watermass mixing

Cibicidoides $\delta^{13}C$ directly relates to ambient ΣCO_2 and the $\delta^{13}C$ of ΣCO_2 can be correlated with dissolved O_2, specifically higher dissolved O_2 with lighter $\delta^{13}C$ values in benthic calcite (Kroopnick, 1985). While dissolved O_2 cannot be measured in Miocene samples, it has been directly linked to manganese (Mn) flux in Indian Ocean sediments, with greater dissolved O_2 reflected in decreased Mn content in sediments (Dickens and Owen, 1994). The sediment Mn flux has been used to infer an extended North Indian Intermediate Water (NIIW) oxygen minimum zone during the Late Miocene, at its most extensive at c. 5 Ma (Dickens and Owen, 1994). The AASW which subduct to form AAIW contain up to 40% modern NIIW, but during the LGM glacial AAIW was indistinguishable from antarctic surface waters, implying a reduced contribution from NIIW (Lynch-Stieglitz et al., 1994). This was either because of reduced NIIW production, or more effective incorporation of antarctic surface waters into glacial AAIW due to invigorated circulation in the Southern Ocean (Lynch-Stieglitz et al., 1994). If something similar occurred during the Miocene Mi Zones, then the more effective incorporation of antarctic surface water into SCIW would result in a more ventilated signal (heavy $\delta^{13}C$) in intermediate water calcite, in addition to the thermodynamic tagging. There is evidence for increased SCIW production between 15.6-13.8 Ma based on the increased benthic $\delta^{18}O$ vertical gradient in the South Pacific (Flower and Kennett, 1995).

Overall the *Cibicidoides* $\delta^{13}C$ record is heavier than those from Atlantic sites, but involves a similar range of values to those from Hole 747, Kerguelen Plateau, also at intermediate depths (Wright and Miller, 1992). If during the Late Miocene glacials there was also a reduced, lighter $\delta^{13}C$ NIIW input, then the Hole 593 *Cibicidoides* $\delta^{13}C$ should show heavier values. Up to and including Mi5, the Miocene glacials are indeed accompanied by CM, as is the SCIW cooling at 6.4-6.2 Ma, and the glacials

at 5.2 and 5.4 Ma (Fig. 15). Mi6 is accompanied by a carbon minima, and the SCIW cooling is preceded by the carbon minima identified as the MCS.

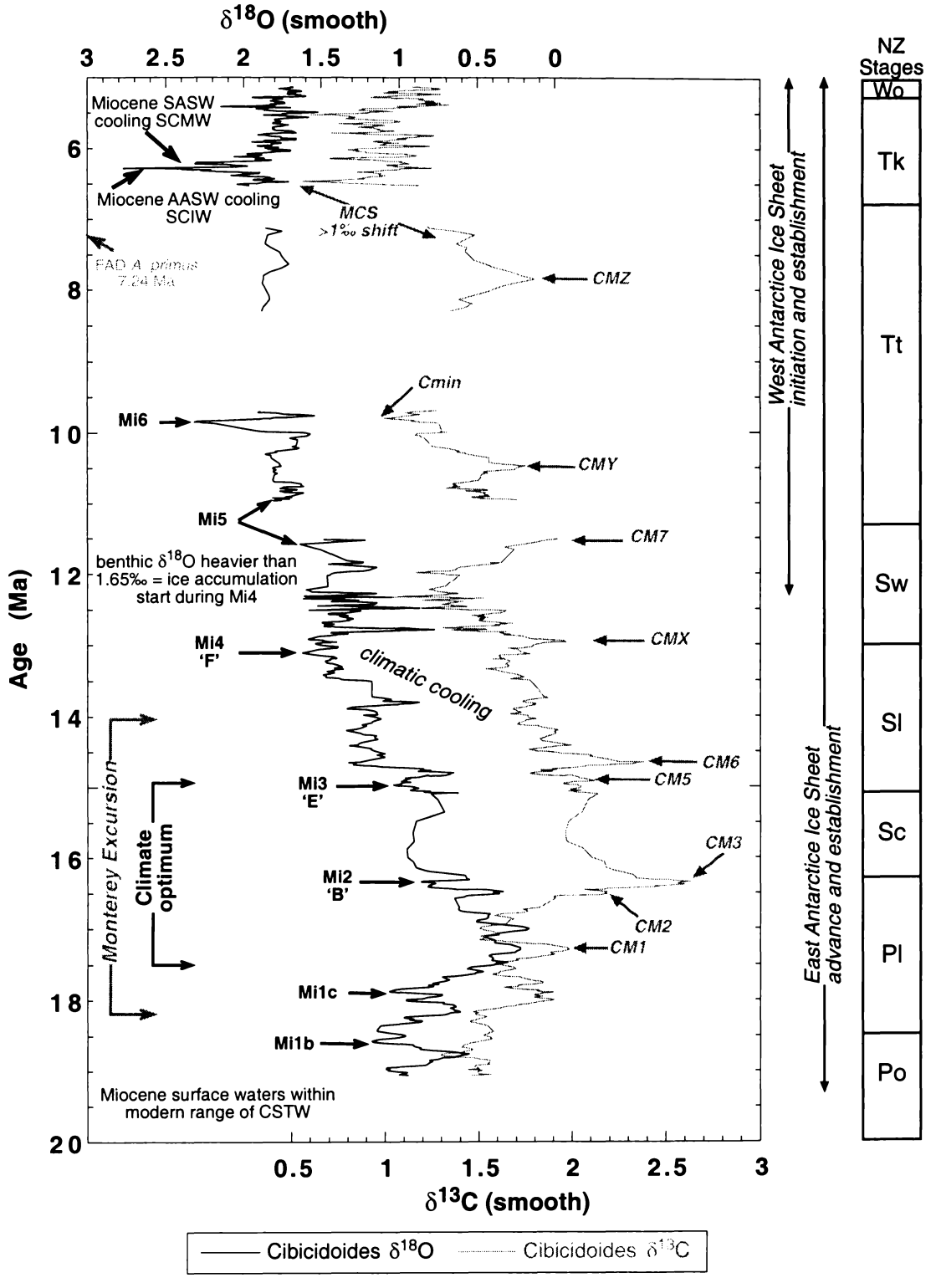


Figure 15 Early-Late Miocene $\delta^{18}O$ Mi Zones and benthic $\delta^{13}C$ CM events from Hole 593. The Monterey Excursion includes CM1-6. FAD of *Amorolithus primus* at 7.24 Ma (in the Pacific, see Raffi and Flores, 1995) occurs just before the Messinian Carbon Shift (MCS) following Hsü et al. (1977). Glacials marked B, E and F are those identified by Woodruff and Savin (1991) and correspond with the labelled Mi Zones. Note Zone Mi4 is associated with a carbon maxima, namely CMX. To aid comparison this figure is presented with Figure 3 on A3 at the end of the chapter.

CONCLUSIONS

This study represents the first moderately high-resolution (c. 3-20 ka per sample), full water column (surface and intermediate waters) palaeoceanographic investigation of the Southwest Pacific through the Miocene. Several benthic (*Cibicidoides kullenbergi, cenop,* and *rugosa*) and planktic (*Globigerina woodi* and *bulloides, Orbulina universa, and Globorotalia miotumida*) foraminiferal species were used from DSDP Hole 593 to determine $\delta^{18}O$ and $\delta^{13}C$ changes over time, and vertically through the southern Tasman Sea water column over the Challenger Plateau.

The depth habitat of the extinct planktic foraminifera *Globorotalia miotumida* (sin) has been established from the $\delta^{18}O$ records which indicate it secreted calcite at depths below the surface dwelling *Orbulina universa* and *Globigerina bulloides*, but above the intermediate depth benthic *Cibicidoides cenop*. This is further supported by the $\delta^{13}C$ records, where *Globorotalia miotumida* has slightly lighter values than the other planktic species, but heavier than the benthic. The *Globigerina woodi* $\delta^{18}O$ record is consistently lighter than the benthic record as expected from a (extinct) planktic species, but the $\delta^{13}C$ record is more problematic to interpret as the absolute values are similar for much of the benthic record. Without an additional planktic $\delta^{13}C$ record it is not possible to determine why. Possible explanations include vital effect fractionation and upwelling – although the latter should be evident in the $\delta^{18}O$ record and it is not.

Using the planktic $\delta^{18}O$ records, *Orbulina universa* and *Globigerina bulloides* are linked to surface waters similar to modern Cool Subtropical Water through the Late Miocene. The Early-Middle Miocene *Globigerina woodi* $\delta^{18}O$ record is also linked to Cool Subtropical Water, while the deeper dwelling *Globorotalia miotumida* (sin) record is interpreted as upper permanent thermocline or mode water, specifically Late Miocene Southern Component Mode Water. The benthic *Cibicidoides* record is linked to intermediate depth Southern Component Intermediate Water.

All $\delta^{18}O$ records exhibit fluctuations interpreted as due to glacial to interglacial changes because of the good covariance between the planktic and benthic data

(Fig. 5). Globally-recognised Early to Late Miocene glacial Zones Mi1b-Mi6 are identified in the Hole 593 record (Fig. 15). Zones Mi1b to Mi3 are identified in both benthic and planktic records, Zone Mi4 is evident in the benthic $\delta^{18}O$ curve, and is identified in the planktic record by a slight increase in the $\delta^{18}O$ record. Previous studies have lacked a planktic record for Mi4. Zone Mi5 is clearly evident in the planktic records at c. 11 Ma, but its identification in the benthic curve is unfortunately interrupted by a data gap. There is, however, an increase in benthic $\delta^{18}O$ of 0.4‰ between 11.5 Ma and 11 Ma, interpreted as Mi5. Glacial Mi6 is evident in all Hole 593 $\delta^{18}O$ records at c. 9.9 Ma as a c. 0.5‰ shift to heavier values. Other 'unlabelled' glacial events are also evident in the $\delta^{18}O$ records, particularly at 5.4 and 5.2 Ma.

Zones Mi3, Mi4, and Mi5 exhibit a stepwise increase in $\delta^{18}O$ where the curves shift to heavier values, and remain at approximately those values (Fig. 8). The records of these Zones do not follow the trend evident in the deep water records where the Mi Zones are point events. This step-wise enrichment is interpreted as ice volume increases during the glacials, with stabilisation of cooler Southern Component Intermediate Water temperatures after the glacial event.

Ice volume estimates suggest that whenever the intermediate depth benthic *Cibicidoides* $\delta^{18}O$ values are heavier than c. 1.65‰ there was an active increase in the polar ice volume (Fig. 11). This involves most of the Late Miocene Tongaporutuan-Kapitean record from Hole 593 certainly younger than Mi5, and possibly even Mi4, following the trend of the deep waters. Expansion of the East Antarctic Ice Sheet has been linked to Zone Mi3 and Mi4, with initiation of the West Antarctic Ice Sheet linked to Mi5 and Mi6.

The latest Miocene (Kapitean) excursion of c. 0.8‰ in the benthic *Cibicidoides cenop* $\delta^{18}O$ record between 6.4 and 6.2 Ma is not interpreted as a large change in ice volume because the planktic *Globorotalia miotumida* (sin) record exhibits warming over this interval (Fig. 9). Rather it is inferred to reflect significant cooling of Southern Component Intermediate Water linked to the expansion of the West Antarctic Ice Sheet and development of sea ice, with minor ice volume changes.

The latest Early to Middle Miocene climate optimum Southern Component Intermediate Water palaeotemperatures are consistently >10°C. Through Mi3 to Mi5, bottom water palaeotemperatures cool to c. 8°C, and during Mi6 to c. 5.5°C (Fig. 12). Mi6 represents the first time Southern Component Intermediate Water palaeotemperatures cool to those of its modern equivalent, Antarctic Intermediate Water, returning to c. 8°C after Mi6. During the cooling event at 6.4-6.2 Ma Southern Component Intermediate Water palaeotemperatures drop to c. 5°C. They return to 7.5-9°C through the remaining Kapitean record, except during the glacial at c. 5.4 Ma, where they cool to c. 7°C.

Southern Component Mode Water palaeotemperatures in the southern Tasman Sea were generally 9-12°C during the early Tongaporutuan, decreasing to 8-10°C during the late Kapitean (Fig. 13). Exceptions occur at Mi5 (cooling to 8°C) and Mi6 (cooling to 9°C) and in the glacial at 5.4 Ma (cooling to 8°C). Over the interval 6.4-6.2 Ma Southern Component Mode Water palaeotemperatures warmed to c. 12°C. This period exhibits Southern Component Intermediate Water cooling and Southern Component Mode Water warming because the two records diverge, after which time the two records covary again with glacial/interglacial cycles.

The *Cibicidoides cenop* excursion at 6.4-6.2 Ma to heavier $\delta^{18}O$ values is interpreted as predominantly Southern Component Intermediate Water cooling of c. 3.5°C because the Southern Component Mode Water palaeotemperatures warm by c. 2°C over the same time interval. The up to 7°C divergence of the two records is inferred to indicate this event is not the result of large ice volume changes, as these should be evident in the planktic records. However, the benthic $\delta^{18}O$ values during this event are heavier than modern by c. 0.3‰, equivalent to 1.2°C, which suggests that 0.3‰ can be attributed to ice volume changes, and the remaining enrichment equates to Southern Component Intermediate Water cooling in the order of 2.3°C. However, the Southern Component Intermediate Water cooling could be interpreted as a glacial if the Southern Component Mode Water cooling signal at 6.15 Ma was delayed 50 ka by Tasman Sea sea surface palaeotemperature changes masking the ice volume changes. Something similar happened during the Last Glacial Maximum to Holocene transition, where sea surface palaeotemperature did not cool as reported by Nelson et al. (1994). Such palaeoceanographic delay is linked to the

circulation constriction through the Indonesian gateway during glacial periods, redirecting warm tropical flow southwards into the Tasman Sea.

The Early to Middle Miocene sea surface palaeotemperatures generated from the *Globigerina woodi* record of c. 13-18°C, are interpreted as indicating that the southern Tasman Sea surface waters at the time were similar to those of the modern Cool Subtropical Water which range from 10-17°C (Fig. 12). The Late Miocene sea surface palaeotemperatures from *Globigerina bulloides* and *Orbulina universa* cool slightly to 11-14°C. While there appears to be a slight decrease in sea surface palaeotemperature, this may reflect summer (*Globigerina woodi*) and winter (*Globigerina bulloides* and *Orbulina universa*) conditions in the southern Tasman Sea.

Identification of globally recognised Miocene carbon maxima CM1-7 is possible in the benthic Hole 593 record. Most of these CM events occur within the Monterey Excursion (c. 18-13 Ma), evident in the Hole 593 record by heavy $\delta^{13}C$ values (Fig. 15). Events CM3, CM6, and CM7 are associated with Zones Mi2, Mi3, and Mi5, and this supports the inference that lowered sea levels during the Mi glacials are causally linked to carbon deposition (via upwelling and phytoplankton productivity). Zone Mi4 in the Hole 593 $\delta^{18}O$ record is also associated with a carbon maxima (CMX), a situation not previously reported from deep water records but fitting the overall pattern of CM associated with glacial events. However, the absolute $\delta^{13}C$ values of this record are considerably heavier than those reported from other sites, and this is accounted for by the high ventilation rates of antarctic surface waters 'thermodynamically tagging' the subducted water forming the Southern Component Intermediate Water.

A $\delta^{13}C$ shift of >1.0‰ between 7.15-6.45 Ma is tentatively identified as the 'Chron 6' Messinian Carbon Shift (Fig. 15). This carbon minima occurs just before the Southern Component Intermediate Water cooling event and supports the inference that only a small part (c. 0.3‰) of the enrichment was in fact due to ice volume change and lowering sea level, and that the remaining part was due to cooling, because if it was due to glacial ice volume, a carbon maxima would be expected if the previous trends were followed.

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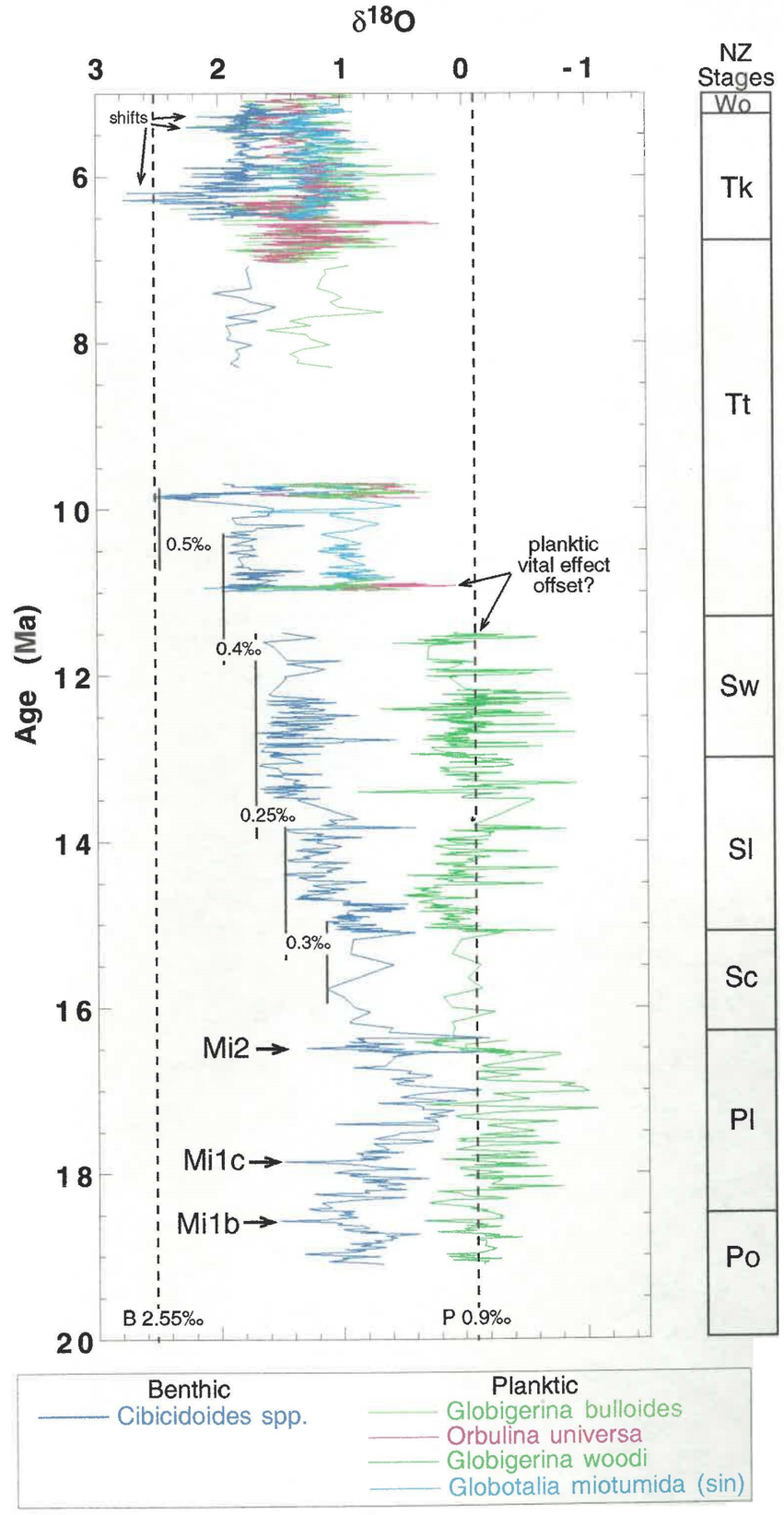
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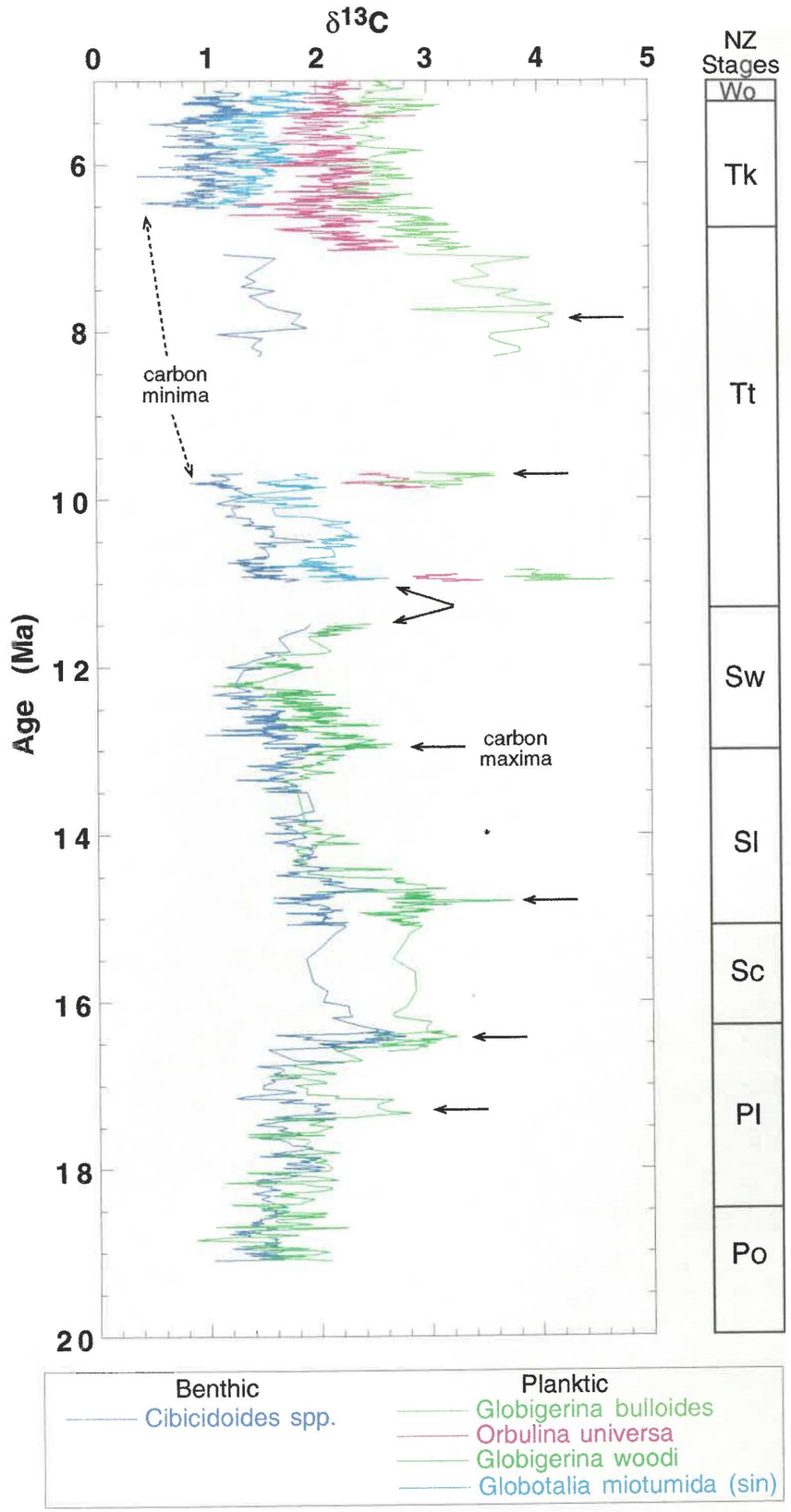
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Chapter 3

Figure 5. Early to Late Miocene benthic and planktic $\delta^{18}O$ records from Hole 593. Glacial Zones Mi1b, Mi1c, and Mi2 after Scott et al. (1994). Holocene benthic (2.55‰) and planktic (0.9‰) values are included for comparison (after Nelson, et al., 1994). For New Zealand Stages see Fig. 2 and the Glossary.



Chapter 3

Figure 6. Early to Late Miocene benthic and planktic $\delta^{13}C$ records from Hole 593. Significant enrichment spikes evident in both benthic and plantkic data are marked with arrows. For New Zealand Stages see Fig. 2 and the Glossary.

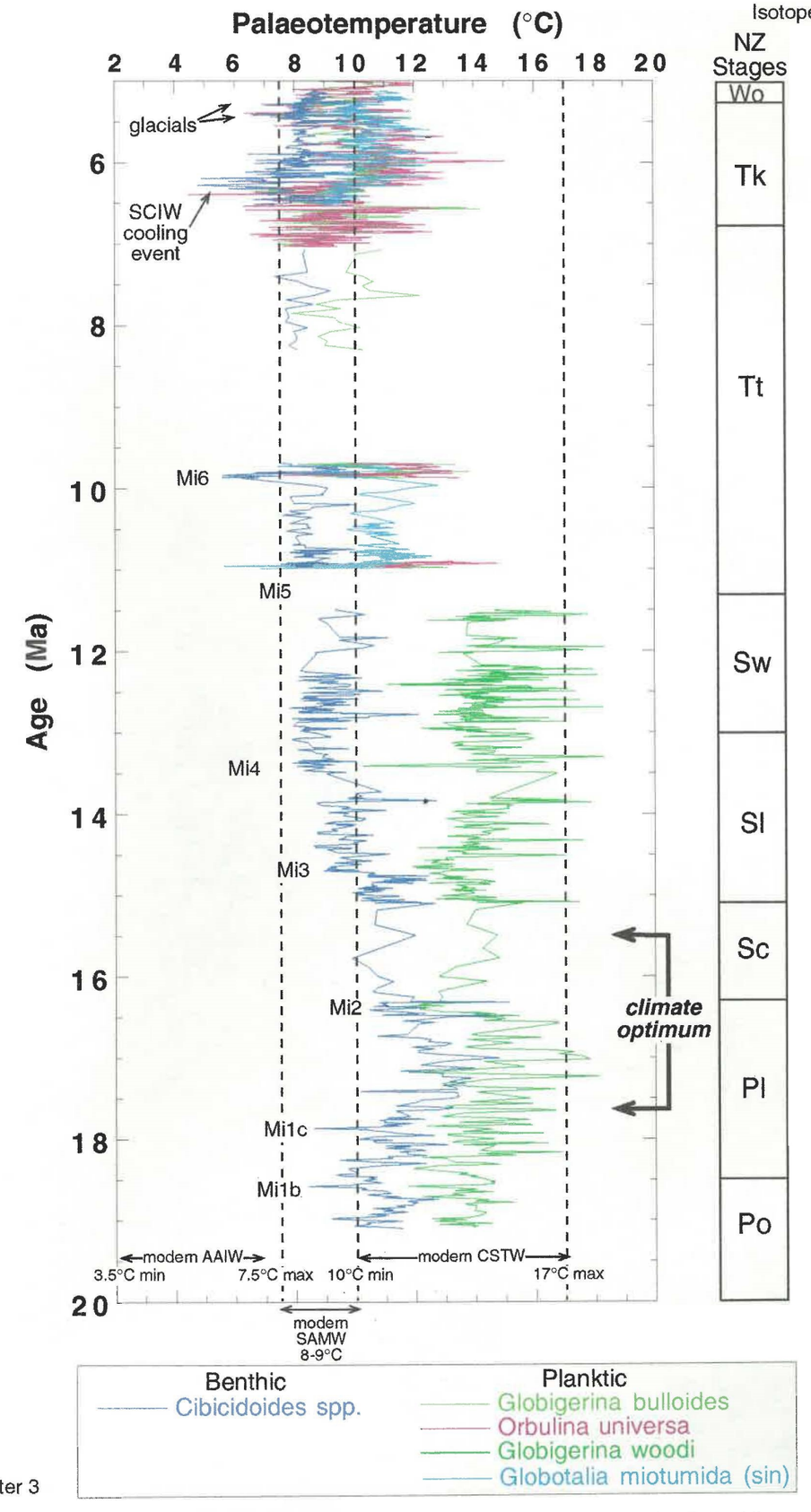


Figure 12. Hole 593 Early-Late Miocene calculated palaeotemperature records. Dotted lines mark: 10°C and 17°C = minimum (winter) and maximum (summer) mondern CSTW SST in southern Tasman Sea; 7.5°C = maximum modern AAIW BWT in southern Tasman Sea. For New Zealand Stages see Fig. 2 and the Glossary.

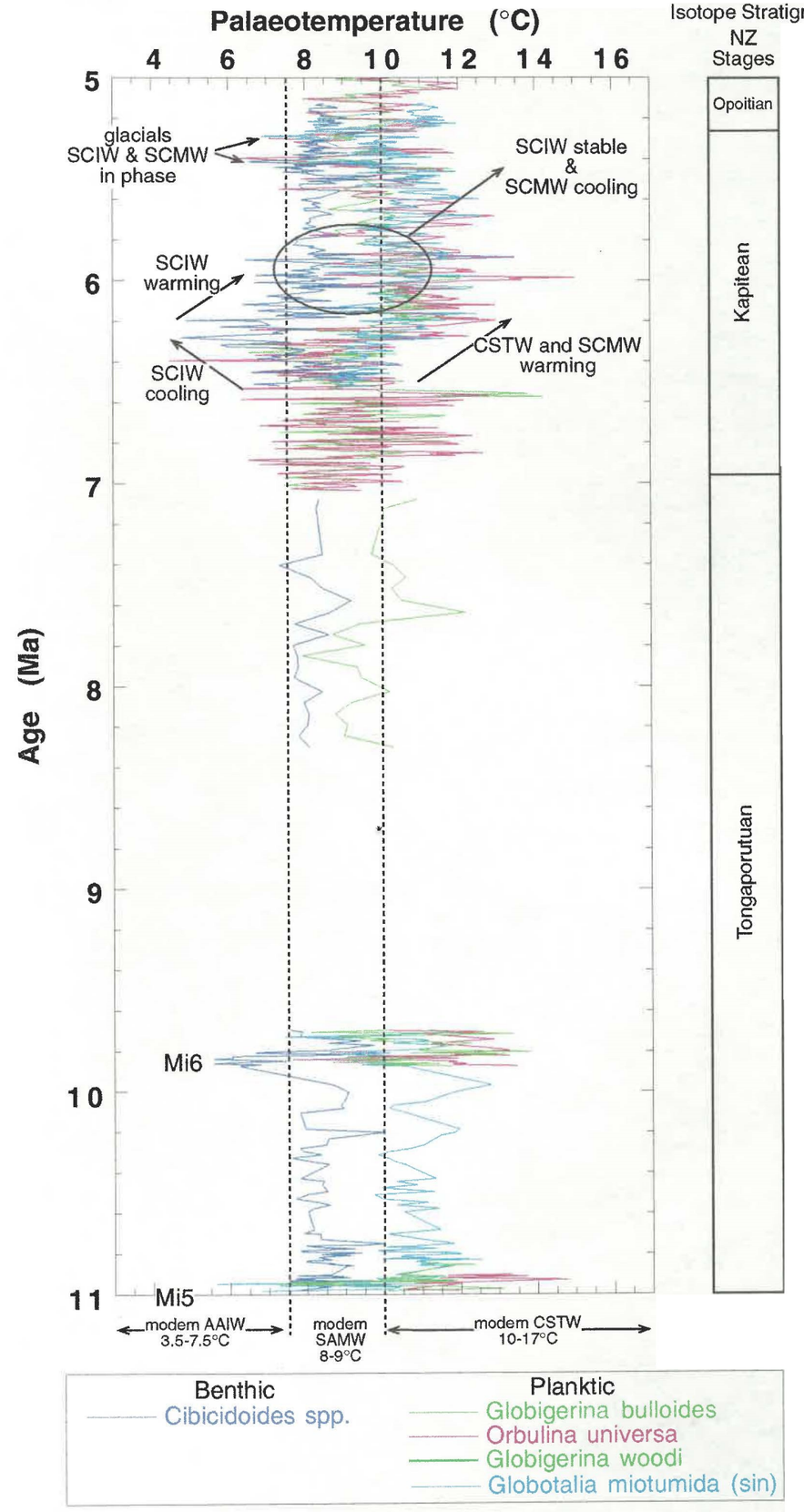


Figure13. Hole 593 expanded Late Miocene calculated palaeotemperature records. Dotted lines mark: 10°C = minimum (winter) CSTW SST in southern Tasman Sea; 7.5°C = maximum modern AAIW BWT in southern Tasman Sea.

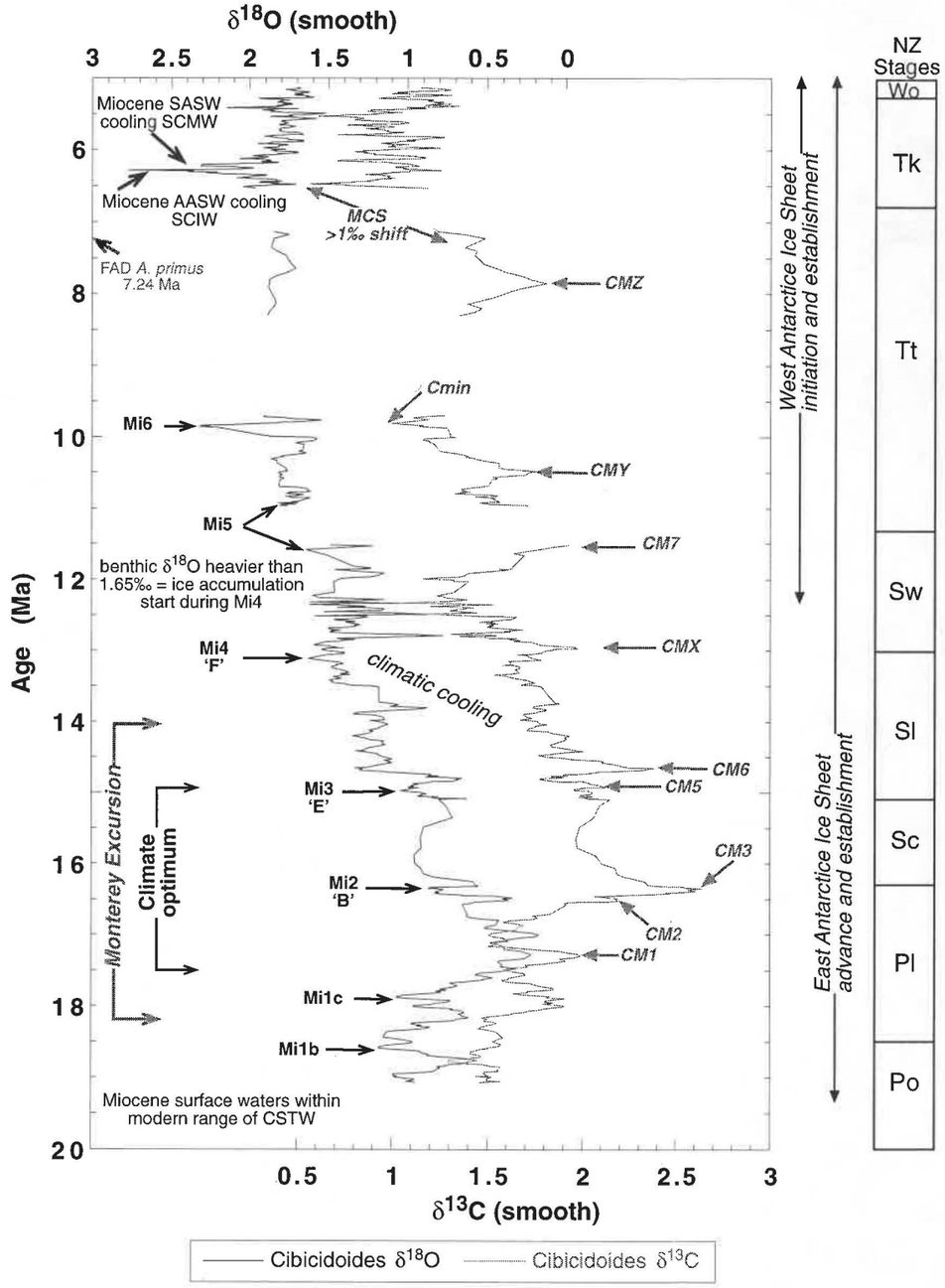


Figure 15: Miocene isotope stratigraphy from Hole 593

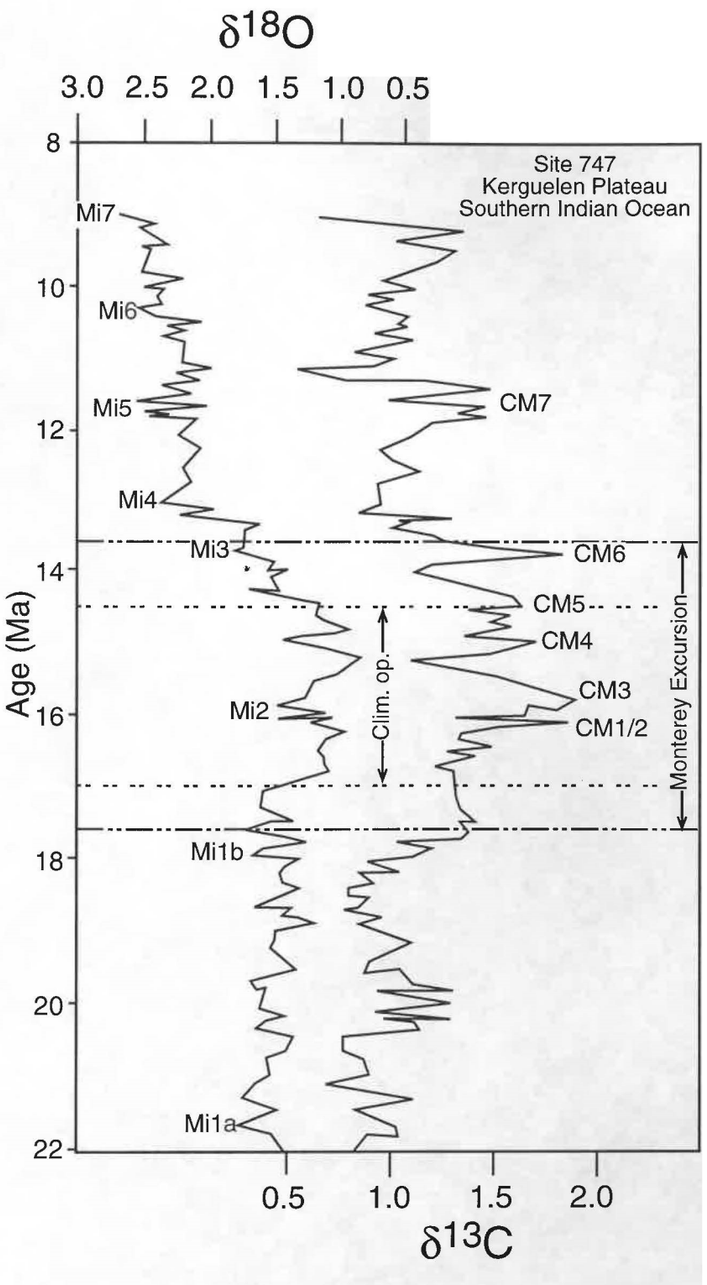


Figure 3: Miocene isotope stratigraphy from Hole 747

Chapter 4

Palaeoceanographic Controls On Coiling Direction In Globorotalia (Globoconella) miotumida From The Late Miocene Of Hole 593, Southern Tasman Sea

There was a young man from Cornell,
Who pronounced every delta‰ as del‰
But the spirit of Urey,
Returned in a fury
And transferred the poor fellow to hell.

Harman Craig

Palaeoceanographic controls on coiling direction in *Globorotalia (Globoconella) miotumida* from the Late Miocene of Hole 593, southern Tasman Sea

ABSTRACT

Tests of the planktic foraminifera *Globorotalia (Globoconella) miotumida* exhibit predominantly sinistral coiling through the Late Miocene section of Hole 593, southern Tasman Sea, except during three short intervals where the contribution of dextral individuals increases to constitute distinctive 'dextral coiling zones'. These coiling zones have regional correlation significance. This paper investigates the oxygen and carbon isotopic signatures of these dextral coiling events. Two of the three zones coincided with major Late Miocene glacial events, identified as Zones Mi6 and Mi5, the third to a prominent intermediate water cooling event and glacial. It is inferred that the coiling events are causally linked to the glacials by means of ocean structural changes in the depth of the permanent thermocline. This was achieved by increased volumes of Southern Ocean-derived (Southern Component) intermediate and mode water production during glacials. This in turn forced the permanent thermocline to shallow, and it is this oceanic structural change that is inferred to have affected the reproductive success of sinistral *Globorotalia miotumida*, allowing the dextral version to increase in numbers. Oceanic reorganization after the glacials changed the reproductive success, resulting in the sinistral form once again becoming dominant.

INTRODUCTION

Foraminifera live in a dynamic oceanic system which changes with the seasons and over geological timescales. Within the pelagic ecosystem each watermass provides a relatively homogeneous habitat, but where overall environmental physiochemical properties vary with depth and latitude. Physical barriers to dispersal, such as oceanic fronts and tectonically-controlled oceanic gateways, effectively isolate populations of foraminifera and restrict gene flow. This often results in identifiable characteristics being associated with specific watermasses, including the shape and size of planktic foraminiferal tests, and possibly test coiling directions (Hemleben et al., 1989). Recently published work on the genetic links between various species of foraminifera has made the case for the transfer of individuals and their genes 'across' oceanic fronts (Darling et al., 2000). This transfer is required to explain the bi-polar nature of many planktic foraminiferal populations. However, these authors make the point that oceanic fronts pose a formidable barrier to planktic foraminifera and they are unlikely to simply cross through them. Instead it is possible that the transfer might occur beneath the fronts, with individuals brought back to the surface waters by upwelling. Benthic foraminifera do not face such clearly defined barriers, and their wider distribution reflects this (Hemleben et al., 1989).

Through the Late Miocene section of nannofossil ooze in DSDP Hole 593, the planktic foraminifera *Globorotalia (Globoconella) miotumida* population exhibits predominantly sinistrally coiled tests. However, there are three zones where the number of dextrally coiled individuals increases to levels which make them a noticeable component of the planktic foraminiferal population (Crundwell et al., 1997b). These dextral coiling zones have also been reported from several onland New Zealand sections of Late Miocene age (Scott, 1995; Crundwell et al., 1997b) and it is evident that the coiling zones provided excellent stratigraphic markers for regional correlation (e.g., Thiede, 1971; Hornibrook and Jenkins, 1994; Scott, 1995). It has been assumed that some environmental factors, such as water temperature, might explain the incursions of dextrally coiling zones within the otherwise predominantly sinistrally coiled Late Miocene interval. This study explores possible palaeoenvironmental reasons for the coiling changes by analysing the oxygen and carbon stable isotope stratigraphy for the three coiling zones in Hole 593, named

Kaiti (Early Tongaporutuan), Tukemokihi (Late Tongaporutuan), and Palliser (Late Kapitean) Coiling Zones by Crundwell et al. (1997b).

COILING DIRECTIONS IN PLANKTIC FORAMINIFERA

The direction of coiling in trochospiral foraminifera is probably under genetic control and appears to be set during the early growth stage of the juvenile foraminifera (Hemleben et al., 1989). The coiling direction in planktic foraminifera has been shown to occur in equal proportions at the first appearance of the species in the geological record and that during evolution of the species coiling trends can be identified (Bolli, 1950). Four such trends have been recognised: (1) those with random coiling preference throughout their evolution; (2) those that initially coil randomly then adopt a moderate preference; (3) those that start out randomly and rapidly exhibit a preferred coiling direction and maintain it; and (4) those which start out like (3) but over time switch preference (Bolli, 1967). It is this latter group which can be particularly useful as stratigraphic markers (Bolli, 1967).

In an attempt to explain the repeated switching of direction, environmental controls on population assemblage such as water temperature, salinity and oxygenation have been correlated with changes in coiling direction. For example, in *Neogloboquadrina pachyderma* a predominance of sinistral coiling has been correlated with polar/subpolar surface waters (Bandy, 1960, 1972; Jenkins, 1971; Vella et al., 1975), and with Late Neogene glacials (Lourens and Hilgen, 1997). Recent work on the genetic coding of this species indicates that coiling direction in *Neogloboquadrina pachyderma* is associated with genetic divergence and is unlikely to be influenced by water temperature during development (Darling et al., 2000).

Coiling direction changes have also been noted in *Globorotalia truncatulinoides* where the sinistral form has been associated with cooler waters and the dextral with warmer conditions (Bandy, 1960). However, several studies either did not find such an obvious correlation (e.g., Ericson et al., 1954), or found the reverse (e.g., Thiede, 1971), or found correlation with some other watermass parameter, such as nutrients or salinity (Thiede, 1971; Haynes, 1981). Recent work using living *Globorotalia truncatulinoides* from plankton tows, and their shells from sediment traps underlying

the location of the tows, has indicated that a combination of the depth to the base of the permanent thermocline and the reproductive pattern of this species can explain the fluctuations in the dominant coiling direction, rather than simply relating it to water temperature (Lohmann, 1992). Reproducing planktic foraminifera sink through the water column and the cytoplasm of the adult foraminifera is consumed in gamete production (gametogenesis), leaving an empty shell which eventually sinks to the seafloor (Bé and Anderson, 1976; Hemleben et al., 1989). The gametes then need to return to the surface waters. However, if the reproductive cycle extends below the density isopycnal representing the permanent thermocline, they may have difficulty in returning through this 'barrier' to the surface (Lohmann and Schweitzer, 1990; Lohmann, 1992). It appears that the sinistral *Globorotalia truncatulinoides* individuals spend a relatively short time in shallow water and sink faster (than dextral ones) through the thermocline, while dextral populations persist above it throughout the year; this may explain why the sinistral forms are affected by shallowing of thermocline depths (Lohmann and Schweitzer, 1990). Oceanographic controls were hinted at by Thiede (1971), when he noted that sinistral *Globorotalia truncatulinoides* dominated the population during winter and that dextral individuals were present throughout the year.

Genetic studies on several extant planktic foraminiferal species appear to suggest that the two coiling directions detected in some populations of planktic foraminifera need to be considered as separate subspecies distinguished by differences in such matters as, reproductive timing, and/or nutrient requirements (Darling et al., 2000). Whatever the cause of coiling, it appears that changes in the thermocline depth can force changes in the dominant coiling direction of a population (Lohmann and Schweitzer, 1990). It is this premise that is used to shed light on the origin of the three Late Miocene coiling zones, as any controlling mechanisms, such as changes in thermocline depth, must have persisted on a long enough time scale for the coiling zones to show up in the geological record.

Populations of living planktic foraminifera exhibit depth habitat zonation and/or a seasonal distribution which are reflected in the isotopic composition of their shell calcite (Curry and Matthews, 1981; Spero, 1992; Spero and Lea, 1996). If the change in coiling direction is linked to the water temperature during calcite secretion

this should be reflected in the oxygen isotopic composition of shell calcite. If the premise that sinistral coiling corresponds with cooler surface waters and dextral coiling with warmer surface waters is correct, the difference should be evident in the $\delta^{18}O$ records of each *Globorotalia miotumida* coiling direction.

The only living species of the *Globoconella* subgenus is *Globorotalia (Globoconella) inflata* (Kennett and Srinivasan, 1983; Scott et al., 1990), and in this species the $\delta^{18}O$ calcite values correspond with winter sea surface temperatures (Ganssen and Sarnthein, 1981). *Globorotalia (Globoconella) inflata* reproduces at depths of c. 400 m (Hemleben et al., 1989). The phylogeny and isotopic records of the globoconellids led Norris et al. (1994) to conclude that they lived within the main (permanent) thermocline, and hence that they should give a deep-dwelling planktic signal.

PHYSICAL SETTING OF SITE 593

Site 593: Modern oceanographic setting

Site 593 (1068 m water depth) is located on the western flank of the Challenger Plateau (Lord Howe Rise) which bounds the Tasman Basin in the southern Tasman Sea (Fig. 1). The general circulation pattern of the region is related to the southern Subtropical Gyre in the Pacific Ocean, the western arm of which flows along the coast of Australia as the East Australian Current. The bulk of this water travels across the Tasman Sea as flow along the Tasman Front (B. Stanton, 1999, pers. comm.) and enters the Pacific Ocean to the north of New Zealand, continuing south and eastwards as the East Auckland Current (Stanton et al., 1997). In the southern Tasman Sea there is a slow anticyclonic gyre with west to east flow as the Tasman Current along the Subtropical Front (Heath, 1985). As this current reaches the coast of South Island it splits, with one part flowing northwards, either through Cook Strait or around northern New Zealand. The southwards flowing arm travels around South Island forming flow along the Southland Front before turning eastwards along the Chatham Rise and re-joining the South Pacific Current along the Subtropical Front (Tomczak and Godfrey, 1994; Stramma et al., 1995).

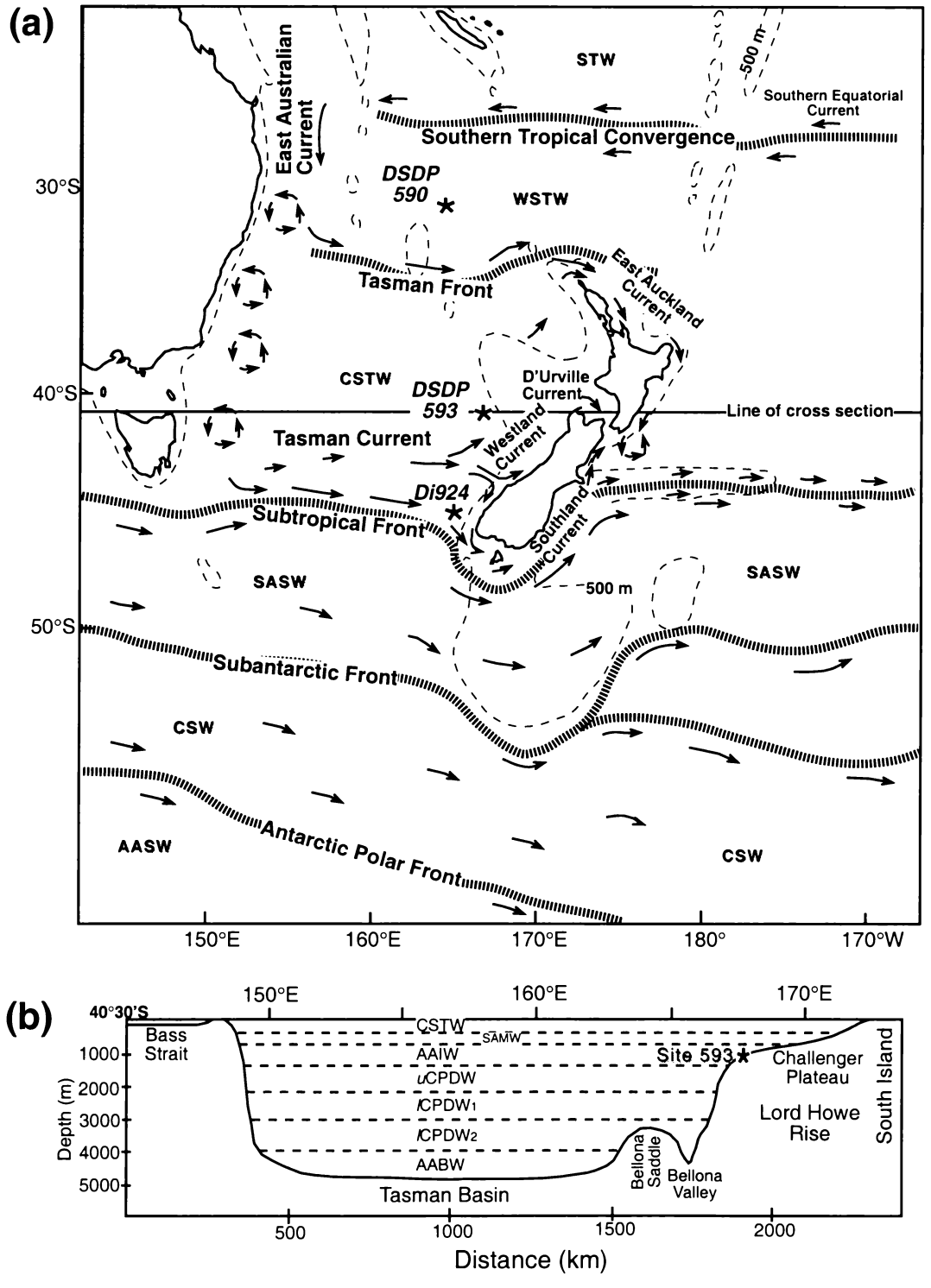


Figure 1 New Zealand regional physical oceanographic setting (a) Oceanic fronts and surface watermasses in the Tasman Sea and surroundings; (b) cross section through 40°30'S showing watermasses in relation to Site 593 (in 1068 m water depth). CSTW = Cool Subtropical Water - warm, saline surface watermass; SAMW = Subantarctic Mode Water - subsurface oxygen maximum and thermostad; AAIW = Antarctic Intermediate Water - regional salinity minimum; *u*CPDW = upper Circumpolar Deep Water - oxygen min below salinity min; *l*CPDW$_1$ = lower Circumpolar Deep Water 1 - deep salinity max; *l*CPDW$_2$ = deep oxygen max; AABW = Antarctic Bottom Water - deep temperature minimum where present. After Wyrtki (1961, 1962), Garner (1962, 1967), Garner and Ridgway (1965), Drewry (1983), Rodman and Gordon (1982) and Heath (1985).

In addition to the latitudinal circulation pattern it is important to consider circulation relative to depth (Fig. 1b) because foraminifera live throughout the water column and bottom sediments. In the Tasman Sea the surface mixed layer extends to c. 200-300 m depth (Garner, 1962, 1967; Garner and Ridgway, 1965; Rahmstorf, 1992) and represents the zone of active mixing between the ocean and the atmosphere. Below this is the seasonal thermocline, seen in the salinity, temperature, depth (STD) profile from station Di924 (Fig. 2) as a rapid temperature decrease with depth which, with seasonal cooling, disappears altogether in winter in the southwest Pacific (Garner, 1962, 1967; Garner and Ridgway, 1965; Tomczak and Godfrey, 1994).

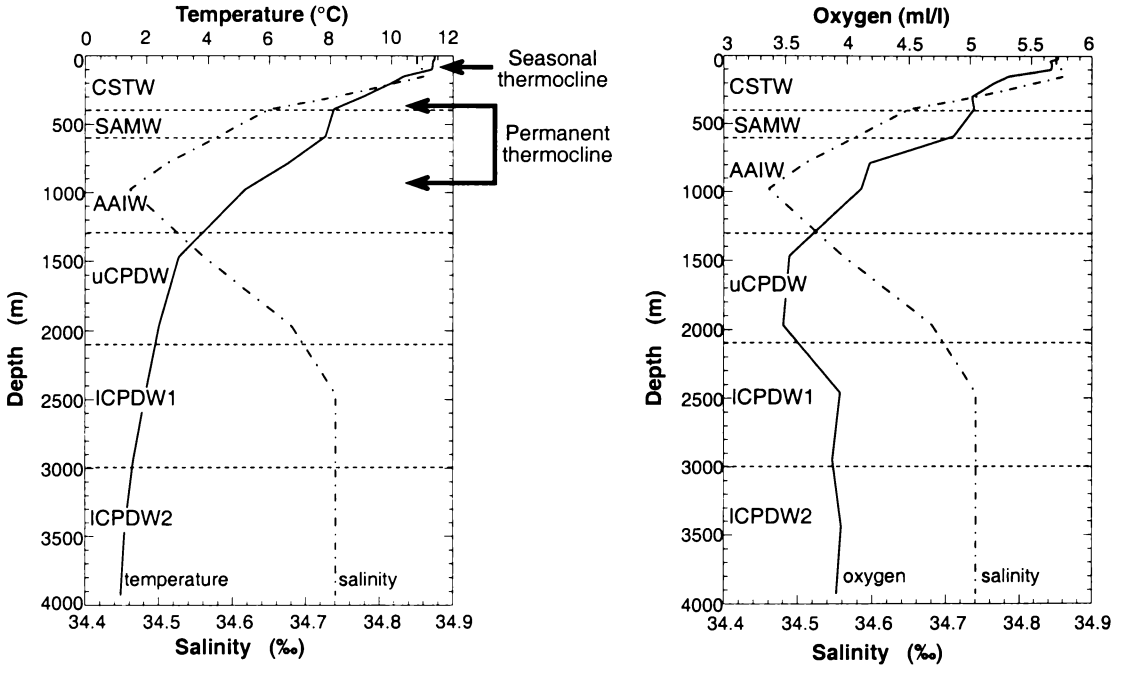


Figure 2 Winter STD profile from station Di924, south of Site 593 (Garner, 1962), illustrating the depth of the modern permanent thermocline and watermasses in the Tasman Sea (see Fig. 1 for location). Note: this STD profile is not deep enough to record AABW. The permanent thermocline evident in this STD profile illustrates that it does not fall exactly between the SAMW and AAIW because it represents a density isopycnal, and the station is located close to the surface expression, namely the STF.

The permanent thermocline lies below this seasonal feature with Intermediate waters spreading northwards just below it. The ventilation of the permanent thermocline occurs with the formation of Subantarctic Mode Water (SAMW) which forms by winter cooling of surface waters between the Subantarctic Front (SAF) and Subtropical Front (STF) (McCartney, 1982). This cool surface layer sinks in the summer and is isolated again by winter surface waters forming a distinct

thermostad, a layer characterised by a minimal vertical temperature gradient (Passlow et al., 1997). SAMW is recognised as a subsurface oxygen maximum in the southwest Pacific as it moves north and eastwards from source (McCartney, 1982) at around 300-700 m depth. Western South Pacific Central Water is a general term for surface waters north of the STF (Sverdrup et al., 1942) which are formed by the mixing of mode water with surface waters (Thompson and Edwards, 1981; McCartney, 1982; Sprintall and Tomczak, 1993), and are now referred to as Cool Subtropical Water (CSTW). The base of the permanent thermocline therefore corresponds with an isopycnal starting at the STF and descending through the SAMW down to the top of AAIW (Fig. 2, also 1b).

Late winter breakdown of surface stratification enables the ventilation of the permanent thermocline and often produces seasonal upwelling which brings nutrients to the surface. However, the CSTW in the Tasman Sea is generally considered to be a nutrient-depleted watermass with upwelling only occurring in localised areas (Bradford and Roberts, 1978).

Miocene watermass nomenclature

The modern watermass nomenclature (Figs. 1 and 2) relates to specific, measurable water properties. This obviously becomes problematic for palaeoceanography, and so the nomenclature proposed by Wright et al. (1992) and Flower and Kennett (1995) is followed here, in which watermasses originating in the Southern Ocean are referred to simply as Southern Component Water. Thus intermediate-depth waters in the Miocene are referred to as Southern Component Intermediate Water, or SCIW. Details of the complete isotope stratigraphy for the Neogene section of Hole 593 are presented in Chapter 3.

CORE STRATIGRAPHY

Lithostratigraphy

The stratigraphy for Hole 593 is presented in Fig. 3a, and an expanded interval including the samples in this study forms Fig. 3b. The previously established biostratigraphic framework for Hole 593 (Kennett and von der Borch, 1986b) using both foraminiferal (Jenkins and Srinivasan, 1986) and nannofossil (Lohman, 1986)

biostratigraphies has been refined here following Crundwell et al. (1997a; 1997b) and, where possible, updated using Berggren et al. (1995) (Table 1). Owing to the lack of good palaeomagnetic age control in Hole 593, it has been necessary to attempt correlation with other ODP holes in the region, which do have some age control. In particular, correlations have been made with some of the newly drilled Leg 181 sites to the east of New Zealand, where some excellent Neogene palaeomagnetic records have been acquired (Leg 181 Shipboard Scientific Party, 1999)

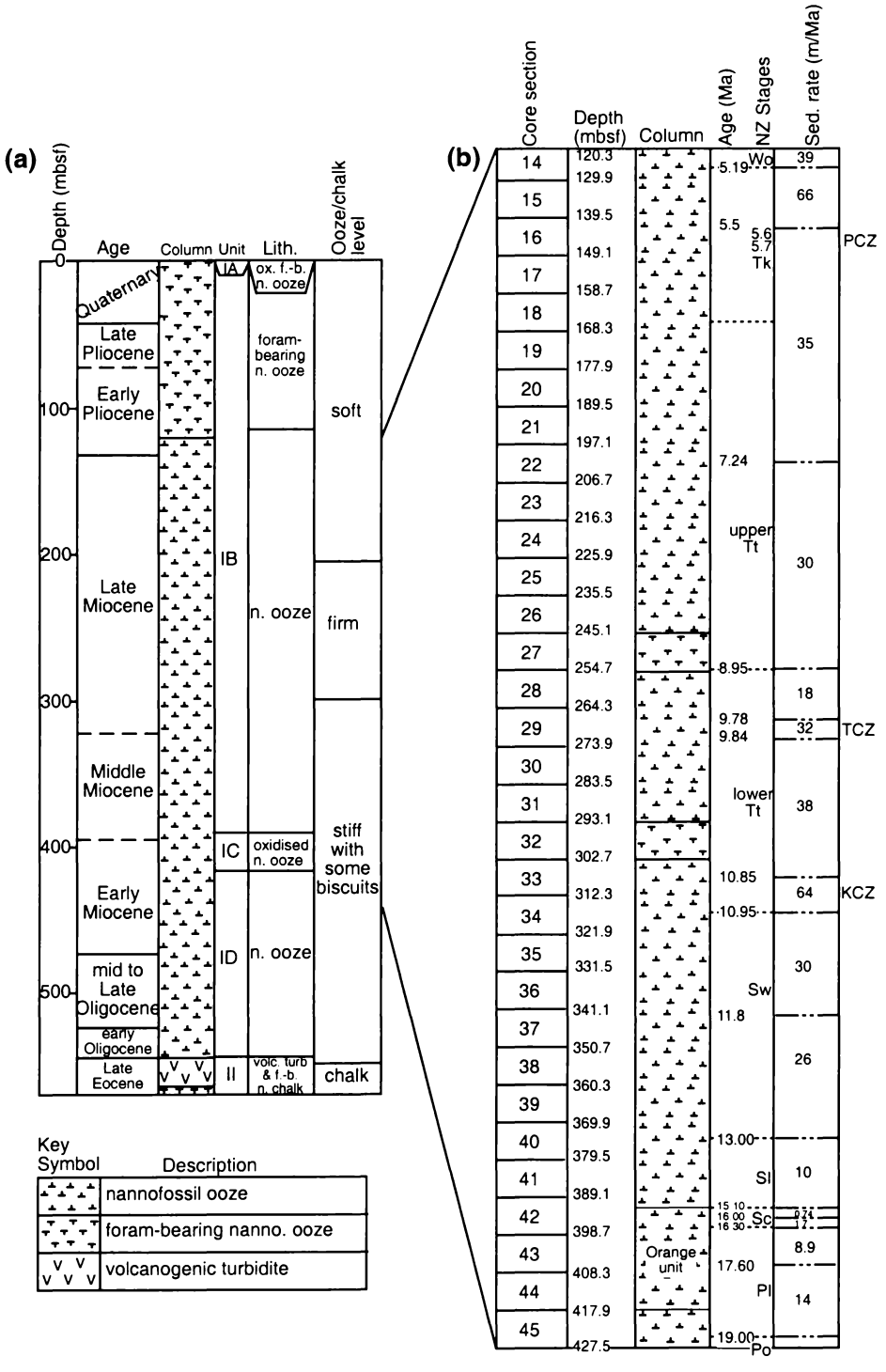


Figure 3 (a) General Site 593 stratigraphy using Leg 90 biostratigraphy, unit IA-D = ooze, unit II = volcanogenic turbidite. After Nelson (1986); (b) detailed stratigraphy for the Miocene section used in this study (After Kennett and von der Borch, 1986a) updated using the geopolarity timescale (GPTS) of Berggren et al. (1995) and biostratigraphy of Crundwell (in prep.). New Zealand stages: Po = Otaian, Pl = Altonian, Sc = Clifdenian, Sl = Lillburnian, Sw = Waiauan, Tt = Tongaporutuan, Tk = Kapitean and Wo = Opoitian. PCZ = Palliser Coiling Zone. TCZ = Tukemokihi Coiling Zone, KCZ = Kaiti Coiling Zone.

Table 1. Biostratigraphic events used to calculate Late Miocene sedimentation rates for Hole 593. N = nannofossil datum; P = planktic foraminiferal datum.

Event	Depth (mbsf)	Age (Ma)
First occurrence *Globorotalia puncticulata* (P)	126.30	5.12
First occurrence *Globorotalia sphericomiozea* (P)	143.53	5.51
Top Palliser Coiling Zone	153.97	5.81
Base Palliser Coiling Zone	158.10	5.93
First occurrence *Amorolithus primus* (N)	203.42	7.24
Last occurrence *Globoquidrina dehiscens* (P)	254.49	8.95
Top Tukemokihi Coiling Zone	269.28	9.78
Base Tukemokihi Coiling Zone	270.72	9.84
Top Kaiti Coiling Zone	309.11	10.85
Base Kaiti Coiling Zone	315.19	10.95
NN6/7 boundary (N)	341.16	11.80

On this basis, the three coiling zones have the following approximate ages: KCZ, c. 10.95-10.85 Ma; TCZ, 9.84-9.78 Ma; PCZ, 5.93-5.81 Ma. Dating of glacial Zones Mi5 (11.5-11.0 Ma) and Mi6 (10-9.8 Ma) in Hole 593 is dependent on the choice of GPTS systems, with recent astronomical dating of Mi6 at 10.4 Ma (Oslick et al., 1994; Turco et al., 2001) being slightly older than the age scheme followed here. This discrepancy remains to be resolved.

Coiling zones stratigraphy

The coiling zones are identified as a series of dextrally coiling excursions of *Globorotalia miotumida* (and is descendent species) compared with the rest of the core where the dominant coiling direction is sinistral (Crundwell, in prep.). Recognition of the 'clumps' of dextral excursions is sufficient to enable these to be described as a coiling zone (Fig. 4), and for them to be of use in regional stratigraphic correlation (Scott, 1995; M. Crundwell, pers. comm., 2001). The upper and lower boundaries of the coiling zones are placed where the proportion of the population which coils dextrally is mainly >30%, with many samples dominated by dextral coiling shells (M. Crundwell, pers. comm., 2001). The statistical definitions of the three collections of coiling excursions is in progress (M. Crundwell and G. Scott, pers. comm., 2001). Previous work on one of the zones from Site 593 and one from Site 590 (Scott, 1995) indicated that the clear boundaries of these zones (Fig. 4) were statistically valid, and this has been assumed in this study where samples designated 'dextrally dominated' have been used. Of the three coiling

zones identified at Site 593, the lower two are within the New Zealand Tongaporutuan (Tt) stage and the upper one within the Kapitean (Tk) (Crundwell et al., 1997b).

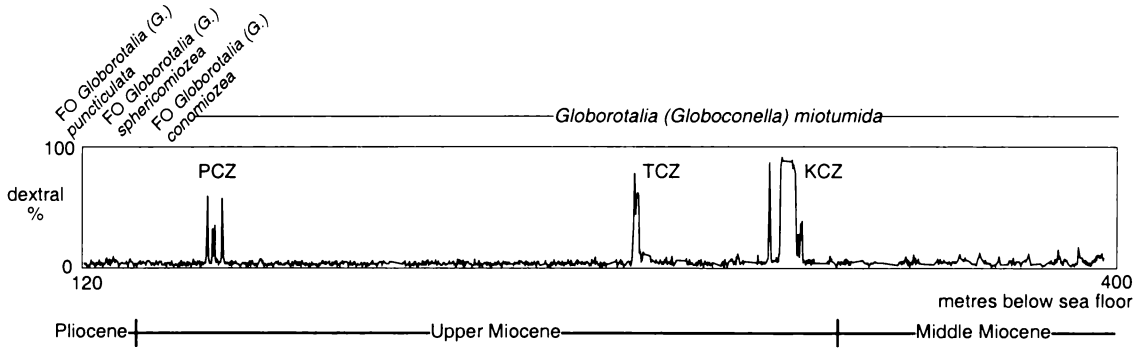


Figure 4 Miocene coiling history of *Globorotalia (Globoconella) miotumida* and its descendent species in Hole 593 (Crundwell, in prep.).

In order to distinguish the two Tt coiling zones Crundwell et al. (1997b) and Scott (1995) used the Last Occurrence (LO) of *Paragloborotalia mayeri* which corresponds with either the base of the upper Tt coiling zone, or occurs very closely below it. The LO of *Paragloborotalia mayeri* was used by Scott (1995) to correlate a coiling zone in Hole 590, north of Hole 593, with the oxygen isotope record and a Miocene glacial zone of Miller et al. (1991). The isotopic records from a number of locations, including Site 590, were used by Miller et al. (1991) to identify two glacial events, Mi5 and Mi6, in the latest Middle Miocene-early Late Miocene (they did not clearly denote Mi6 in the Hole 590 data). Owing to the lack of a palaeomagnetic record in both Holes 590 and 593, Scott (1995) noted that in North Atlantic Hole 608, event Mi6 occurred above the LO of *Paragloborotalia mayeri*. He further suggested that the two events (Mi6 and the coiling zone) were correlated in Hole 590, as the lower glacial (Mi5) occurred within the range of *Paragloborotalia mayeri* in both Holes 590 and 608. Hence, Scott (1995) tentatively correlated the coiling zone in Hole 590 with the global oxygen isotope event Mi6 of Miller et al. (1991). A similar relationship can be established for the Mediterranean data of Turco et al. (2001), where Mi5 occurs within the range of *Paragloborotalia mayeri*, and Mi6 occurs after the last occurrence.

By correlating the coiling zones with the foraminiferal and bolboform biostratigraphy in Hole 593, Crundwell et al. (1997b) established that the coiling zone in Hole 590

(Fig. 1) is the same event as the upper Tt dextral coiling zone in Hole 593 (confirmed by G. Scott, pers. comm., 1999) and formally called it the Tukemokihi Coiling Zone (TCZ). The lower Tt event was previously named the Kaiti Coiling Zone (KCZ) (Scott, 1995), and the Tk event was named the Palliser Coiling Zone (PCZ) by Crundwell et al. (1997b). All three coiling zones are named after New Zealand onland locations where they have been found. As there is now correlation between the coiling zones at Sites 590 and 593 (Crundwell et al., 1997b) and the Late Miocene glacials, is it possible that the coiling zones are somehow caused by, or the result of, these glacial Zones?.

Structure of the coiling zones

The intervals over which Late Miocene samples contain 30% plus dextral coiling in Hole 593 are given in Table 2. Note that both KCZ and PCZ intervals are not continuous and comprise three and two segments, respectively, interpreted as dextral coiling excursions within the zone. This intermittent dextral dominance is unlike the coiling zone in Hole 590, where the dextral excursions comprising the zone are strongly dominant (Scott, 1995).

Table 2. Coiling zones depths intervals from Hole 593, where samples contain >30% of dextrally coiled *Globorotalia miotumida*.

Coiling zone	Segments (mbsf)
Palliser Coiling Zone (PCZ)	154.13-153.97
	155.94-155.24
	158.10-157.93
Tukemokihi Coiling Zone (TCZ)	270.72-269.28
Kaiti Coiling Zone (KCZ)	306.54-306.11
	315.19-309.11

CONTROLS ON $\delta^{18}O$ AND $\delta^{13}C$ SIGNATURES IN FORAMINIFERAL CALCITE

Calcification in foraminifera

Foraminifera secrete calcite throughout their life time as they grow and add successive, usually larger, chambers. As a result, isotopic analysis of whole tests provides a composite sample, weighted towards the later chambers which provide

most of the calcite, therefore there is no single depth of calcification in planktic foraminifera. However, as planktic foraminiferal depth habitats have been established (e.g., Hemleben et al., 1989; Spero and Lea, 1993, 1996), the isotopic analysis of tests from a given species are interpreted as maximum calcification depth at which latest ontogeny is reached, prior to reproduction and death. In order to remove any variability due to individual tests being at different stages of ontogeny, adult tests of similar size, and assumed ontogenetic stage, were used for isotopic analysis.

Individual tests exhibiting calcite overgrowths, and/or secondary calcification have been avoided as far as possible using binocular microscope examination, as secondary calcification will affect the isotopic results (e.g., Pearson et al., 2001; Schwarzschild, 2001). The preservation of the Hole 593 samples is excellent (Gardner et al., 1986), with little or no calcite recrystallisation on SEM examination (Hess and Schilling, 1986), so Hole 593 isotopic analyses are assumed to reflect genuine palaeoenvironmental conditions.

Planktic foraminiferal ontogeny can result in tests exhibiting kummerform growth, where the final chamber is smaller than the preceding one. The nature of kummerform growth has not been definitively established, and may be due to environmental stress, or stage of reproductive development where the adult has reached the growth limit of the species (Olsson, 1973). Often kummerform test calcite is thicker, which may reflect secondary calcification, therefore kummerform tests, from any species, have not been used in this study.

Foraminiferal species selection

Globorotalia (Globoconella) miotumida is not found in sediments younger than Late Miocene, while its predecessor. Sinistral tests were picked from all samples, and dextral tests from those samples identified as dextrally dominant. The *Globorotalia (Globoconella) miotumida* record is inferred to reflect the Southern Component Mode Water (SCMW) (see Chapter 3 for details).

Two other planktic species were picked to provide known surface water isotopic comparisons. *Globigerina bulloides* is a spinose, non-symbiont species commonly

associated with areas of upwelling (Fairbanks et al., 1982; Kroon and Darling, 1995; Weaver et al., 1997) and is generally considered a shallow-dwelling (0-100 m) species (Hemleben et al., 1989). It has been found living below the seasonal thermocline and follows upwelling water to the surface (Ganssen and Sarnthein, 1981; Fairbanks et al., 1982). *Orbulina universa* is a shallow-dwelling planktic species which maintains algal symbionts that may contribute to the $\delta^{13}C$ value of secreted shell calcite (Spero, 1992). However, it can be reliably used for isotopic studies provided sufficient numbers and large test sizes are used (Schiffelbein and Hills, 1984). In the modern ocean this species appears to calcify in oxygen equilibrium with seawater during its maximum productivity phase in winter (Sautter and Thunell, 1991). By comparing $\delta^{18}O$ compositions of shells from species which are known to inhabit the surface mixed layer (e.g., *Orbulina universa* and *Globigerina bulloides*), with those of a species where depth preference has no modern example (i.e., *Globorotalia miotumida*), it is possible to infer depth of calcification from the systematic departures in isotopic values of the shallow-dwelling species (Norris et al., 1993, 1994).

The benthic foraminifera *Cibicidoides cenop* was used in this study and this genus has been shown to secrete calcite offset from oxygen equilibrium by c. 0.64 ‰ (Shackleton and Opdyke, 1973; Shackleton et al., 1984); however, no correction is made here because the record is wholly from *Cibicidoides*. The genus is epibenthic (Lutze and Thiel, 1989; Linke and Lutze, 1993) and its test calcite reflects the $\delta^{13}C$ of dissolved inorganic carbon in bottom waters (Graham et al., 1981; Vincent et al., 1981; Grossman, 1987; Duplessy et al., 1988). This benthic isotope record is provided for comparison since it is derived from test from the same samples from which the *Globorotalia miotumida* was picked, and it provides a comparison with bottom water signals, in this case Southern Component Intermediate Water (SCIW).

Changes in $\delta^{13}C$ of foraminiferal calcite can provide information on palaeoproductivity. As ^{12}C is preferentially taken up by marine phytoplankton and incorporated into organic material this enriches surface waters in ^{13}C. As a result, planktic foraminiferal calcite $\delta^{13}C$ is highest in shallow-dwelling species (Kroopnick, 1985). Planktic foraminifera which live below the surface (deep-dwelling species) reflect this by exhibiting slightly less enriched $\delta^{13}C$ values. If the two coiling

directions of *Globorotalia miotumida* do live at different maximum depths, the $\delta^{13}C$ signal might be able to distinguish their habitat depths.

Hypotheses examined

It appears that the naturally predominant coiling direction in *Globorotalia miotumida* is sinistral as the majority of individuals are left-coiling. The three Late Miocene coiling zones identified here are interpreted to be examples of trend 4 of Bolli (1967). This suggests that something skews the reproductive success of the dextral coiling individuals so that their numbers increase to around 30% of the population throughout the time intervals represented by the coiling zones, but not during the rest of the time. Several hypotheses can be considered:

a) That the coiling direction changes are linked to significant water temperature differences: either dextral coiling is the result of warmer water, and sinistral of colder, or visa versa, i.e., that coiling directions are ecophenotypes. The evidence will be in the $\delta^{18}O$ records, where the calcite secreted in colder water would be expected to have heavier values. Equally, if salinity differences were involved (often linked to water temperature), calcite secreted in more saline waters would generate heavier values.

b) That the coiling direction changes are linked to depth habitat selection: dextral coiling have a shallower reproductive habitat, similar to modern *Globorotalia truncatulinoides* (Lohmann, 1992). If the reproductive success of either coiling direction is linked to the depth of the base of the permanent thermocline then the $\delta^{18}O$ records may not show any difference between coiling directions as the bulk of the calcite would be secreted in the same (surface) watermass above this oceanographic boundary. However, the $\delta^{13}C$ records might distinguish between them, as the $\delta^{13}C$ profile using modern planktic foraminifera readily distinguishes between surface-dwelling species and those dwelling deeper in the water column.

c) If the isotopic records do not exhibit any distinguishable differences between the coiling directions then this would suggest that some factor other than temperature, salinity, and thermocline depth controls the predominance of a given coiling direction.

d) If post-depositional factors were involved in removing specimens of a given coiling direction, such as dissolution or winnowing, their effects would be expected to affect more than just a single species of planktic foraminifera because the bulk of the sediments are calcareous (see Chapter 2).

METHODS

Sample processing is detailed in Chapter 2. All specimens for isotopic analysis were picked from the >150 μm sand fraction which is the standard size range for biostratigraphic studies. Specimens used were free of any obvious pyrite, calcareous overgrowths, or encrusting. All tests from a given species were picked to ensure they were approximately the same size. Around 30 *Globorotalia miotumida* tests (for both coiling directions) were selected from the samples used. Every effort made to ensure tests were of a similar size, in order to endeavour to use adult individuals of a similar age/developmental stage. Approximately 10 *Globorotalia miotumida* specimens were used per sample for isotopic analysis. For more details of the isotopic methods and other species see Chapter 3.

RESULTS

Oxygen and carbon Isotopic records are presented for the Late Miocene including the three coiling zones (Fig. 5). Previously identified glacial events Mi5 and Mi6, and the SCIW cooling event at c. 6.3 Ma, are noted on the $\delta^{18}O$ panel (for details of these events see Chapter 3).

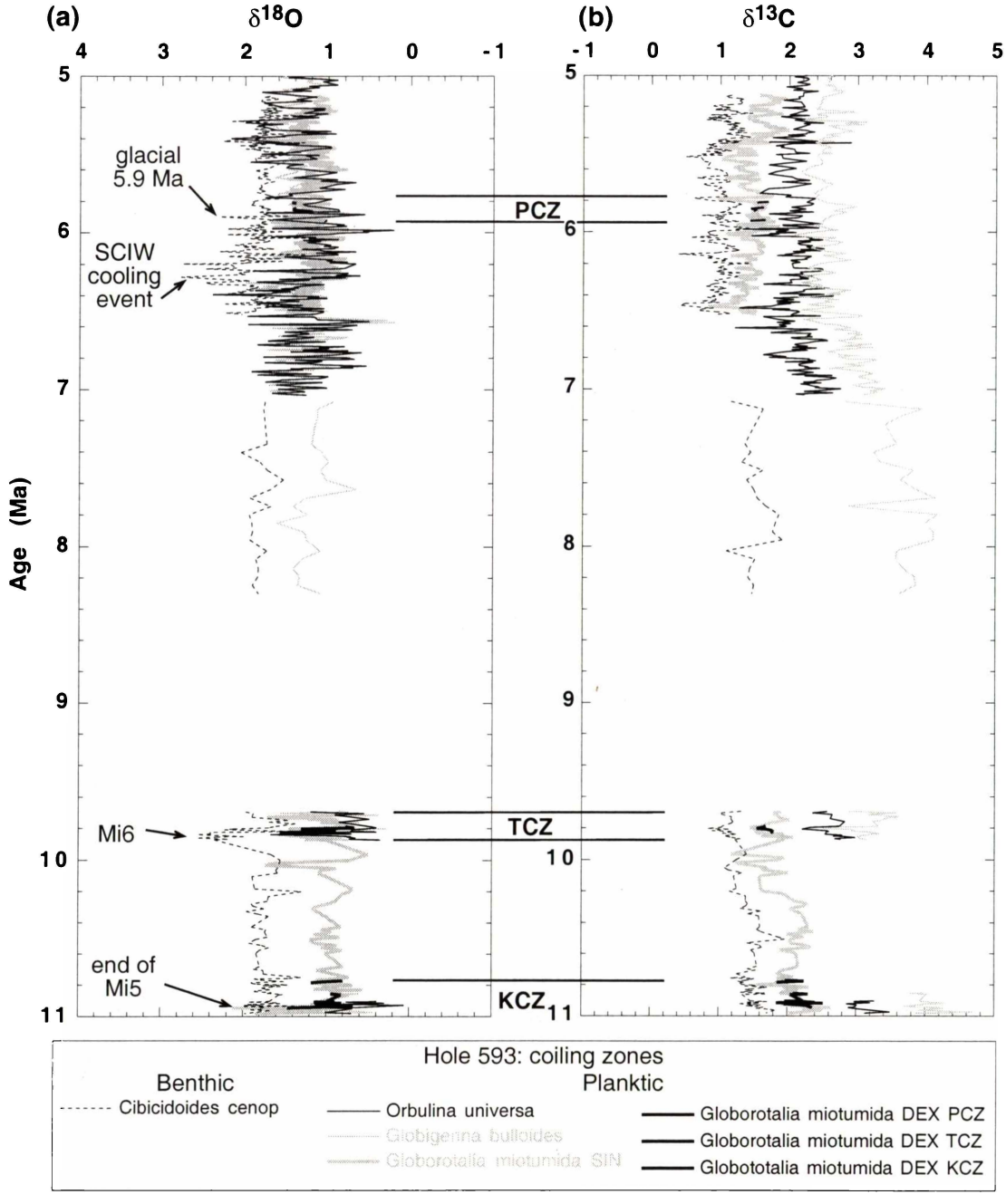


Figure 5 Isotopic records for the Late Miocene (11-5 Ma) section of Hole 593 with the three coiling zones, KCZ = Kaiti Coiling Zone; TCZ = Tukemokihi Coiling Zone; PCZ = Palliser Coiling Zone: (a) $\delta^{18}O$ with glacial events Mi5, Mi6, and SCIW cooling event noted; (b) $\delta^{13}C$.

Kaiti Coiling Zone (10.95-10.85 Ma)

This coiling zone is comprised of two segments (Fig. 6).

Oxygen

The dextral isotopic record (Fig. 6a) essentially overlaps the sinistral record, or is slightly heavier by c. 0.3‰ than it.

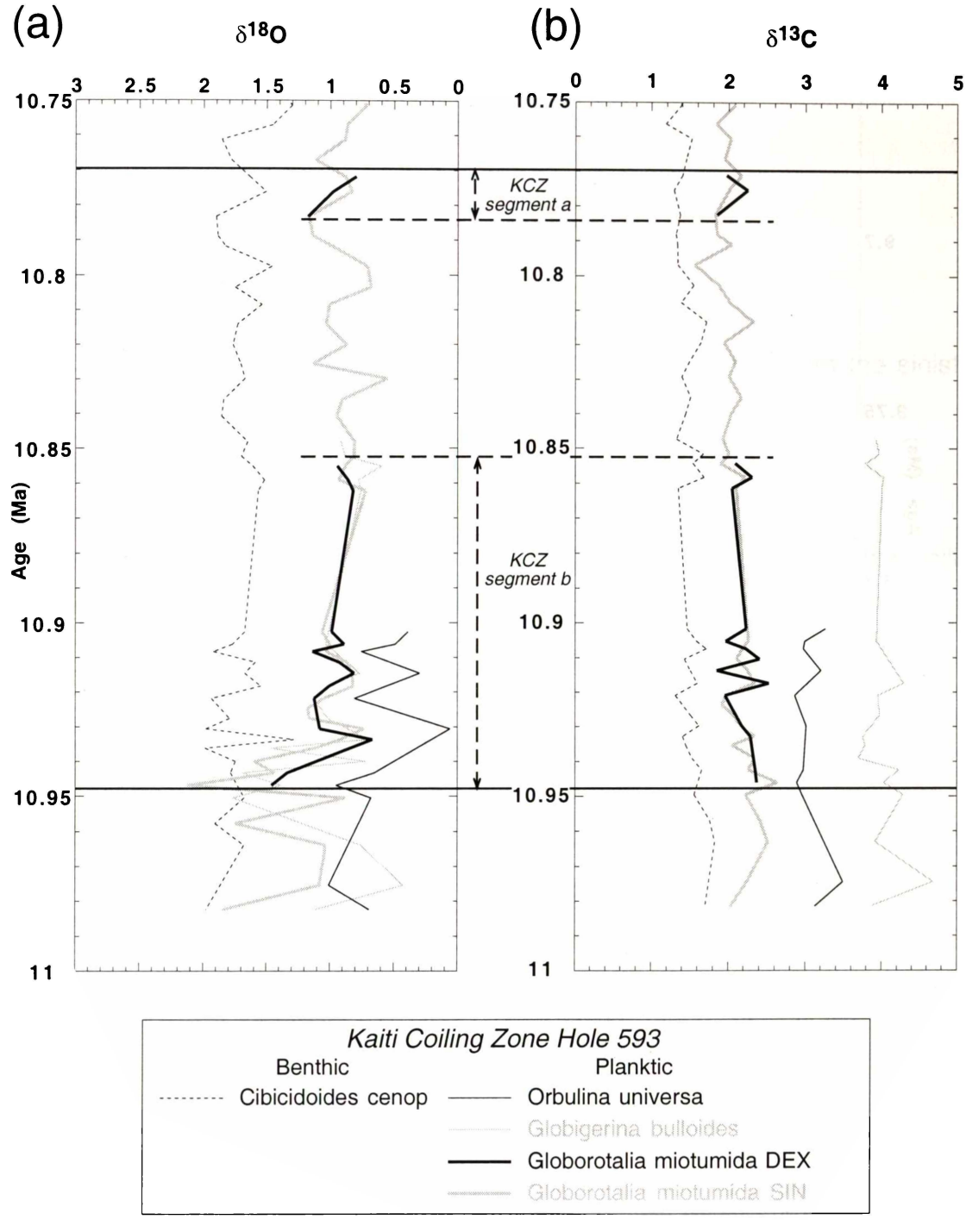


Figure 6 Detailed isotopic records for the Kaiti Coiling Zone (KCZ): (a) $\delta^{18}O$; (b) $\delta^{13}C$. This coiling zone occurs about 500 ka after the start of Mi5. KCZ exists as two segments.

Carbon

The dextral isotopic record (Fig. 6b) is either similar to the sinistral one, or slightly lighter by c. 0.2‰ than it.

Tukemokihi Coiling Zone (9.84-9.78 Ma)

This coiling zone comprises 1 continuous segment (Fig. 7).

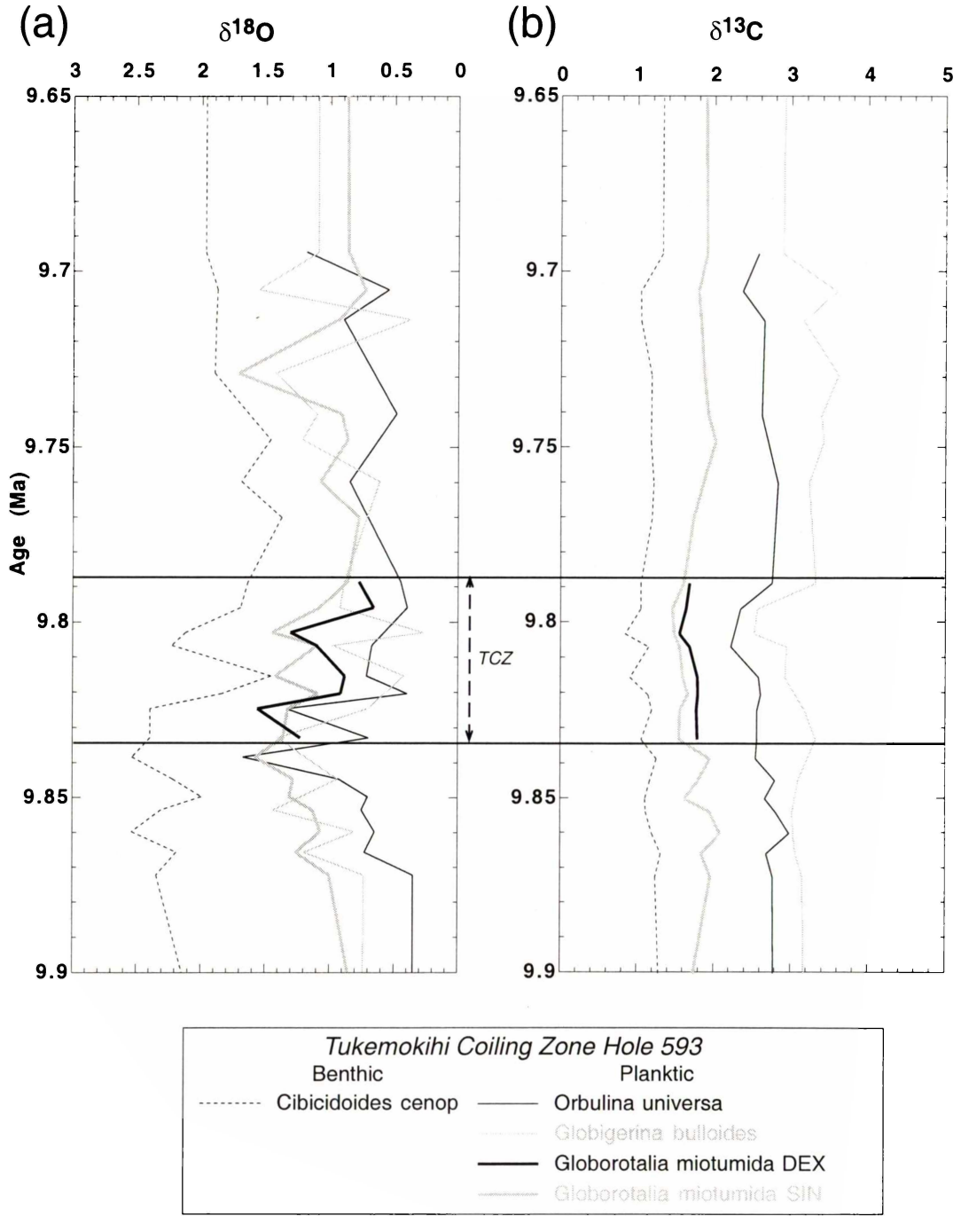


Figure 7 Detailed isotopic records for the Tukemokihi Coiling Zone (TCZ): (a) $\delta^{18}O$; (b) $\delta^{13}C$. This coiling zone occurs during and just after the enrichment event identified as Mi6. TCZ exists as one segment.

Oxygen

The dextral values are similar to the sinistral ones (Fig. 7a), but are overall up to 0.5‰ lighter, except at c. 9.83 Ma where they are c. 0.2‰ heavier. All the $\delta^{18}O$

records exhibit a 0.5-1 ‰ shift to heavier values at c. 9.82 Ma before moving back towards lighter values at c. 9.8 Ma.

Carbon

The $\delta^{13}C$ record of the dextral coiling tests (Fig. 7b) is consistently offset toward heavier values from the sinistral record by 0.1-0.2‰.

Palliser Coiling Zone (5.81-5.93 Ma)

This coiling zone comprises three segments (Fig. 8).

Oxygen

The dextral values are the same or slightly heavier by c. 0.1‰ than the sinistral values (Fig. 8a).

Carbon

The dextral values are indistinguishable from the sinistral record through this coiling zone (Fig. 8b).

0

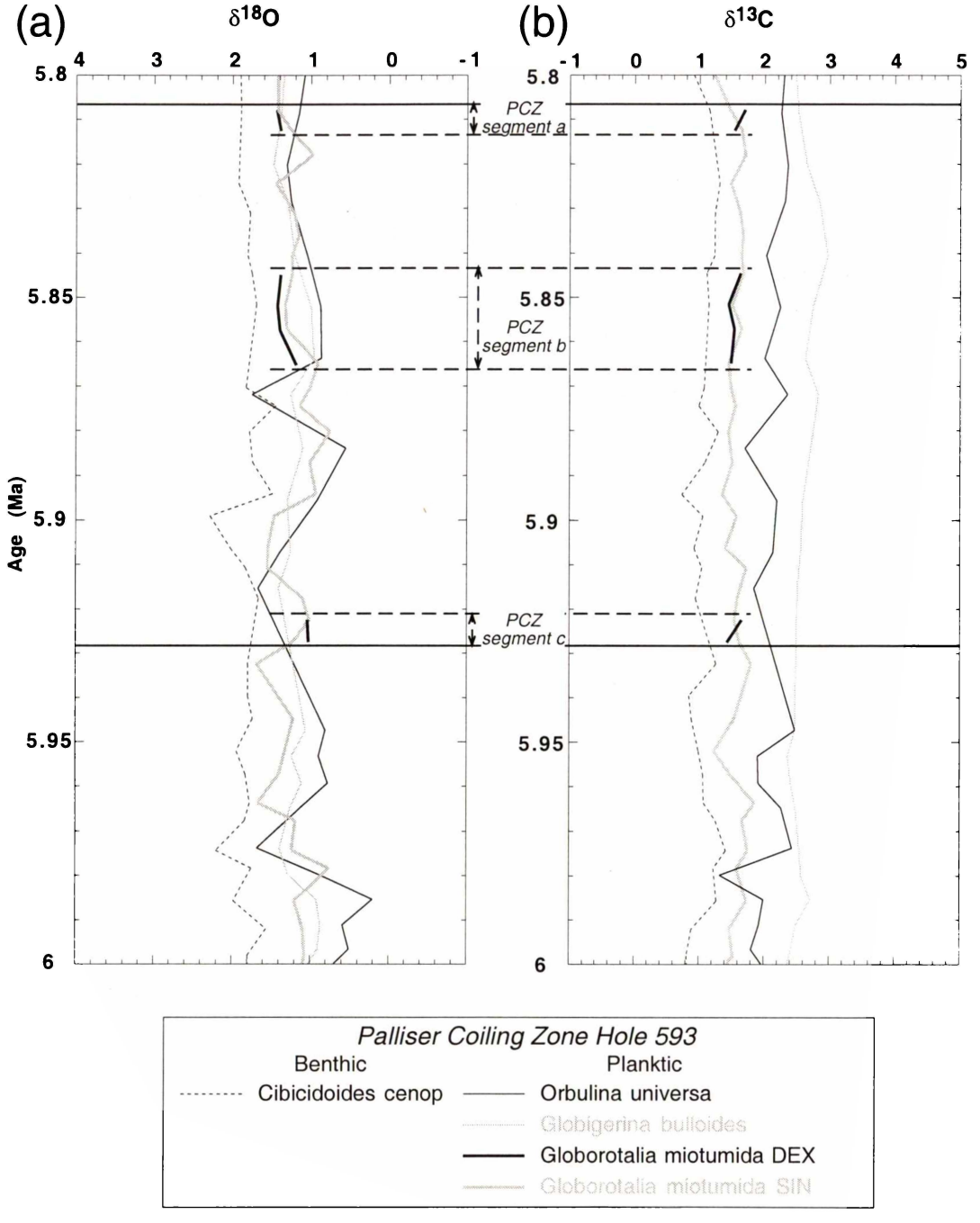


Figure 8 Detailed isotopic records for the Palliser Coiling Zone (PCZ): (a) $\delta^{18}O$; (b) $\delta^{13}C$. This coiling zone occurs about 600 ka after the SCIW cooling event, and about 200 ka after a relatively large glacial at 5.9 ka (Fig. 5). PCZ exists as three segments.

PALAEOTEMPERATURE CALCULATIONS

The relative change in $\delta^{18}O$ versus water temperature can be estimated using the equation of (Epstein et al., 1951; 1953). This indicates that c. 4°C/1‰ $\delta^{18}O$ change is reasonable, and assumes no significant salinity change and does not include ice volume effects (Kennett, 1986). Absolute palaeotemperatures can be calculated from foraminiferal calcite using the following equations: (1a) for bottom waters (after Craig, 1965); and (1b) for surface waters (after Erez and Luz, 1983 and Zachos et al., 1994),

$$T°C = 16.9-4.2(\delta^{18}O_c-\delta^{18}O_w)+0.13(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (1a)$$

$$T°C = 16.998-4.52(\delta^{18}O_c-\delta^{18}O_w)+0.028(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (1b)$$

where $\delta^{18}O_c$ = foraminiferal calcite$_{(vpdb)}$ and $\delta^{18}O_w$ = seawater $_{(vsmow)}$. For detailed explanations about the palaeotemperature equations see Chapter 3.

The $\delta^{18}O_w$ value used in these equations is dependent on the assumptions made regarding ice volume during the Late Miocene. The best estimates for $\delta^{18}O_w$ in this study (Table 3) are based on the summary presented by Feary et al. (1991), and its modifications detailed in Chapter 3. The best estimate of $\delta^{18}O_{w(vsmow)}$ for the Late Miocene is -0.43‰ (Feary et al., 1991), and this provides a starting point. The youngest age bracket values (-0.30‰ and 0.39‰) represent the modern measured values of the AAIW and CSTW in the New Zealand region, respectively, with the intervening values spaced equidistance over the time intervals used.

The palaeotemperature calculations generate estimates of mean water temperature and will therefore slightly overestimate the watermass cooling during glacials as no additional correction is included for ice volume increases. Equally, during interglacials these calculations will slightly underestimate the watermass warming as no correction is included for ice melting (Fig. 9).

Table 3. The $\delta^{18}O_w$ used for calculating palaeotemperatures for SCIW (benthic), and CSTW and SCMW (planktic). Modern measured $\delta^{18}O_w$ values, along with the Late Miocene estimated value of -0.43‰, provide 'anchor' points, with the intervening values calculated based on the age model of Feary et al. (1991). Note benthic age model uses less time intervals because the SCIW is required to make less change through the Neogene to reach the modern $\delta^{18}O_w$value.

Benthic		Planktic	
interval (Ma)	$\delta^{18}O_w$(vsmow)	interval (Ma)	$\delta^{18}O_w$(vsmow)
12-5.2	-0.43	12-6.2	-0.43
5.2-4.3	-0.37	6.2-4.3	-0.225
4.3-0	-0.30 (modern value)	4.3-3.4	-0.02
		3.4-1.6	0.185
		1.6-0	0.39 (modern value)

The palaeotemperature records for each coiling zone have been expanded in Fig. 10a-c. Through the KCZ (Fig. 10a) there is a section (c. 10.945 Ma) where planktic palaeotemperatures (except for *Orbulina universa*) appear to chill to those of the benthic record; otherwise the planktic palaeotemperatures (= sea surface palaeotemperatures SSPTs) are c. 2-3°C warmer than the benthic palaeotemperatures (= bottom water palaeotemperatures BWPTs). Through the TCZ the SSPTs are 2-5°C warmer than the BWPTs. Between the two older coiling zones the SCIW cooled by c. 2°C, from 8-10°C to 6-9.5°C. The *Globorotalia miotumida* record (inferred to be representative of the thermocline or SCMW) also cools between these two coiling zones, from 10-12°C to 8-11°C. Through the PCZ both surface and intermediate waters maintain the range of palaeotemperatures reached during the TCZ.

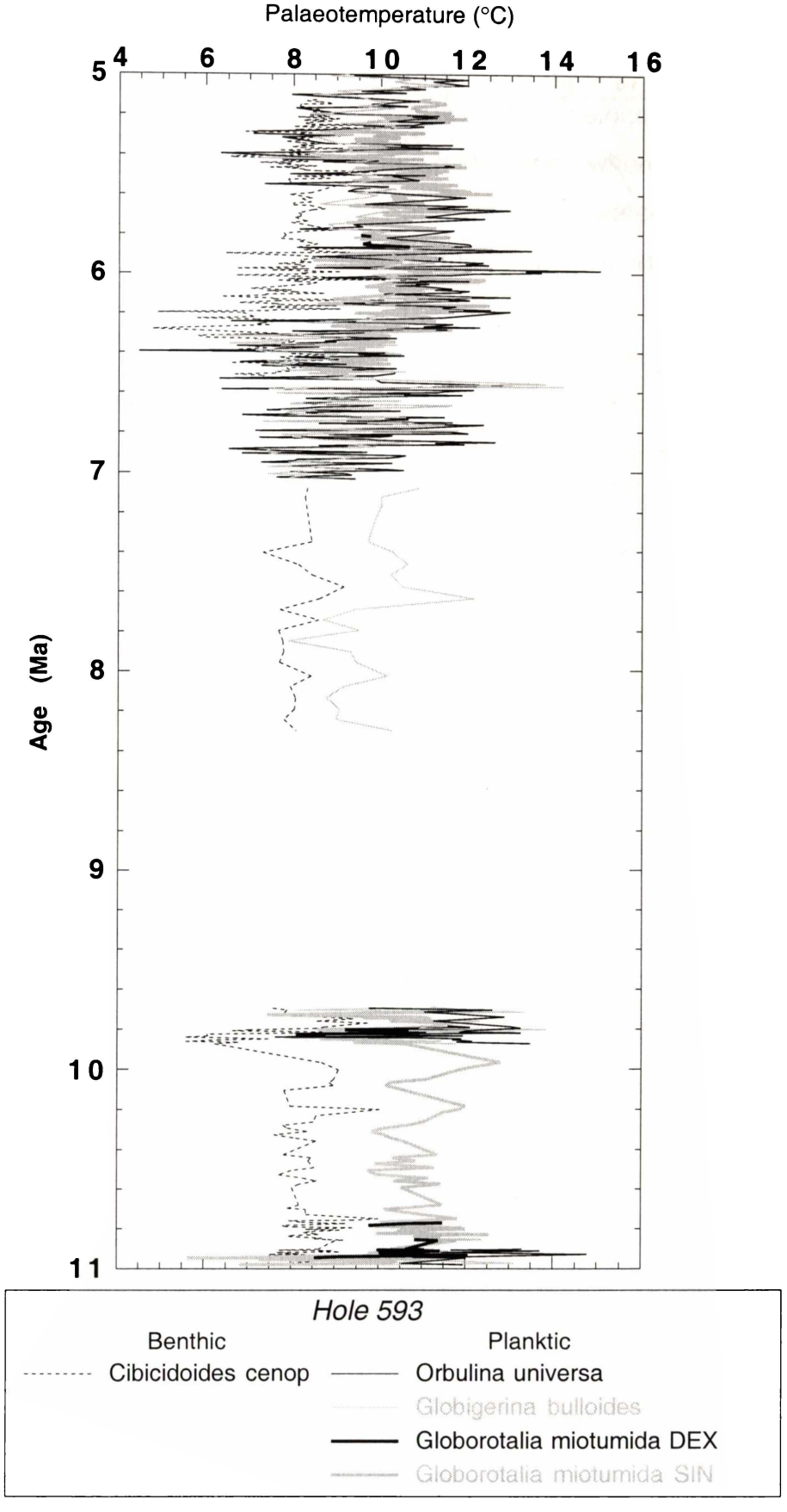


Figure 9 Palaeotemperature curves for the Late Miocene section of Hole 593, calculated using $\delta^{18}O_w$ values defined in Table 3. An A3 version is provided at the end of the chapter.

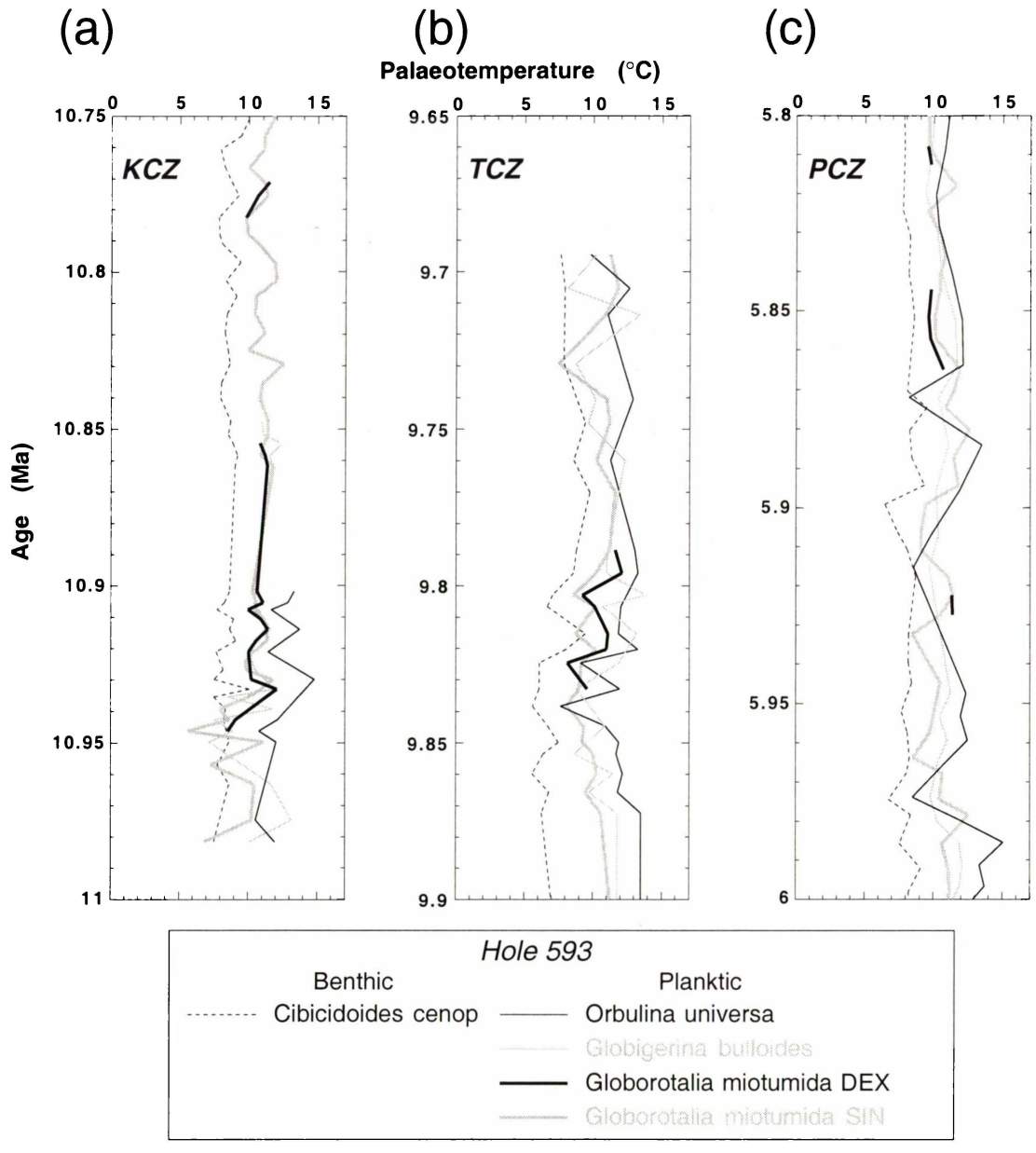


Figure 10 Expanded palaeotemperature records for all three coiling zones: (a) KCZ; (b) TCZ; (c) PCZ.

DISCUSSION

The lack of a significant difference in the $\delta^{18}O$ values between the co-occurring dextral and sinistral *Globorotalia miotumida* throughout all three coiling zones is interpreted as indicating that the coiling morphotypes do not reflect separate thermal watermass origins. In particular, that the dextral individuals have not accumulated the bulk of their calcite in significantly warmer waters and therefore do not appear to have been transported into the southern Tasman Sea via a warmer/tropical watermass.

The relative position of the *Globorotalia miotumida* $\delta^{18}O$ records (sin and dex), below those of *Orbulina universa* and *Globigerina bulloides*, and above that of *Cibicidoides cenop*, supports the contention that this extinct species was a deep-dwelling planktic foraminifera. This agrees with conclusions reached by others using *Globorotalia conoidea* (= *Globorotalia miotumida*), where $\delta^{18}O$ values were heavier than those of *Orbulina universa*, and were interpreted as indicating that globoconellids lived in deeper water than O. *universa* (Savin et al., 1985; Norris et al., 1994; Schneider and Kennett, 1996). Through the coiling zones the difference in $\delta^{18}O$ between *Orbulina universa* (surface mixed layer) and *Globorotalia miotumida* (within the permanent thermocline) is c. 0.5‰ (extremes 0 to c. 0.8‰) or up to c. 2.8°C. It is therefore inferred that *Globorotalia miotumida* secreted most of its calcite in water at least 2°C (0.5‰) cooler than the surface mixed layer. This thermal difference is about the same as the nearest modern comparison between *Globorotalia inflata* and *Globigerinoides sacculifer* (Norris et al., 1994). Seasonality (i.e., the difference between summer and winter surface water temperatures) is unlikely to have been more extreme during the Late Miocene compared with modern conditions, as the latitudinal climatic gradients have generally increased since the Middle Miocene (e.g., Kennett and von der Borch, 1986b; Wright et al., 1991; Flower and Kennett, 1995) and therefore can be ruled out to explain this difference.

The cooling evident in the TCZ planktic records just prior to the coiling zone is not as evident in the benthic record, which suggests that the surface watermasses were cooling and that the change cannot be ascribed to ice volume alone (which would cause both records to covary). If this cooling was the result of upwelling where cool, ^{12}C-rich water is brought to the surface and incorporated into foraminiferal calcite (Berger and Vincent, 1986), then the planktic $\delta^{13}C$ would be expected to exhibit depletion. This is not evident in the TCZ records (Fig. 7). Through the TCZ all the $\delta^{18}O$ records exhibit depletion, with correspondingly warmer temperatures of up to c. 14°C, especially associated with the surface *Orbulina universa* record.

Independently of the palaeotemperature calculations, an estimate of the effect of ice volume is possible as the difference of 0.9‰, between modern mean ocean $\delta^{18}O_w$ at -0.28‰ vpdb, and the estimated ice free mean ocean $\delta^{18}O_w$ at -1.2‰ vpdb, represents the modern ice volume contribution to the mean ocean $\delta^{18}O_w$. If it is

assumed that intermediate waters cannot have been significantly colder than modern without increasing the volume of ice (see Miller et al., 1987, 1991). When 0.9‰ is deducted from the modern *Cibicidoides*-equivalent benthic foraminiferal calcite value of 2.55‰ (Nelson et al., 1994), the difference (1.65‰) represents a guide to the foraminiferal calcite values versus ice volume (i.e., values heavier than 1.65‰ indicate ice volume increases in excess of modern). Therefore where the Late Miocene Hole 593 $\delta^{18}O$ benthic curves exceed 1.65‰ (i.e., for most of the record), the calculated palaeotemperature of the SCIW is likely to be too cold, as a part of the excess will be ice volume. The amount of the overestimate is realistically too difficult to determine (see Chapter 3).

The degree of offset in the TCZ carbon records between the two morphotypes suggests that the dextral form was secreting its calcite in water which was slightly more enriched in ^{12}C (Fig. 7b). The other two coiling zones do not exhibit a consistent $\delta^{13}C$ offset. Within both the KCZ and PCZ the dextral values are up to 0.2‰ more depleted than the sinistral ones in parts of the record but c. 0.2‰ more enriched in others. A possible explanation for the TCZ $\delta^{13}C$ offset is a shallower secretion depth for the dextral population, which is not reflected in a large change in water temperature. As there appears to be little difference in the water temperature inferred for calcite secretion between the sinistral and dextral forms of *Globorotalia miotumida*, but the carbon isotopic evidence hints at the dextral forms secreting calcite nearer the surface waters, this suggests that the surface watermass(s) above the permanent thermocline were relatively isothermal but well stratified. Modern Tasman Sea surface watermasses become relatively isothermal during winter due to the breakdown of the seasonal thermocline (see Chapter 1 for more physical oceanographic detail). The sectional nature of the other two zones (KCZ and PCZ) may reflect fluctuating oceanic changes.

Palaeocirculation vs. permanent thermocline

Any change to either the geographical area of cooling (ice) or heating (Pacific warm pool) will affect the meridional temperature gradient (Woodruff et al., 1981). Redistribution of heat energy occurs via atmospheric air masses and oceanic currents. Roughly two-thirds to half of the modern excess heat received at low latitudes is transported towards the polar regions as sensible atmospheric heat, and

the remaining one-third is transported by the ocean currents (Barry and Chorley, 1987; Gasperi and Kennett, 1993b). Therefore, during glacials the meridional gradient would have increased. In addition, Cenozoic tectonic changes, such as increasing restriction of the Indonesian gateway, have resulted in Pacific-wide circulation changes and therefore changes in the heat distribution (Kennett et al., 1975, 1985; Kennett and von der Borch, 1986b). During the Miocene, the SCIW reached its coldest palaeotemperatures (<6°C; this study see Chapter 3) between 11 and 9 Ma, also noted by Kennett (1986) in other Lord Howe Rise sites, coinciding with the glacials Mi5 and Mi6 of Miller et al. (1991). This climatic cooling has been linked to deep water cooling as a result of East Antarctic Ice Sheet (EAIS) expansion, then West Antarctic Ice Sheet (WAIS) development (Shackleton and Kennett, 1975; Woodruff and Savin, 1989, 1991; Wright et al., 1991, 1992), resulting in an increase in SCW sources (Flower and Kennett, 1995).

During the glacials, contraction of the Hadley Cell atmospheric circulation might reasonably be expected to 'pull' the TF and STF northwards. Cooling/expansion of the antarctic zone would 'push' the STF northwards, resulting in changes to the position of the fronts and the depth of the thermocline relative to Site 593. There is however, no microfaunal nor isotopic evidence to indicate the STF migrated as far north as Site 593 (Kennett and von der Borch, 1986b; this study). Cooling of the SCIW is evident because the Late Miocene SCIW *Cibicidoides cenop* palaeotemperature record at 9-8°C is 1.5°C warmer than modern AAIW. Hence SCIW has probably cooled by at least 1.5°C over the last 5 Ma. The *Globorotalia miotumida* records are interpreted to reflect Late Miocene SCMW palaeotemperatures, which where warmer than modern SAMW by up to 4°C. However, the Late Miocene SCMW cooled by 1.5°C between 11-5 Ma to reach modern SSTs (9-8°C for SAMW). Hence the mode water had reached modern temperatures by 5 Ma, while the intermediate waters continued to cool through the Pliocene. For more detailed discussion of the temperature records through the Miocene see Chapter 3.

Based on the palaeotemperatures, it appears that it was the SCMW which was most affected by the Late Miocene oceanic changes (Fig. 9 and 10). Assuming the permanent thermocline was located between the mode and intermediate waters, it

seems reasonable that the permanent thermocline depth may have fluctuated. Hence any foraminiferal reproduction influenced by the thermocline would also be affected. Changes in the Late Miocene oceanic thermocline have been recorded in other sites from the region. Through the Late Miocene interval of Hole 289 (western equatorial Pacific) the $\delta^{18}O$ depth stratification of planktic foraminifera was interpreted as reflecting a well developed permanent thermocline (Gasperi and Kennett, 1993a, b). Similarly, in the Gippsland Basin, off southeastern south Australia, palaeoenvironmental interpretation of the shelf/slope faunas younger than 14.5 Ma indicate the ocean system became more vertically stratified (gradients became more extreme) with a well developed thermocline (Gallagher et al., 2001). Closer to Site 593, the early Middle Miocene upslope migration of several benthic foraminiferal assemblages between Holes 206, 590, and 591 has been interpreted as due to an increase in the volume deeper watermasses along the eastern Lord Howe Rise (Kurihara and Kennett, 1986, 1992). The consequence of this volume change be the shallowing of the permanent thermocline, with the increase in watermass volume related to expanding antarctic ice sheets (Kurihara and Kennett, 1986, 1992).

Thermocline control on coiling direction

Using the ventilated thermocline model of Luyten et al. (1983a, b), and assuming the ocean structure was similar to the modern situation with the thermocline boundary between the mode water and intermediate water (or rather their Late Miocene equivalents, SCMW and SCIW), fluctuations in the thermal regime around Antarctica will affect the depth of this boundary. As cooling increased, the base of the permanent thermocline would be forced towards the surface as the volume of Antarctic-derived watermasses increased (Fig. 11a). Something similar is seen in the North Atlantic during the LGM where glacial thermocline waters were cooler with a steeper temperature gradient, and the base of the thermocline was shallower (Slowey and Curry, 1992).

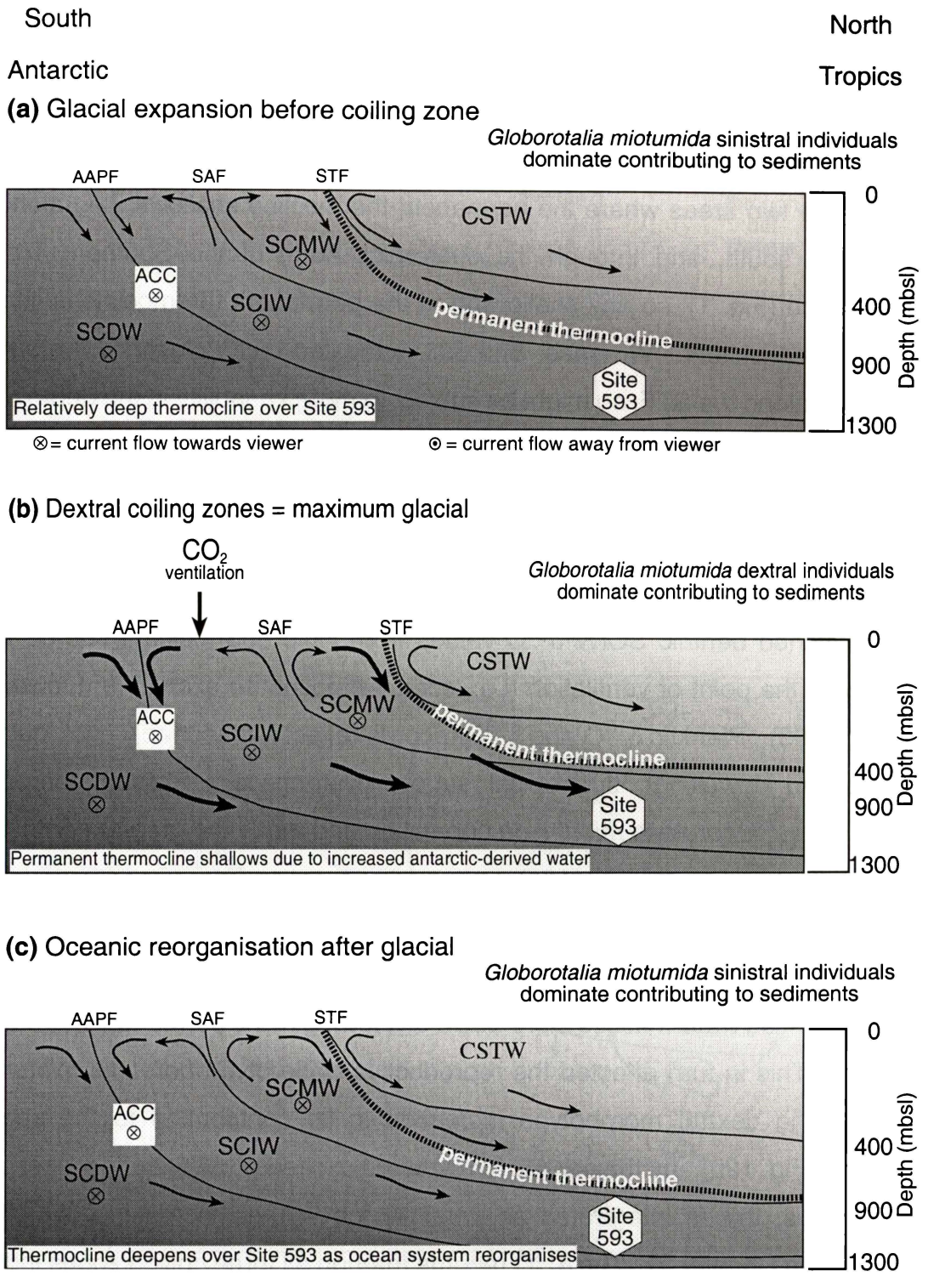


Figure 11 Palaeoceanographic model which may explain the ocean system control on coiling direction dominance in *Globorotalia miotumida* from Hole 593. (a) During Mi glacials increased Southern Component watermass volumes push the permanent thermocline towards the surface; (b) at the maximum extent the permanent thermocline is shallowest, up to 500 ka after the start of the glacial; (c) oceanic thermal reorganization after the extreme Mi glacials results in deepening of the permanent thermocline. A version on A3 is provided at the end of the chapter.

The regional nature of the Late Miocene coiling zones, extending as far north as Site 590 (at approximately 35°S palaeolatitude), is interpreted as indicating that in the

Tasman Sea the extent of antarctic-derived water and its affect on the thermocline spread at least as far north as this site. The Site 590 coiling zone comprises very high dextral numbers throughout (Scott, 1995) and might indicate an consistently shallow thermocline over this site during the coiling zone. Equally, Site 590 is located along the eastern margin of the Lord Howe Rise at c. 1300 m water depth between the two areas where the permanent thermocline shallows, i.e., along the STF to the south, and through the subtropics north of the Southern Tropical Convergence (Fig. 1), so any shallowing of the permanent thermocline is likely to have been consistent. Whereas, Site 593 is located much closer to the surface expression along the STF, so might be subject to more variability in the depth of this oceanic feature.

During the Mi5 and Mi6 glacials, and the SCIW cooling event (Fig. 5), the circulation system would be at equilibrium, with the main ocean thermocline ventilated at the STF. Enriched benthic SCIW $\delta^{13}C$ values from Hole 593 indicate source water proximity to the point of ventilation (i.e., ocean-atmosphere exchange; Flower and Kennett, 1995). Planktic $\delta^{18}O$ and $\delta^{13}C$ records reflect a reasonably cool, nutrient-depleted (no upwelling), subtropical surface watermass. Sinistral individuals dominate the *Globorotalia miotumida* population and make the greater contribution to the seafloor sediments (Fig. 12a).

As ice accumulated, and the thermal gradient increased with the expansion of antarctic-derived watermasses there was a shallowing of the permanent thermocline (Fig 11b). This in turn affected the reproductive cycle of *Globorotalia miotumida*, such that the dextral morphotype increased in its contribution to the seafloor sediments (Fig. 12b). As the benthic $\delta^{18}O$ record exceeds 1.65‰ during most of the coiling zones, this is interpreted as antarctic ice volume increasing over these intervals (see Chapter 3). The $\delta^{13}C$ records through all three coiling zones indicate the southern Tasman Sea was well stratified during the Late Miocene. Through the KCZ and PCZ, the dextral *Globorotalia miotumida* record indicates very little difference in the stratification of the coiling morphotypes. However, through the TCZ the dextral $\delta^{13}C$ record is consistently heavier, with the inference that it secreted its calcite shallower in the water column. The segmented nature of the KCZ and PCZ may indicate slight instability in the thermocline through these zones.

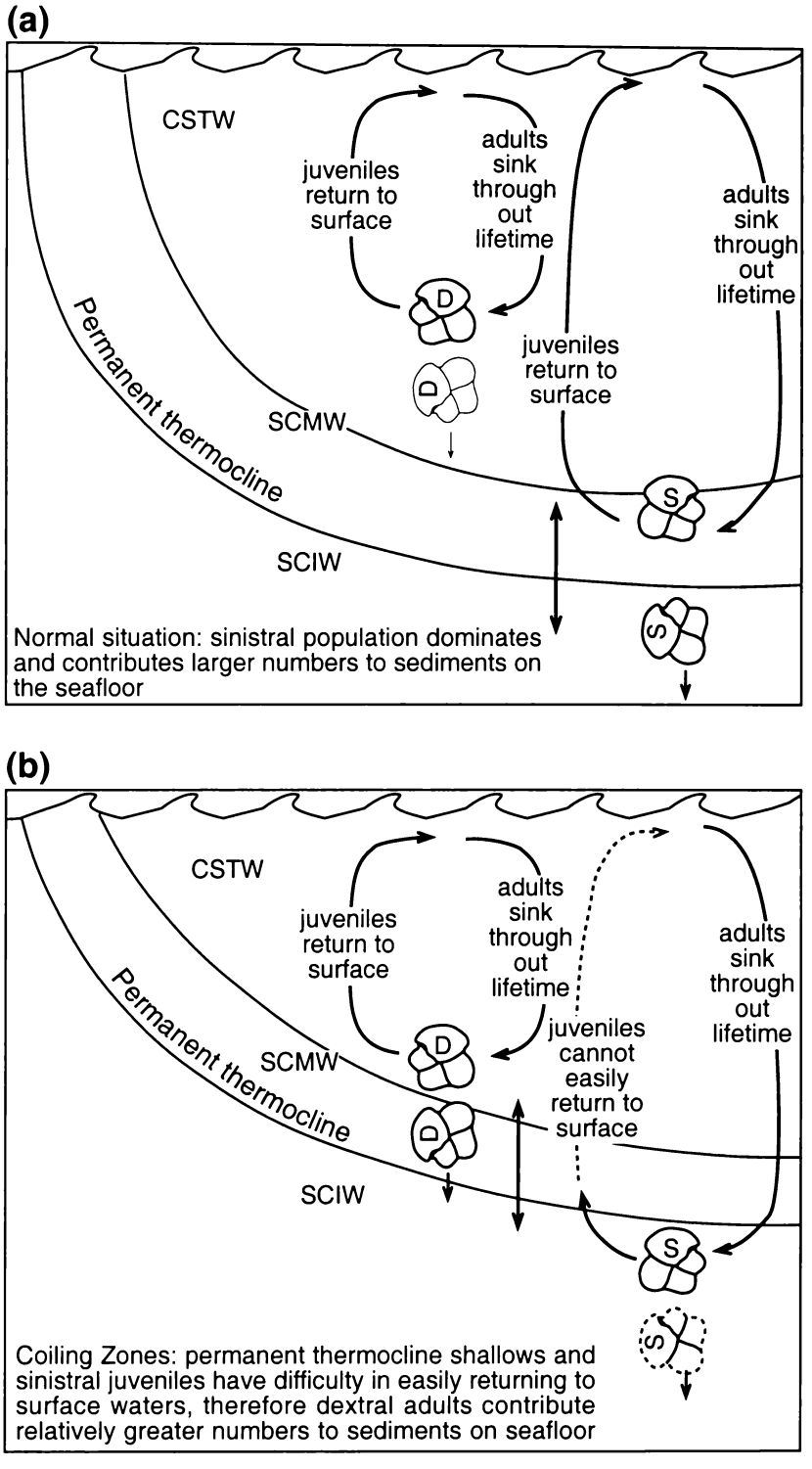


Figure 12 Possible reproductive strategy in response to palaeoceanographic changes (Fig. 11) for *Globorotalia miotumida* in the Late Miocene of Hole 593. (a) With a deep permanent thermocline, the sinistral population is the dominant contributor to the seafloor sediments; (b) as the permanent thermocline shallows, juvenile sinistral *Globorotalia miotumida* have difficulty in returning (in large numbers) to the surface waters, and so the dextral population contribution to seafloor sediments increases significantly.

After each of the Mi6 and Mi5 glacial events, subsequent oceanic stabilisation and slight climatic warming (Kennett, 1986; Miller et al., 1987, 1991) resulted in the thermocline adjusting to the lop-sided nature of the ocean thermal gradient at the

time (i.e., as there was no large volume of ice in the Arctic, the Inter-Tropical Convergence Zone, now at c. 5°N, may possibly have been even further north (Flohn, 1978; Tomczak and Godfrey, 1994; Flower and Kennett, 1995)). As the thermocline deepened the coiling dominance returned to sinistral (Fig. 11c). The coiling zones occur near the end of the glacials and this may reflect the thermal inertia of the oceanic system reaching a critical threshold, then moving the permanent thermocline as this threshold is crossed.

CONCLUSIONS

Hole 593, located in the southern Tasman Sea, is overlain by Cool Subtropical Water and Antarctic Intermediate Water, and as the depth to the seafloor has not changed through the Neogene, this is likely to have been the case during the Late Miocene. Benthic foraminiferal isotopic data record Southern Component Intermediate Water through the Neogene, and the planktic foraminiferal records are interpreted as Neogene Cool Subtropical Water (very similar to modern). Therefore any palaeoceanographic changes must be due to circulation and environmental conditions, and not to water depth changes over the site. One significant palaeoceanographic boundary which is predicted to have changed is the relative position of the permanent thermocline. The isotopic record from the planktic foraminifera Globorotalia *(Globoconella) miotumida* has been interpreted as recording conditions in the Southern Component Mode Water, a watermass located just above the base of the permanent thermocline in the Pacific Ocean.

The dominant coiling direction in *Globorotalia (Globoconella) miotumida* is sinistral (Fig. 4). There are three intervals in the Late Miocene of Hole 593 (and also several onland sections), where the numbers of dextral individuals increases, to levels described as a dextral coiling zone. These are the Kaiti, Tukemokihi, and Palliser Coiling Zones. If the coiling direction was controlled by oceanic physiochemical changes, such as water temperature, then the mode water record from *Globorotalia (Globoconella) miotumida* would be expected to show this, and it does not.

The $\delta^{18}O$ records of the dextral individuals through all three coiling zones does not appear significantly different to the sinistral records (Figs. 5-8). This suggest that the opposing coiling directions in *Globorotalia miotumida* cannot be simply ascribed

to water temperature (Fig. 10) or obvious salinity differences in the growth habitat of the two morphotypes. Southern Component Mode Water palaeotemperatures are around 8-12°C and reflect a wider thermal range than modern Subantarctic Mode Water at 8-9°C. Consequently, the coiling directions are not interpreted as ecophenotypes with respect to water temperature.

However, coiling direction is likely to reflect climatic changes as these affect the permanent thermocline which may explain the apparent coincidence of sinistral coiling associated with Late Miocene glacials, Mi5 and Mi6.

The $\delta^{13}C$ records from both the Tukemokihi and Kaiti Coiling Zones (Figs 5-8) hint at some depth stratification between coiling directions because the dextral $\delta^{13}C$ values are c. 0.2‰ heavier (through the whole Tukemokihi Coiling Zone, and parts of the Kaiti Coiling Zone). This may indicate a dextral-population depth habitat closer to the zone of ^{13}C enrichment in surface waters, and therefore calcite secretion shallower in the water column than for the sinistral form.

Irrespective of coiling direction, the $\delta^{18}O$ and $\delta^{13}C$ records for *Globorotalia miotumida* indicate a depth habitat for the composite calcite secretion that was deeper than the surface-dwelling planktic foraminifera *Globigerina bulloides* and *Orbulina universa*, but not as deep as the Southern Component Intermediate Water-bathed benthic *Cibicidoides cenop* (Fig. 5).

A model for inferring depth-permanent thermocline controlled reproductive strategy in *Globorotalia miotumida* is based on the *Globorotalia truncatulinoides* data of (Lohmann and Schweitzer, 1990; Lohmann, 1992, 1995), where coiling direction can be linked to reproductive strategy, and the depth of the permanent thermocline (Fig. 11 and 12).

The dextral coiling zones may correspond with changes in regional circulation patterns associated with glacial Mi events (Kaiti Coiling Zone = Zone Mi5; Tukemokihi Coiling Zone = Zone Mi6; Palliser Coiling Zone = Kapitean Southern Component Intermediate Water cooling event, and unnumbered glacial). It is inferred that these glacials/cooling events would result in a shallowing of the

permanent thermocline, which in turn would affect the reproductive success of the sinistral coiling individuals.

The Palliser Coiling Zone expression (three very short dextral coiling excursions within the zone) makes comparison difficult given the resolution of the sampling interval (Fig. 8). Hence, increasing the sampling density through all the coiling zones may generate better records, but is unlikely to significantly alter the general trends.

Correlation of coiling direction with water temperature of calcite secretion in *Globorotalia miotumida* does not follow a latitudinal, right-coiling/warmer system, but probably a right-coiling/shallower permanent thermocline and therefore slightly warmer system. With the dextral population isolated from the sinistral one, restriction of the reproduction of sinistral adults resulted in greater dextral contribution for relatively short periods of time when ocean reorganisation shallowed the thermocline. Consequently, the coiling direction changes are linked to a combination of climatic and palaeocirculation changes (Figs. 11 and 12).

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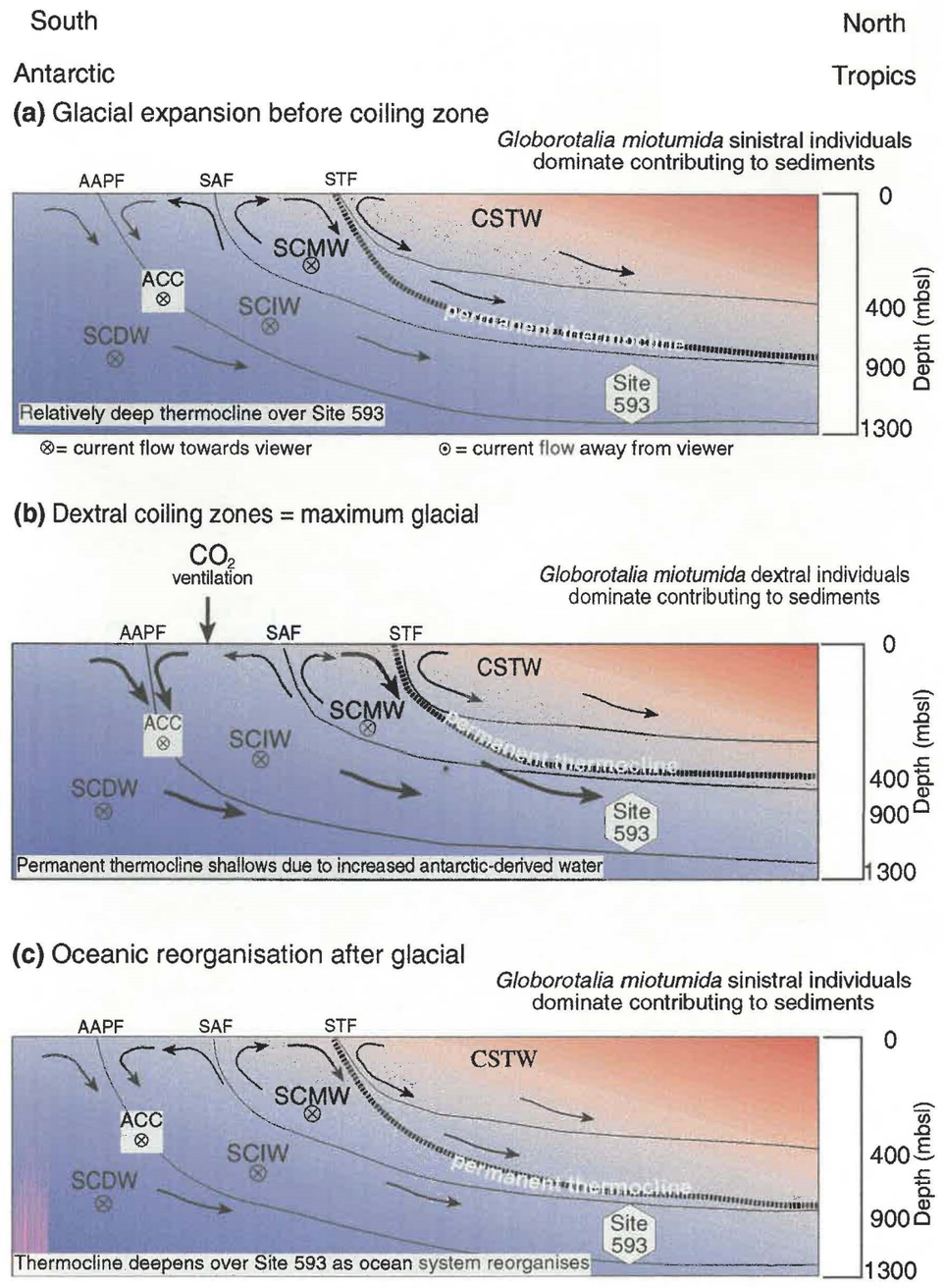
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Chapter 4

Figure 11. Palaeoceanogaphic model which may explain the ocean system control on coiling direction dominance in *Globorotalia miotumida* from Hole 593. (a) During Mi glacials increased Southern Component watermass volumes puch the permanent thermocline towards the surface; (b) at the maximum extent the permanent thermocline is shallowest up to 500 ka after the start of the glacial; (c) oceanic thermal reorganisation after the extreme Mi glacials results in deepening of the permanent thermocline.

Chapter 5

Bolboforma As Monitors Of Cenozoic Palaeoceanographic Changes In The Southern Ocean

We recommend a concerted effort to further document the nature and distribution of Bolboforma.

Poag and Karowe (1986)

Bolboforma as monitors of Cenozoic palaeoceanographic changes in the Southern Ocean

ABSTRACT

Bolboforma distribution in space and time is analysed from a circum-Antarctic belt of lower Eocene to uppermost Miocene sediments from DSDP/ODP sites in the Southwest Pacific, Southeast Pacific (Bellinghausen Basin), Maud Rise and South Atlantic, and Indian Ocean (Kerguelen Plateau). A correlation panel using the established Cenozoic planktic foraminiferal and calcareous nannofossil zonations is linked to the Bolboform zonation scheme for the Southern Ocean. Evolution of surface watermasses and their boundaries, the major oceanic fronts, are tracked using the microfossil distributions and general sediment characteristics, and are in turn linked to the *Bolboforma* distribution. Specifically, the migration of both the Antarctic Polar Front and Subtropical Front northwards from continental Antarctica, starting in the earliest Oligocene and culminating in the Late Miocene establishment of 'modern' conditions, links the bolboforms in the Southern Ocean with subantarctic watermass conditions between the equivalent of today's Subantarctic and Subtropical Fronts.

The occurrence of bolboforms in sediments including subtropical microfossil assemblages from north of the subtropical front, as in the Tasman Sea, is anomalous. Therefore it is suggested that they were transported into the region by subsurface (intermediate depth) waters generated by subduction of subantarctic surface water at southern oceanic fronts. The distribution of bolboforms more widely outside the Southern Ocean may define the pathways of Southern Component Intermediate Water (Antarctic Intermediate Water) during the Tertiary, and account for their bipolar distribution. Bolboforms exhibit a circum-Antarctic distribution prior to the development of a full circum-Antarctic circulation system following the opening of both the Tasmanian and Drake gateways. It is inferred that a West Antarctic Seaway between the Ross Sea and Weddell Sea embayments may have afforded oceanic connection between the Southwest Pacific and the southern Atlantic during the Eocene-Oligocene, facilitating dispersal and such a distribution.

INTRODUCTION

In the course of documenting Tertiary benthic foraminifera from DSDP Hole 593 (Leg 90) in southern Tasman Sea, Boersma (1986) mentioned the presence of radiolarians in the Late Miocene section of the core and used their occurrence to infer palaeoceanographic changes in the Tasman Sea. In contrast, radiolarians were not reported by Caulet (1986) in his general overview of this microfossil group from Leg 90 sites. During this study of upper Miocene microfaunal assemblages from Hole 593, acid dissolution showed that the radiolarians noted by Boersma (1986) were in fact calcareous, not siliceous, and subsequently a radiolarian specialist confirmed they were not radiolarians (C. Hollis, pers. comm.,1997). While viewing SEM images of these 'problematic' microfossils, A. Edwards (pers. comm., 1997) suggested that they appeared like *Bolboforma*, an identification subsequently confirmed by D. Spiegler, a bolboform specialist. Misidentification of this group of calcareous microfossils may be applicable to other micropalaeontological studies where, due to their simple form, size, and often highly ornamented tests, bolboforms can be mistakenly identified as either radiolarians or simple unilocular benthic foraminifera (Spiegler and von Daniels, 1991). The first descriptions of *Bolboforma*, were as benthic foraminifera, namely *Lagena costairregularis* (Toering and van Voorthuysen, 1973), *Lagena metzmacheri* (Clodius, 1922), and *Lagena pisiformis* (Margerel, 1968).

Nature of bolboforms

Bolboforma was introduced by von Daniels and Spiegler (1974) as a genus of *incerate sedis* belonging to a group of problematic marine protozoans, although the subsequent finding of encapsulated tests suggested a close affinity with marine protophytes (Spiegler, 1987). Bolboforms probably represent dormant protophyte cysts formed after the vegetative life phase (Spiegler and Erlenkeuser, 2001). However, Kennett and Kennett (1990) have questioned why marine phytoplankton would produce resting cysts as part of their life cycle, which then sink to depths of over 2000 m in the open ocean, out of the photic zone. Hence the classification of this group remains uncertain. To date they have only been found in marine sediments.

Bolboform tests generally consist of hollow, single spheroidal or subspheroidal chambers composed of monocrystalline low-Mg calcite (von Daniels and Spiegler, 1974). They have a simple aperture surrounded by a short neck or collar. Surface morphology ranges from smooth to highly ornamented, with spines, knobs, reticulations, ribs, ridges, and flanges. Several bolboform species are known to encapsulate a smaller chamber within the exterior test, with rare bi-chambered test being observed (D. Spiegler, pers. comm, 2000). Test sizes range from 70-250 µm, although most specimens are <150 µm. Most studies have used the >63 µm fraction to check for bolboforms (Kennett and Kennett, 1990; Spiegler, 1991; Mackensen and Spiegler, 1992; Grützmacher, 1993; Crundwell et al., 1997). Selected images of several Middle to Late Miocene *Bolboforma* are presented in Appendix D.

Global occurrence of bolboforms

Globally, the *Bolboforma* age distribution extends from Early Eocene to Late Pliocene. In the Southern Ocean region the distribution is from the Early Eocene (c. 53 Ma) on Campbell Plateau (Grützmacher, 1993; Berggren et al., 1995) and the Middle Eocene (c. 46-44 Ma) on Maud Rise (Kennett and Kennett, 1990; Spiegler, 1991) to the Early Pliocene (c. 3.9 Ma) on Kerguelen Plateau (Mackensen and Spiegler, 1992). In the North Atlantic the youngest record was also Early Pliocene (Poag and Karowe, 1986; Qvale and Spiegler, 1989) until a recent find at 2.84 Ma by Spiegler (1999) from Hatton-Rockall Basin. *Bolboforma* have not been recorded in Quaternary sediments anywhere to date. The greatest diversity and number of species occur during two time intervals, namely the Late Eocene-Early Oligocene, and in the Middle-Late Miocene (Kennett and Kennett, 1990; Spiegler and von Daniels, 1991; Mackensen and Spiegler, 1992; Grützmacher, 1993; Crundwell et al., 1997). Their distribution appears to be broadly bipolar and they occur most commonly in sediments interpreted to have originated in cool waters at mid to higher latitudes (Poag and Karowe, 1986; Spiegler and von Daniels, 1991; Crundwell et al., 1997). They appear resistant to dissolution and exhibit good preservation in sediments where planktic foraminifera otherwise indicate damage due to corrosive bottom waters (Müller et al., 1985).

Aim of this study

The catalyst for studying the bolboforms at Site 593 has been two-fold: one, to ascertain their potential for improving biostratigraphic subdivision within the Late Miocene of the Southwest Pacific region (Crundwell et al., 1997; Crundwell, in prep.), and the other to attempt to better understand the palaeoceanographic significance of the bolboform distributions in the deposits, which is addressed here. Some previous studies at Southwest Pacific sites (e.g., Poag and Karowe, 1986; Grützmacher, 1993) have suggested an ecological preference of bolboforms for cool subtropical or temperate conditions. However, their occurrence in middle-upper Miocene sediments from subantarctic Hole 594 southeast of New Zealand, considered in light of the migration history of the New Zealand subcontinent through the Cenozoic (King et al., 1999; King, 2000), necessitates reconsideration of their palaeoenvironmental implications. Here the possibility is explored that the circum-antarctic distribution of *Bolboforma* is linked to the Cenozoic (they are reported from both Palaeogene and Neogene sections from around Antarctica) development of Southern Ocean palaeoceanography, and specifically to the evolution and migration of oceanic fronts that bound the subantarctic watermass.

MODERN WATERMASSES AND OCEANIC FRONTS

In the modern Southern Ocean, surface watermasses are divided by oceanic fronts and underlain by characteristic sediment facies (Figs. 1 and 2). The Antarctic Polar Front (AAPF) forms the boundary between subantarctic and antarctic conditions and lies within the Antarctic Polar Front Zone (AAPFZ) (see Chapter 1). The Subtropical Front (STF) separates surface waters of tropical origin from those of antarctic origin. The AAPFZ supports high surface-water biosiliceous productivity, which is reflected in the mainly diatomaceous siliceous sediments beneath it, the so-called 'diatom belt' (Burckle and Cirilli, 1987; Westall and Fenner, 1991). The northern boundary of this zone, marked by the Subantarctic Front (SAF; Belkin and Gordon, 1996), corresponds with the 8°C surface isotherm (Burling, 1961; Edwards and Emery, 1982) and divides the watermasses into cool subantarctic surface water (Circumpolar Surface Water - CSW) south of the SAF, and warm subantarctic surface water (Subantarctic Surface Water - SASW) between SAF and the STF (Edwards and Emery, 1982; Heath, 1985).

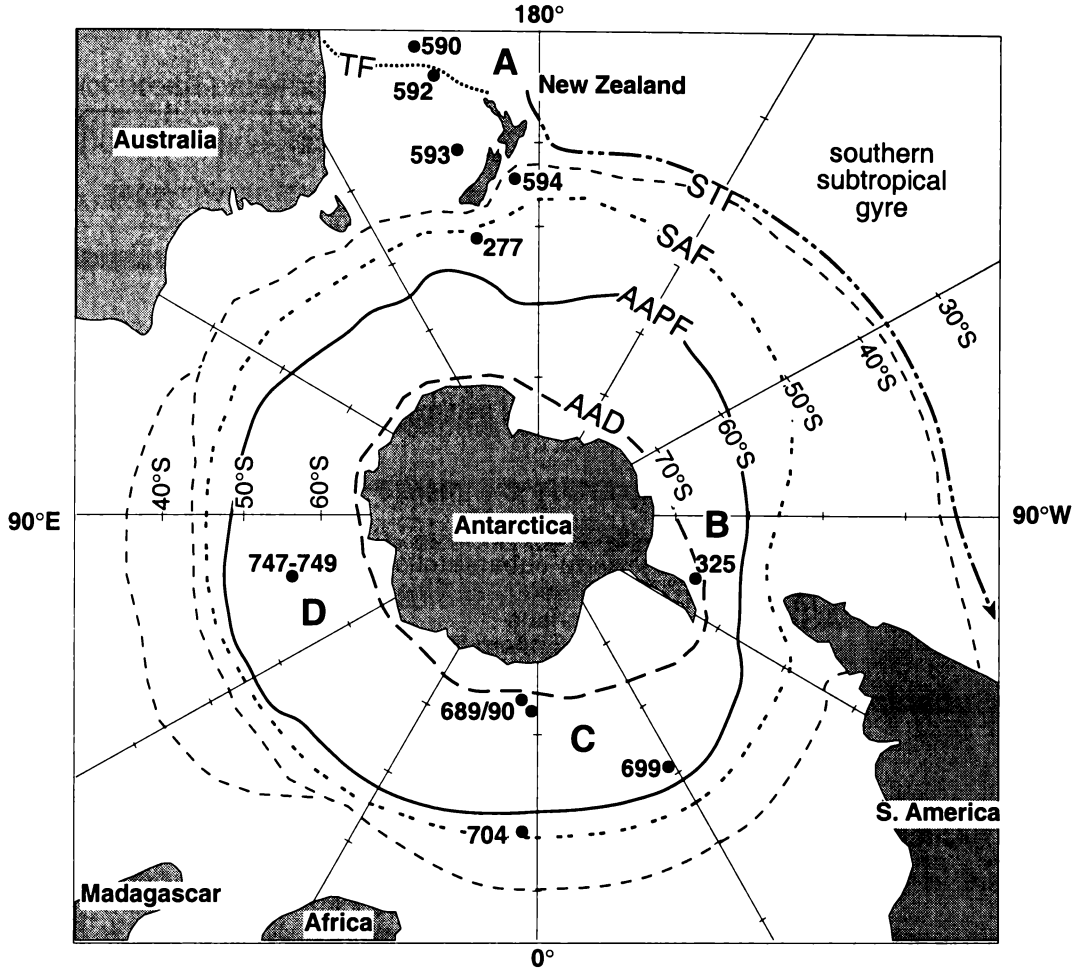


Figure 1 Modern ODP/DSDP site locations where *Bolboforma* have been recorded in relation to modern Southern Ocean frontal positions. Physical oceanography after: Reid (1965; 1997), Gordon et al. (1978), Edwards and Emery (1982), Park et al. (1993), Tomczak and Godfrey (1994), Stramma et al. (1995), Belkin and Gordon (1996) and Smythe-Wright et al. (1996). Bolboform distribution: Region A, Southwest Pacific (Poag and Karowe, 1986; Grützmacher, 1993; Crundwell et al., 1997); Region B, Bellinghausen Basin (Rögl and Hochuli, 1976); Region C, Maud Rise (Kennett and Kennett, 1990) and South Atlantic (Spiegler, 1991; and unpublished data of D. Spiegler, pers. comm., 1998); Region D, Central Kerguelen Plateau (Mackensen and Spiegler, 1992). STF = Subtropical Front, SAF = Subantarctic Front, AAPF = Antarctic Polar Front, AAD = Antarctic Divergence. Note at 70°E the STF, SAF and AAPF all lie within 5° of latitude. An A3 version of all maps is provided at the end of the chapter.

South of the diatom belt and AAPFZ, winter sea-ice restricts phytoplankton productivity except during spring sea-ice meltback when reduced surface-water salinity allows upwelling to resume, increasing surface water nutrient supply and instigating limited diatom productivity (Burckle and Cirilli, 1987). North of the SAF and the diatom belt, the sediments are higher in biogenic carbonate. The boundary between subantarctic and subtropical surface waters occurs along the STF, marked by the 15°C summer/10°C winter isotherm (Chiswell, 1994). The temperate surface watermass north of the STF referred to as Cool Subtropical Water (CSTW) and is

separated from Warm Subtropical Water (WSTW) by the Tasman Front at the 20°C summer isotherm (Fig. 2).

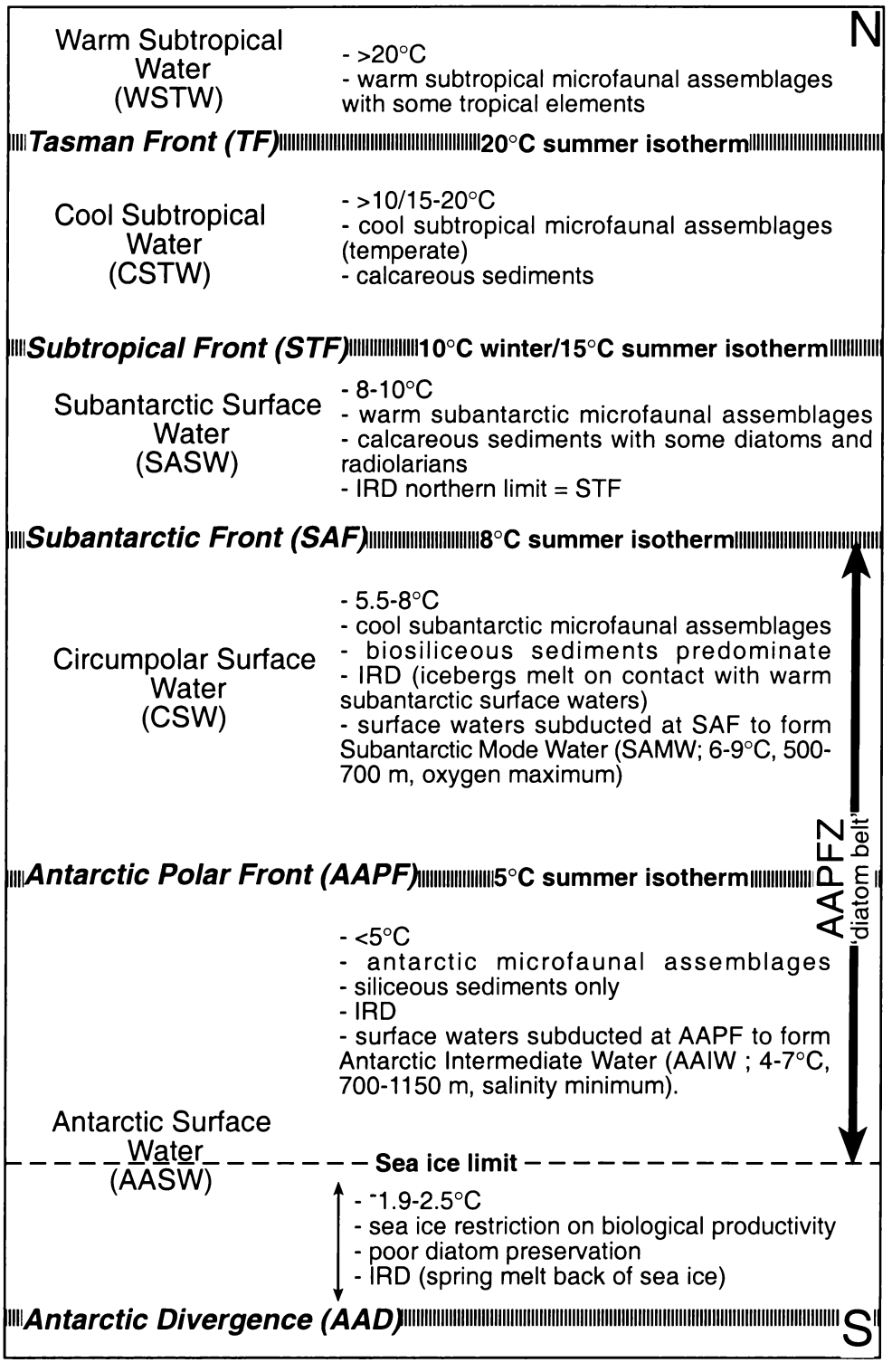


Figure 2 Modern oceanic fronts and associated physical oceanographic features of the Tasman Sea and Southwest Pacific, (after Wyrtki, 1961; Garner, 1962, 1962a, 1962b; Garner and Ridgway, 1965, 1967; Neil, 1997), and the associated sedimentological and micropalaeontological characteristics of the underlying sediments (after Burns and Andrews, 1973; Kennett and von der Borch, 1986b; Nelson, 1986). AAPFZ = Antarctic Polar Front Zone.

Recognising palaeofront positions

As the oceanic fronts are surface-watermass features, an attempt is made here to reconstruct broad palaeoceanographic conditions in the Southern Ocean during the Eocene to Pliocene by correlating microfossil assemblages with inferred palaeopositions of the fronts based particularly on the nature of underlying sediments at sites (Fig. 2). The use of sediment proxies for inferring palaeofront positions has been attempted by many workers (e.g., Kennett, 1977; Wise et al., 1992; Nelson and Cooke, 2001). By way of example, Westall and Fenner (1991) interpreted the late Neogene sediment record from Hole 704B in the South Atlantic (Fig. 1). The occurrence of diatom ooze was taken to indicate the AAPFZ over the site; mixed siliceous-carbonate sediments were linked to southward migration of SAF over the site; and calcareous ooze with poorly preserved diatoms equated with the site being bathed by subantarctic surface waters north of the SAF, with the AAPFZ well to the south.

Additionally, in the modern ocean the combination of ice-rafted debris (IRD) found associated with poorly preserved siliceous sediments occurs south of the AAPFZ. This is linked to sea-ice restricting phytoplankton production in surface waters during the winter, and spring meltback of the ice resulting in deposition of IRD (Cooke and Hayes, 1982; Burckle and Cirilli, 1987). The IRD associated with the northern edge of the AAPFZ results from small bergs melting on contact with warmer subantarctic surface waters in the vicinity of the SAF (Westall and Fenner, 1991). In the Southwest Pacific, the STF forms the northernmost limit for ice bergs.

Also the microfossil assemblages themselves can be useful for suggesting relative surface water temperatures. Thus, for example, temperate diatoms are usually found north of the STF (Froelich et al., 1991); radiolarian species can be used to distinguish antarctic versus subantarctic surface waters (Lazarus and Caulet, 1993); and planktic foraminifera can be used to distinguish between warm and cool subtropical surface waters (Kennett and Srinivasan, 1983; Jenkins and Srinivasan, 1986).

SOUTHERN OCEAN BOLBOFORM DISTRIBUTION

Bolboforma species have been reported from only four regions around the Antarctic continent (Fig. 1). Site data are summarised in Table 1.

Table 1. Modern Southern Ocean site locations and watermass conditions where bolboforms have been reported in cored sediments.

Geographic region	DSDP/ODP location	Leg	Holes	Grid reference	Water depth (mbsl)	Bottom w/mass	Surface w/mass
A	Southwest Pacific	90	590B, 592, 593, 594A	31-45°S, 163-174°E	1068-1299	AAIW	CSTW
	Campbell Plateau	29	277 (279A)	52°S,166°E	1232	AAIW	SASW
B	Bellinghausen Basin	35	325	65°S,73°W	3745	CPDW	?AASW
C	Maud Rise	113	689B, 690B	64-65°S, 0-3°E	2080-2914	CPDW	CSW
	South Atlantic	114	699A, 704B	46-51°S, 30°W-7°E	1800-3700	CPDW	CSW
D	Kerguelen Plateau	120	747A, 748B, 749B, (737A)	54-58°S, 76-81°E	1070-2030	AAIW/ CPDW	AASW

AAIW = Antarctic Intermediate Water, CSTW = Cool Subtropical Water, SASW = Subantarctic Surface Water, CSW = Circumpolar Surface Water, CPDW = Circumpolar Deep Water, AASW = Antarctic Surface Water, mbsl = metres below sea level.

Region A – Southwest Pacific

Sites comprise a transect down the Tasman Sea west of New Zealand, where all sites are north of the modern STF, to the Southwest Pacific Ocean south and east of New Zealand where the sites are south of the STF (Site 594) or the SAF (Site 277).

Region B – Bellinghausen Basin

Bellinghausen Basin is located west of the Antarctic Peninsula in the Southeast Pacific Basin and Site 325 is located south of the modern Antarctic Divergence (AAD).

Region C – Maud Rise and South Atlantic

Maud Rise sites (689, 690), near the Weddell Sea, are located just north of the AAD, well south of the AAPF, and lie within the Weddell polynya which remains ice-free during many winter seasons resulting in higher annual bio-productivity compared with other parts of the Weddell Sea (Leg 113 Shipboard Scientific Party, 1988a; 1988b). In addition, the South Atlantic sites located north of Maud Rise straddle the modern AAPF, with Site 703 and 704 north of this front and Sites 699-702 south of it (Gordon and Goldberg, 1970; Gordon, 1971; Allen and Warnke, 1991). Sites 704

and 699, respectively are taken as representative of these South Atlantic locations. Note that in the South Atlantic the tectonic configuration allows the modern AAPF to sit a lot further north (at 50-55°S) than in the South Pacific region (Gordon et al., 1978; Stramma et al., 1995; Belkin and Gordon, 1996; Smythe-Wright et al., 1996).

Region D – Central Kerguelen Plateau

Sites on Central Kerguelen Plateau are all located south of the AAPF (Schlich and Wise, 1992). Although all the principal Southern Ocean fronts (STF, SAF, and AAPF) are present in the southern Indian Ocean, they are compressed to within c. 5° latitude due to deflection of the AAPF north of Kerguelen Island (Belkin and Gordon, 1996), which has the potential to complicate palaeoceanographic reconstructions.

BOLBOFORM BIOSTRATIGRAPHY

Established regional planktic foraminiferal and calcareous nannofossil zonation schemes are used to provide a time frame for the Southern Ocean bolboform biostratigraphy (Fig. 3), which differs slightly from that established for the North Atlantic (Spiegler, 1987; Spiegler and von Daniels, 1991). A striking feature of the southern hemisphere scheme is the lack of bolboforms in sediments dated between the Late Oligocene to latest Early Miocene. The one exception is in Hole 325, Bellinghausen Basin, where they occur in the NN4 Zone in one sample only (Rögl and Hochuli, 1976), most likely related to the coring regime and sampling density. Absence of bolboforms from Southern Ocean sediments of this age is in contrast to the northern hemisphere where they are found at various localities, but mostly in minor quantities (e.g. Müller et al., 1985; Spiegler and von Daniels, 1991). Where necessary, absolute ages reported here have been updated using the geopolarity timescale (GPTS) of Berggren et al. (1995).

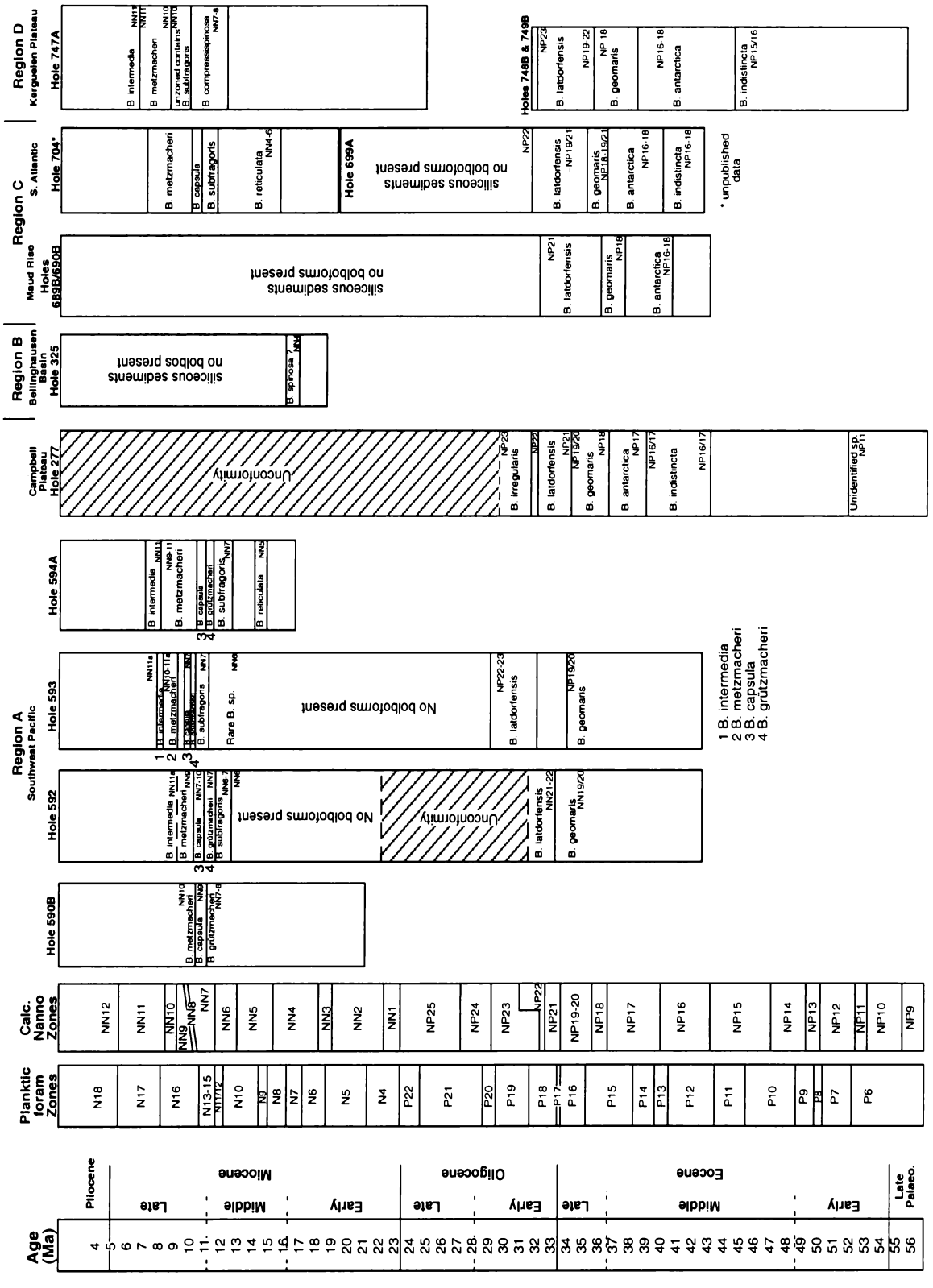


Figure 3 Southern Ocean *Bolboforma* biostratigraphy correlated with calcareous nannofossil and planktic foraminiferal biostratigraphy for the region (after Rögl and Hochuli, 1976; Kennett and Kennett, 1990; Spiegler, 1991 and unpublished data D. Spiegler, pers. comm., 1998; Mackensen and Spiegler, 1992; Grützmacher, 1993; Berggren et al., 1995; Crundwell et al., 1997). An A3 version is provided at the end of the chapter.

Bolboform zonation scheme

Region A (Southwest Pacific Sites 590, 592-594, and 277)

Three holes at Site 588 in northern Tasman Sea, (north of Site 590), were checked for bolboforms by Grützmacher (1993) but none were found. The oldest sediments cored in Hole 590 are Early Miocene (Kennett and von der Borch, 1986b), but bolboforms only occur in upper Miocene sediments (Fig. 3), and then in very small numbers compared with other sites (Grützmacher, 1993).

Holes 592 and 593 contain upper Eocene-lower Oligocene and upper Miocene bolboforms (Grützmacher, 1993), with the oldest sediments in the cores being Middle Eocene (Kennett and von der Borch, 1986a). The upper Miocene low-resolution bolboform record at Hole 593 (Grützmacher, 1993) has been amended by a high-resolution study by Crundwell et al. (1997), with bolboforms recorded across Cores 36-26 (Fig. 3). Boersma (1986) reported radiolarians (= *Bolboforma*, see Introduction) in Cores 39-37, but our subsequent checking of a higher-resolution suite of samples from these cores indicates that bolboforms are only present in Cores 40 and 36 (Elkington, 2000), as also reported by Grützmacher (1993).

In Hole 594 the oldest cored sediments are late Early Miocene (Kennett and von der Borch, 1986b), and this hole contains the largest numbers of bolboforms of any of the Leg 90 sites (Grützmacher, 1993). Hole 594 contains a record of subantarctic microfossils since the late Middle Miocene, co-incident with the presence of bolboforms. At c. 8 Ma the radiolarian assemblage in this hole becomes entirely subantarctic/antarctic (Leg 90 Shipboard Scientific Party, 1986b) and the bolboforms disappear (Grützmacher, 1993).

Campbell Plateau Hole 277 contains the oldest bolboform record to date in the Southern Hemisphere, with specimens reported in lower Eocene (c. 53 Ma) sediments (Leg 29 Shipboard Scientific Party, 1975; Grützmacher, 1993). *Bolboforma* distribution (Fig. 3) extends to the upper Eocene-lower Oligocene *Bolboforma latdorfensis* Zone after which there is a barren section followed by the lower Oligocene *Bolboforma irregularis* Zone at c. 30 Ma (Grützmacher, 1993). Above this interval there is a major unconformity between the late Early Oligocene and Late Pliocene, with the Pliocene represented by only the top 4 m of core (Leg

29 Shipboard Scientific Party, 1975), and so the bolboform record is likely to be incomplete.

Region B (Bellinghausen Basin Site 325)

Core recovery from Hole 325 was limited (Leg 35 Shipboard Scientific Party, 1976) and age determinations often difficult. The oldest cored sediments contain the planktic foraminifera *Globorotalia zealandica incognita* marking the upper lower Miocene Zones N6 to early N7 (Rögl, 1976) with an age of c. 18.8-16.4 Ma. Bolboforms were recovered c. 90 m above the oldest sediments and are therefore younger than 18.8 Ma (Fig. 3). Sediments above the bolboforms were dated as N7 (Leg 35 Shipboard Scientific Party, 1976; Weaver et al., 1976) which suggests the bolboforms are no younger than 16.4 Ma. The low carbonate content and the dominance of arenaceous and deep-water calcareous benthic foraminifera are taken to indicate a depositional water depth of 2000-3000 m (Rögl and Hochuli, 1976). Poor preservation of calcite suggests the sediments were probably close to, or below, the CCD (Craddock and Hollister, 1976), which necessarily has implications for bolboform preservation.

Region C (Maud Rise Sites 689 and 690; South Atlantic Sites 699, 700, 702-704)

At Maud Rise sites *Bolboforma* are reported in middle Eocene to lower Oligocene sediments (Kennett and Kennett, 1990). The oldest sediments containing *Bolboforma* in the South Atlantic holes are Middle Eocene to earliest Oligocene (Spiegler, 1991). Sites 699 and 704 are used as representative in this study. Additionally, unpublished data (D. Spiegler, pers. comm., 1998) record bolboforms in middle-upper Miocene sediments from Hole 704B.

Region D (Central Kerguelen Plateau Sites 747-749)

Bolboforms were recovered from all Leg 120 sites (747-751) on Central Kerguelen Plateau, but as only a few samples in Holes 750 and 751 contained bolboforms these are not discussed further. The oldest sediments containing bolboforms are Middle Eocene (Holes 748B and 749B) and the youngest Late Miocene (Hole 747A; Fig. 3) (Mackensen and Spiegler, 1992).

PALAEOCEANOGRAPHIC PROXIES AND BOLBOFORMS

Palaeoenvironmental interpretations are based on the evidence from core sediment composition, microfossil assemblage information, and isotopically-derived temperatures. These data are used to reconstruct the palaeoceanography at the study sites over time and to infer the palaeoenvironmental conditions associated with the bolboforms occurring in the holes.

Based on DSDP sediment types south of New Zealand, the earliest record of front formation in the Southern Ocean is in the middle Late Eocene when a proto-STF separated antarctic origin surface waters from tropical origin surface waters (Lazarus and Caulet, 1993; Nelson, 1996; Nelson and Cooke, 2001). Formation of this front was associated with the initial build up of ice on East Antarctica during the Late Eocene. As the ice volume increased during the Early Oligocene, the oceanic equator-to-pole thermal gradient also increased (Shackleton and Kennett, 1975) and the boundary between 'cool' and 'warm' surface waters migrated northward with AAPF forming behind it (Nelson and Cooke, 2001). By c. 30 Ma formation of the AAPF created an antarctic zone south of this front and a subantarctic zone between it and the proto-STF (Nelson and Cooke, 2001).

Region A - Southwest Pacific

Palaeogene record

The Late Eocene-Oligocene biostratigraphy of Southwest Pacific sites has been adjusted to account for recent changes in dates of events (Table 2).

In Hole 277 rare Early Eocene specimens of *Bolboforma* (Grützmacher, 1993) correspond to isotopically-derived sea surface palaeotemperatures (SSPTs) of c. 15°C (Shackleton and Kennett, 1975) (Fig. 4). Bolboforms do not become common until the SSPTs drop to c. 11°C in the upper Eocene section of the hole. Upper Eocene bolboforms are also present in Holes 592 and 593 (Grützmacher, 1993). The upper Eocene isotopically-derived palaeotemperatures from all three sites are very similar, with Site 277 being bathed by slightly cooler surface waters. Indications are that the sites were bathed by the same surface and bottom watermasses with no significant thermal boundary or oceanic front between them (Murphy and

Kennett, 1986) (Fig. 5). Hole 592 includes an uppermost Eocene to lower Miocene unconformity (Kennett and von der Borch, 1986b), so no further Palaeogene comparison of bolboforms and SSPTs is possible based on this site.

Table 2. Biostratigraphic events used to update the Late Palaeogene isotope stratigraphy of Murphy and Kennett (1986) for Holes 592, 593 and 277, using Berggren et al. (1995).

Age (Ma)		Biostratigraphic events	Sample Leg-Hole-Core-Section (cm)	Depth (mbsf)
28.5		LCO *Chiloguembelina cubensis*	90-593-50, CC[3]	475.0
			90-593A-24, CC[3]	461.4
(29[1])		(hiatus starts at 4.5 mbsf)	277	4.5
30		LAD *Subbotina angiporoides*	29-277-9, CC[4]	83.0
			90-593-52, CC[3]	489.0
31.4	top NP22	(hiatus starts in NP22 -> youngest age)[2]	90-592-33-3, 90[5]	305.0
33.7	Eo/Olig boundary	LAD *Reticulofenestra oamaruensis*	90-592-35, CC[5]	330.9
			90-593-58-2, 110[5]	544.4
			29-277-20-4, 144[6]	184.0
35.40		FAD *Reticulofenestra oamaruensis*	90-592-37-4, 4[5]	345.0
			29-277-21, CC[6]	197.0
37.00	base NP18	FAD *Chiasmolithus oamaruensis*	90-592-40, CC[5]	379.0
			29-277-28, CC[6]	263.5

[1] LAD *C. cubensis* appears to be within an hiatus in Hole 277 (Murphy and Kennett, 1986).

[2] Hiatus extends into NP22, therefore the maximum youngest age for the start of the hiatus in Hole 592 is the top of NP22 at 31.4 Ma (see Berggren et al., 1995).

[3] (Jenkins and Srinivasan, 1986), [4] (Jenkins, 1975), [5] (Martini, 1986), [6] (Edwards and Perch-Nielsen, 1975).

Thermal segregation between Sites 277 and 593 began in the latest Eocene (c. 36-34 Ma) with calculated SSPTs (Appendix D) at both sites of c. 11°C and bottom water palaeotemperatures (BWPTs) of c. 7°C (Fig 6), but with Hole 277 recording slightly more enriched $\delta^{18}O$ values in both planktic and benthic foraminifera (Murphy and Kennett, 1986). After the earliest Oligocene cooling event the SSPTs in Hole 277 decrease to c. 8°C and in Hole 593 to c. 9°C. This cooling of SSPTs in Hole 277 corresponds with the greatest abundance of bolboforms at the site (Grützmacher, 1993). During the Early Oligocene the temperature gradient between the sites increased further, with SSPTs decreasing to 5-7°C in Hole 277 and within the range 8-10°C in Hole 593. During the Late Oligocene, SSPTs in Hole 593 increased to >10°C. Hole 277 SSPTs are within the range of modern Subantarctic

Surface Water (SASW; Fig. 2), suggesting a proto-STF migrated northward over the site in the Early Oligocene (Fig. 7) allowing cooler watermasses to reach the site (Nelson, 1996). Hole 593 SSPTs of >10°C are within the modern winter range of the Cool Subtropical Water (CSTW) north of the STF. The increase in SSPT in Hole 593 samples coincides with the disappearance of bolboforms (Fig. 8), at least until the Late Miocene. Sites 592 and 593 are considered to have remained at similar mid-bathyal water depths throughout this time (Kennett and von der Borch, 1986b), so dissolution is not considered to have been a factor in the disappearance of the bolboforms.

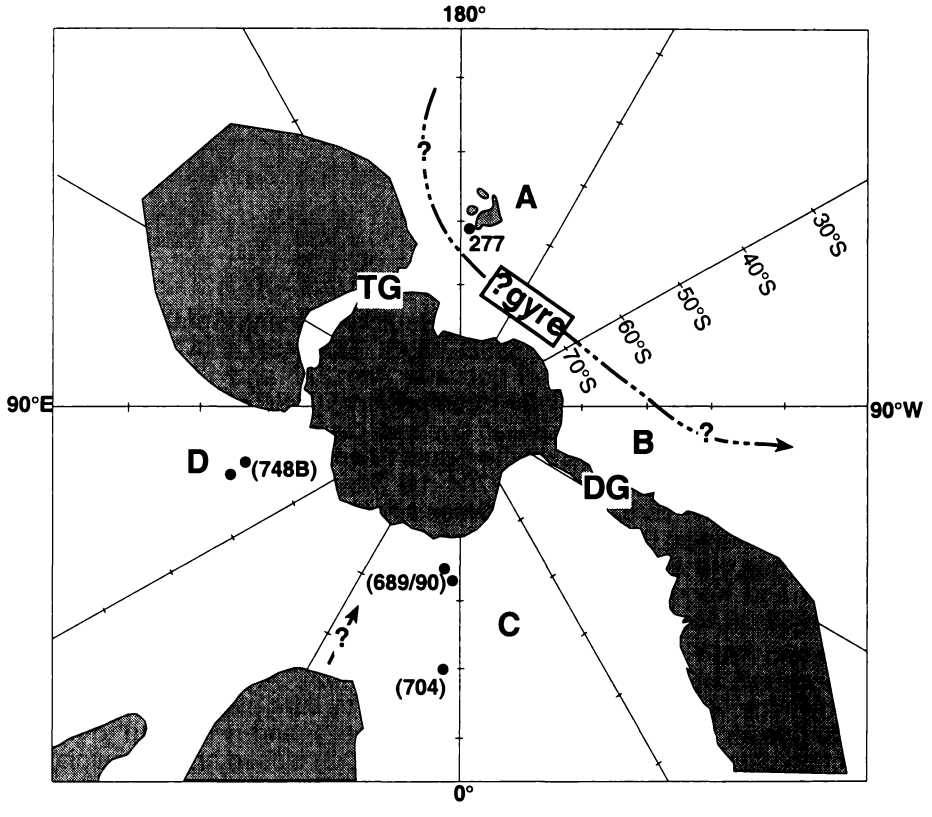


Figure 4 Early Eocene (from c. 53 Ma) Southern Ocean frontal structure. Bolboforms are only present in Hole 277 where warm isotopically-derived sea-surface palaeotemperatures (SSPTs) are taken to indicate subtropical surface waters arriving via a proto-subtropical gyre (Kamp, 1986; Buening et al., 1998). Maud Rise sites are just north of a thermal boundary (?proto-STF) based on SSTs (Stott et al., 1990). South Atlantic sites contain warm planktic foraminiferal faunas from Palaeocene to early Eocene (Nocchi et al., 1991). During planktic foraminiferal Zone P11 (c. 46-44 Ma) faunas changed, but still represented 'warm temperate' conditions (Nocchi et al., 1991). During the latest Cretaceous-earliest Palaeocene there was sharply reduced bioproductivity at 55°S at the southern end of Broken Ridge (Northern Kerguelen Plateau; Rea et al., 1990). Lower Eocene radiolarians show no provincialisation in the Crozet Basin, Indian Ocean (Lazarus and Caulet, 1993). Tasmanian and Drake gateways (TG and DG respectively) are both closed. For all figures plate configuration is after Lawver, et al. (1992) and New Zealand configuration after King et al. (1999) and King (2000).

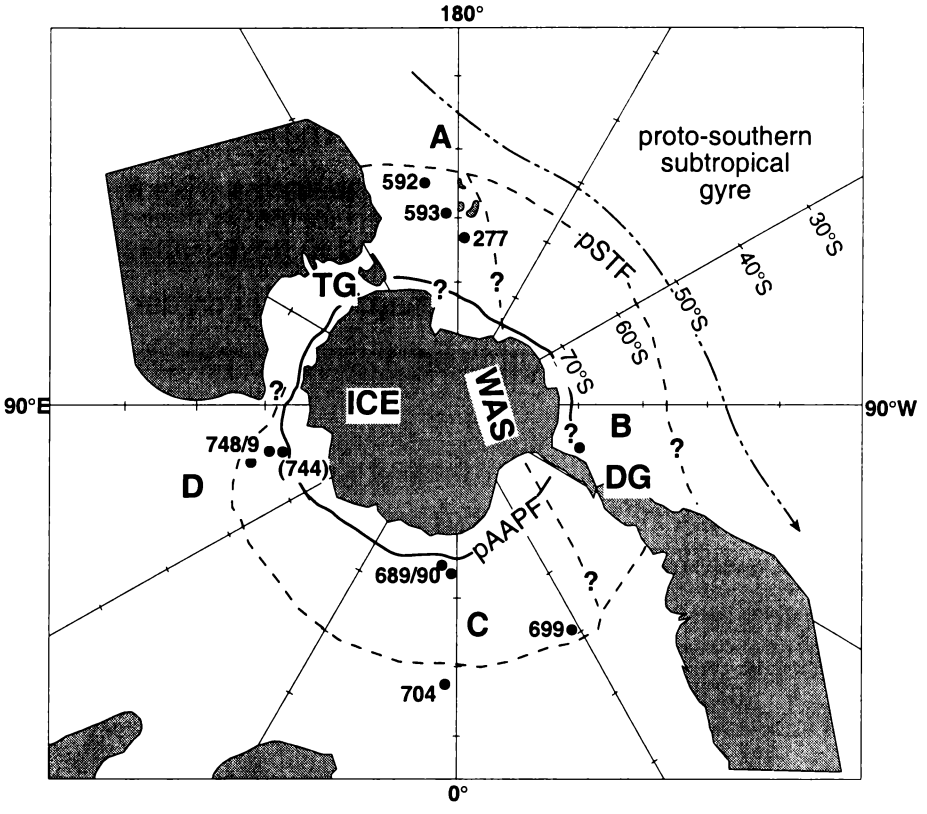


Figure 5 Middle to Late Eocene (from 42 Ma) Southern Ocean frontal structure. Bolboforms present in Holes 277, 593, 592, 699B, 689B, 690, 748B and 749B. A thermal boundary (possibly proto-STF) is inferred between Site 277 and Sites 281/283 on the South Tasman Rise based on sediment composition (Nelson and Cooke, 2001). Planktic foraminiferal SSTs indicate similar oceanic conditions over Sites 277, 593 and 592 (Murphy and Kennett, 1986). In the South Atlantic holes, planktic foraminiferal diversity increases and indicates Sites 703/704 are warmer than Site 699 (Nocchi et al., 1991). Maud Rise sediments alternate between siliceous- and calcareous-dominated (Leg 113 Shipboard Scientific Party, 1988a) inferred to reflect the repeated migration of the proto-AAPF across the area. The middle Eocene appearance of bolboforms at Maud Rise (Kennett and Kennett, 1990) coincides with significant surface water cooling events between 52-36 Ma. In the Kerguelen Plateau sediments, appearance of IRD (implying sea ice and AAPF formation) coincides with a shift in $\delta^{18}O$ to heavier values during the Late Eocene/Early Oligocene (Zachos et al., 1992). At c. 42 Ma the southern margin of Broken Ridge was uplifted about 2.5 km due to intra-plateau rifting between the ridge and Kerguelen Plateau (Schlich and Wise, 1992), and is inferred to have had a major impact on palaeocirculation. Drake gateway (DG) closed and Tasmanian gateway (TG) very restricted opening, surface flow only. If a West Antarctic Seaway (WAS) existed prior to the opening of the Drake gateway (e.g., Wise et al., 1991; Cande et al., 2000) then surface waters may have passed through it to produce a proto-ACC, if only extending to relatively shallow depths (Nelson and Cooke, 2001).

Prior to opening of the Tasmanian gateway (between the South Tasman Rise and Antarctica) during the latest Eocene-earliest Oligocene (c.34-31 Ma), warm subtropical surface waters originating from the South Pacific gyre flowed southward through the Tasman Sea to south of the New Zealand landmass and eastwards off the coast of Antarctica (Kamp, 1986; Buening et al., 1998), as evident in the Early Eocene warm SSPTs from Hole 277 (Shackleton and Kennett, 1975). Following opening of the Tasmanian gateway cool surface waters from the southern Indian

Ocean flowed into the Southwest Pacific and the SSPTs began to decrease (Murphy and Kennett, 1986; Jenkins, 1993a; Buening et al., 1998). This probably resulted in a decoupling of the ocean circulation system (Kennett, 1977; Kamp et al., 1990) with separation of the subtropical gyre and west wind drift along the proto-STF (Fig. 5). Unconformities recorded in Holes 588 (middle Eocene to upper Oligocene), 592 (upper Eocene to lower Miocene), and 277 (at c. 30 Ma) are inferred to relate to vigorous flows initiated by the opening of this gateway (Kennett and von der Borch, 1986b). This regional unconformity is not recorded in Hole 593 as it appears that the invigorated bottom current circulation in the Tasman Sea did not extend as far east as this site (Nelson, 1986).

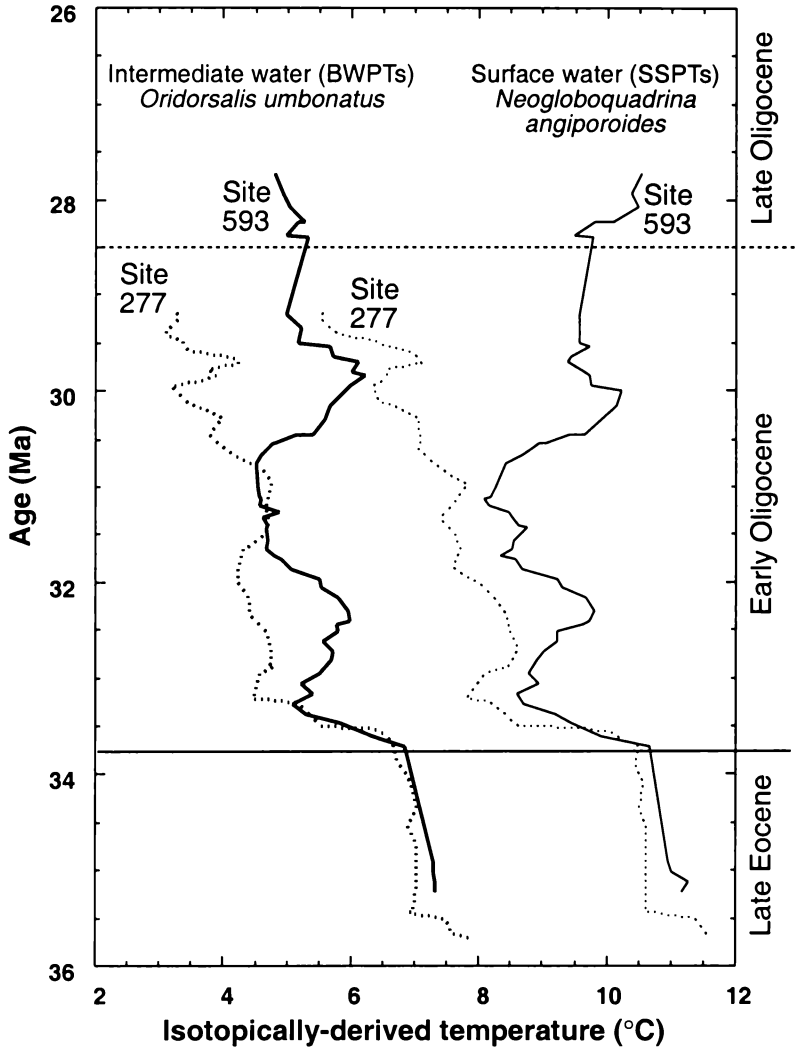


Figure 6 Isotopically-derived SSTs for Holes 277 and 593 (duplicates averaged, data smoothed and temperatures recalculated using Shackleton and Kennett (1975) for bottom waters and Zachos et al (1994) for surface waters, see Chapter 3 and Appendix D). Note that the planktic records for the two sites deviate after the earliest Oligocene cooling event, implying thermal separation (after Keigwin and Shackleton, 1980; Murphy and Kennett, 1986; Berggren et al., 1995).

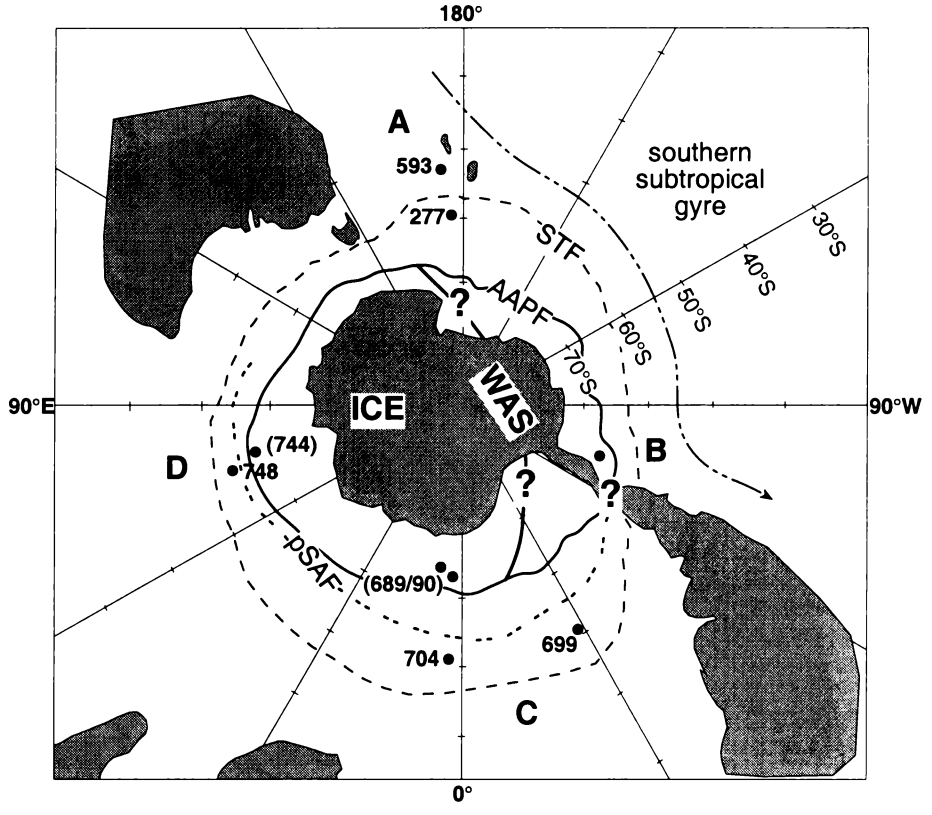


Figure 7 (a) Early Oligocene (from 33.7 Ma) Southern Ocean frontal structure. Bolboforms present in Holes 277, 593, 699, 704 and in Hole 748B only in the very early Oligocene. In Hole 277 an uppermost Oligocene unconformity limits comparisons. An early Oligocene SSPT difference between Sites 592/593 and 277 suggests the presence of a front between them (Murphy and Kennett, 1986). When SSPTs are >10°C (Murphy and Kennett, 1986) in Hole 593 no bolboforms are present (Grützmacher, 1993), while in Hole 277 when SSPTs are c. 5.5-7°C (Murphy and Kennett, 1986) bolboforms are present (Grützmacher, 1993). At Maud Rise the high siliceous component of sediments (O'Connell, 1990) suggests sites were south of the AAPF. In Hole 748B bolboforms disappear (Mackensen, 1992) as IRD appears in sediments (Allen and Warnke, 1991; Breza and Wise, 1992). Kerguelen sites reach modern positions (Schlich and Wise, 1992). Modelling of Southern Ocean circulation suggests that Antarctic Divergence (AAD) development is dependent on flow through, and the sill depth of, the Drake gateway, so that when this gateway is closed there is no AAD front formation (Gill and Bryan, 1971). WAS may be open at this time (Cande et al., 2000; Nelson and Cooke, 2001) and Tasmanian gateway was open to surface flow (Jenkins, 1993b). Front migration between South Atlantic Sites 699 and 704; when STF is north of Site 704 bolboforms are present in sediments, and when the SAF is south of Site 699, bolboforms are present.

Breaching of the Tasmanian gateway may have established a proto-antarctic circumpolar current with flow directed through a possible West Antarctic Seaway (Wise et al., 1991) (WAS; Figs. 7 and 9) within the West Antarctic Rift system (Lawver and Gahagan, 1998; Cande et al., 2000). Cooling of surface waters in the region may be linked to such a circum-Antarctic system (e.g., Nelson and Cooke, 2001).

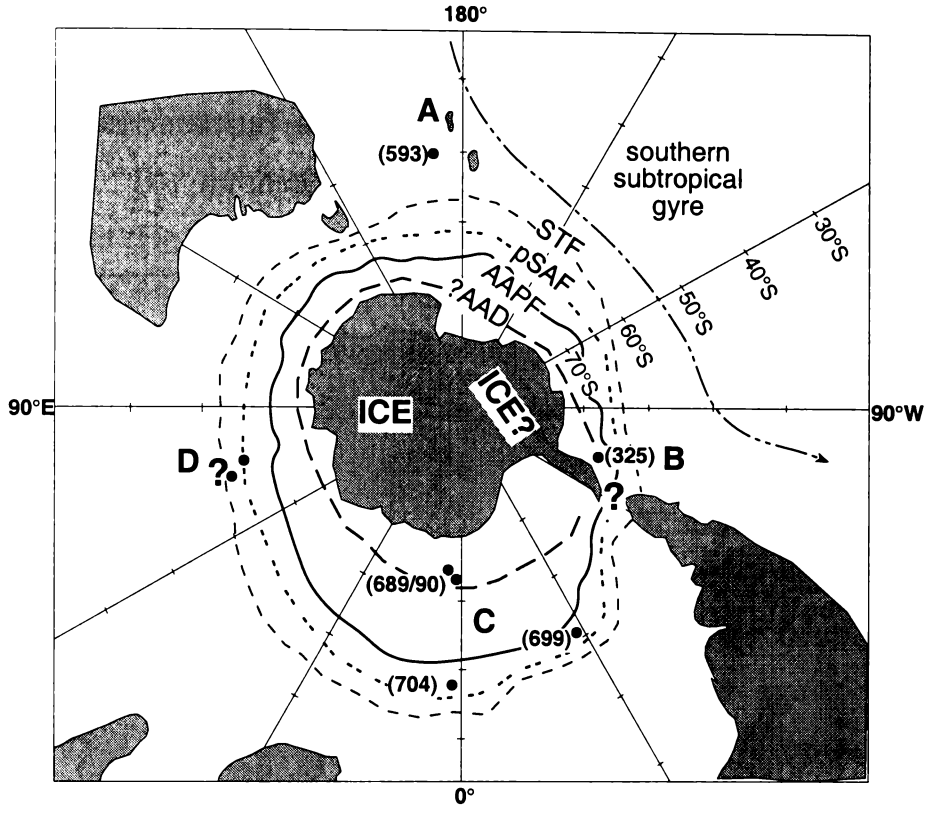


Figure 8 Late Oligocene (from 28.5-23.8 Ma) Southern Ocean frontal structure. Bolboforms are not reported from any sites at this time. Microfaunal assemblage evidence suggests Maud Rise was south of the AAPF (Leg 113 Shipboard Scientific Party, 1988a) and that South Atlantic sites were very close to the AAPFZ with the absence of IRD suggesting the AAPF was south of the sites. Site 593 was north of the STF (this front may link to gyre circulation) and Site 325 was south of the AAPFZ. Unsure of site position in relation to fronts at Kerguelen Plateau. In the South Atlantic during planktic foraminiferal Zones P22-N4 (late Oligocene-early Miocene) higher planktic foraminiferal diversity and presence of low-latitude species indicate an increase in SSTs (Crux, 1991), then during subsequent early Miocene cooling the planktic foraminiferal assemblage changes with the low latitude species disappearing (Müller et al., 1991). Tasman gateway is fully open and the Drake gateway is beginning to open (Lawver et al., 1992; Jenkins, 1993b).

In Hole 592 a mainly poorly preserved, uppermost Eocene genuine radiolarian assemblage (*Cryptoprora ornata* Zone) with tropical affinities is reported in the core between c. 373-346 mbsf (592-40-4, 40-42 cm to 592-37-1, 15-16 cm) (Caulet, 1986). The radiolarians show reasonably good preservation between 373.2-371 mbsf (592-40-4, 40-42 cm to 592-40-2, 40-42 cm) and the sediments also contain abundant tropical diatoms (Caulet, 1986) along with rare occurrences of bolboforms from the lower parts of the *Bolboforma geomaris* Zone (Grützmacher, 1993). However, from 371-346 mbsf (592-39-3, 40-42 cm to 592-37-1, 15-16 cm), the preservation is very poor, consisting mainly of fragments (Caulet, 1986), and the number of bolboforms significantly increases (Grützmacher, 1993). As no Oligocene radiolarians are identified, the Eocene-Oligocene radiolarian boundary

cannot be located in Hole 592, indicating deposition of radiolarians and other siliceous microfossils ceased prior to the Oligocene (Caulet, 1986). The well preserved tropical radiolarians and diatoms indicate Site 592 was most likely located within southward-flowing tropical waters through the Tasman Sea (Caulet, 1986), probably driven by the proto-subtropical gyre (Fig. 5).

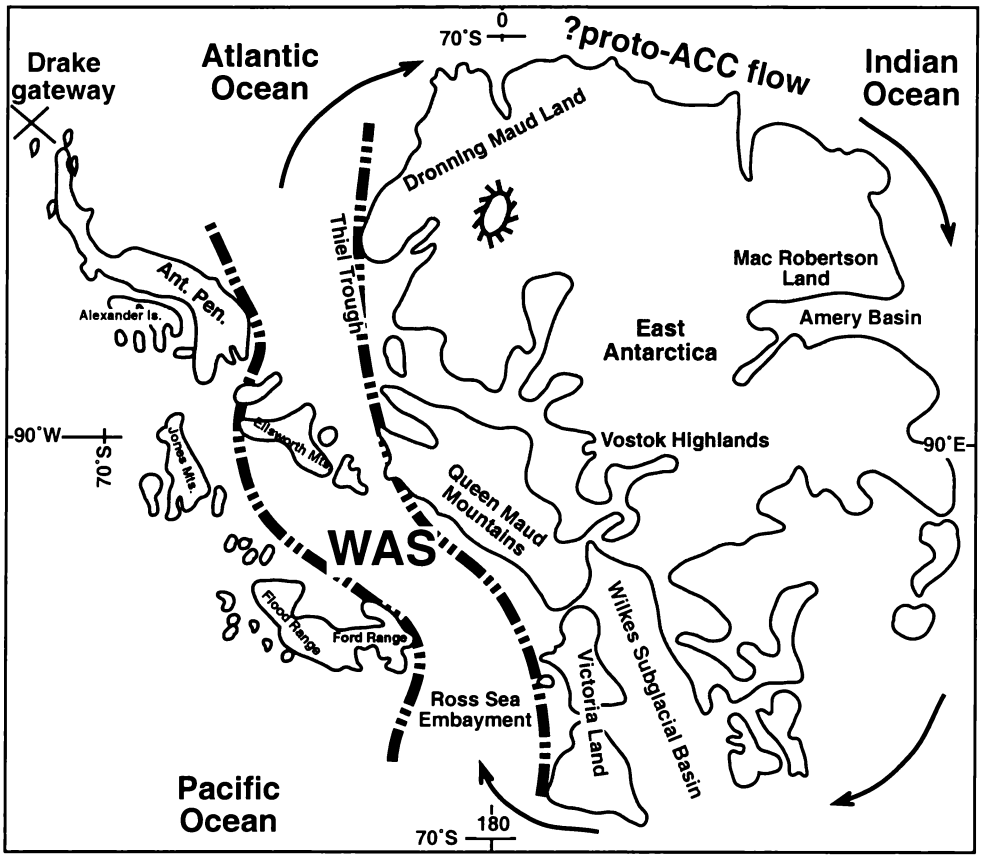


Figure 9 Antarctic subglacial bedrock at 0 m elevation (Drewry, 1983) used to show possible West Antarctic Seaway (WAS) connecting the Pacific Ocean to the Indo/Atlantic Oceans at a time when Drake gateway was closed (see Cande et al., 2000; Nelson and Cooke, 2001). The WAS is inferred to have existed between the Late Eocene to Late Oligocene and may have accommodated circum-Antarctic flow prior to opening of the Drake gateway.

The complete absence of radiolarians in Hole 593 suggests this site was not bathed by such tropical waters, which could indicate the presence of a front between Sites 593 and 592. However, as the isotopically-derived SSPTs indicate a lack of thermal gradient between these sites (Murphy and Kennett, 1986), the presence both of tropical radiolarians and of bolboforms in Hole 592, but only bolboforms in Hole 593, may reflect watermasses entering the region from different directions, the radiolarians from the tropics and the bolboforms from the south, probably via a subsurface (possibly silica dissolving) watermass (see later).

Neogene record

Bolboforms are not reported from Neogene sediments in Region A until the Middle-Late Miocene. As all of the Tasman Sea sites containing *Bolboforma* are currently north of the STF a careful consideration of their palaeoposition in relation to this front is appropriate. The northernmost is Hole 590B, where there are only three bolboform zones (Fig. 3) and the bolboforms occur in much smaller numbers than at other sites to the south (Grützmacher, 1993). Site 590 appears to be the northernmost limit of their distribution in the region as they are not found at Site 588 to the north (Grützmacher, 1993). Both planktic and benthic foraminiferal $\delta^{18}O$ records from Hole 590B exhibit significant cooling between Zones NN7-9, with a large shift in the planktic $\delta^{18}O$ record of c. 0.7‰ (-0.92 to -0.21‰) corresponding with the top of Zone NN7 at c. 11 Ma (Kennett, 1986). This suggests surface waters over the site cooled rapidly by c. 3°C and that the occurrence of *Bolboforma* is coincident with this shift. Subsequent to the cooling, both planktic and benthic foraminiferal $\delta^{18}O$ records exhibit significant shifts of c. 1-0.8‰ towards lighter, and therefore warmer, values (Kennett, 1986), and the bolboforms disappear. The site maintains isotopically-derived SSPTs of c. 20-22°C for the rest of the Neogene section (Kennett, 1986) and bolboforms remain absent.

At Sites 592 and 593 surface-water conditions prior to the return of bolboforms at both sites are inferred to have been warm subtropical (Fig. 10) based on the presence of the planktic foraminifera *Globorotalia peripheroronda*, which migrated from the tropics to reach these sites by c. 16 Ma (Jenkins and Srinivasan, 1986; Jenkins, 1993b). The disappearance of this species is associated with a steady decline in planktic foraminiferal diversity and inferred surface-water temperatures at both sites before the NN6/7 boundary at c. 11.8 Ma (Jenkins and Srinivasan, 1986; Jenkins, 1993b; Berggren et al., 1995). Gradual disappearance of the remaining warm subtropical planktic foraminifera from Hole 593, such as *Globigerinella aequilateralis*, *Globigerina nepenthes,* and *Menardella* sp., suggests partitioning of the Tasman Sea into a warm subtropical zone north of Site 593 and a cool subtropical zone to the south (Fig. 11), as in the modern situation. The partitioning may mark establishment of the Tasman Front. The alternation between the presence of bolboforms but an absence of warm subtropical planktic foraminifera, with the absence of bolboforms when ever warm subtropical planktic foraminifera

are recorded, is taken to indicate alternating (sub)surface-water conditions over the site (Crundwell, in prep.). In addition, the final disappearance of the subtropical planktic foraminiferal signature and the bolboforms occurs at about the same sub-bottom depth at both Sites 593 and 592 (Crundwell, in prep.). This suggests further partitioning of surface watermasses to separate the cooler, *Bolboforma*-containing waters from the subtropical waters. The transition in Hole 594 from Middle Miocene tropical radiolarians, through a Late Miocene radiolarian assemblage lacking warm temperate species to a latest Miocene-Pliocene antarctic/subantarctic-dominated assemblage is indicative of the northwards migration of the STF. This front appears to have reached its modern relative position by about c. 10 Ma (Nelson and Cooke, 2001). Isotopically-derived SSPTs at Site 279A (close to Site 277) are c. 7-10°C by the Middle Miocene (Shackleton and Kennett, 1975), implying subantarctic surface water bathed the site.

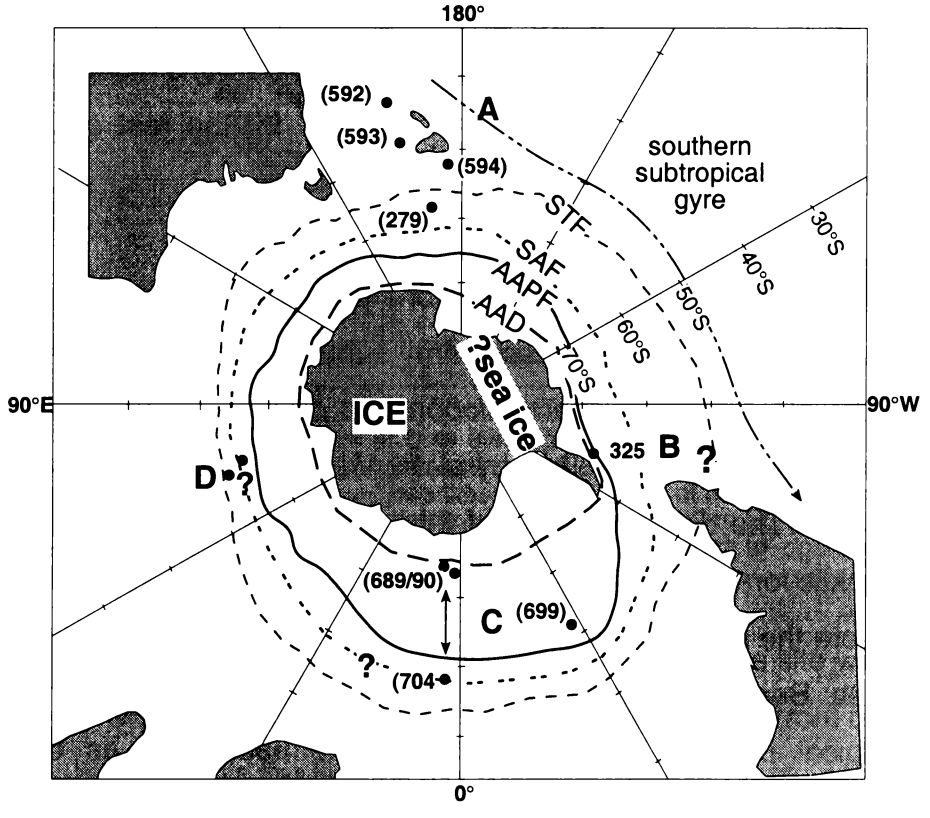


Figure 10 Early to Middle Miocene (from 23.8 Ma) Southern Ocean frontal structure. Bolboforms are only present in Hole 325. Isotopically-derived SSPTs are c. 7-10° in Hole 279A (close to Hole 277) (Shackleton and Kennett, 1975). In Bellinghausen Basin, Site 322 (north of 325) is used to monitor sediment changes as the SAF migrates over both sites: SAF migration northwards over Site 322 is indicted by IRD in sediments and abundant diatoms in Hole 325. During the early Miocene warming the SAF migrates southwards, indicated by claystones in Hole 325 that contain bolboforms. IRD is present in Hole 699A (Allen and Warnke, 1991), and so the site is inferred to lie south of the SAF and probably the AAPF.

The last occurrence of bolboforms in region A occurs within Zone NN11a (8.6-7.2 Ma) in Holes 594, 593 and 592 (Grützmacher, 1993; Berggren et al., 1995; Crundwell et al., 1997) and has been dated at c. 8 Ma in Hole 593 (Crundwell, in prep.) and Hole 594 (Grützmacher, 1993).

Region B - Bellinghausen Basin

Early Neogene record

Late Early Miocene evidence for water temperature at this site comes from the sediment composition rather than from isotopically-derived SSPTs, as used at other sites. The earliest IRD in Hole 325 is preceded in all cases by deposition of diatomaceous sediment, taken to indicate northward migration of the AAPFZ (Tucholke et al., 1976). The interspersing of very thin nannofossil claystone/chalk in Cores 325-8 and -7 with the diatomaceous sediments is linked to repeated migration of the SAF, the northern margin of the AAPFZ (Fig. 10), over the site. Nannofossils in the claystones are a cold-water assemblage (Haq, 1976) linked to changes in surface-water conditions either by southward migration of AAPFZ over the site and/or local upwelling of relatively warmer, carbonate-rich subsurface water (Tucholke et al., 1976). The earliest IRD occurs at c. 620 mbsf (Leg 35 Shipboard Scientific Party, 1976), with bolboforms reported at 615.3 mbsf (sample 325-8-2, 133-135 cm) from one of the thin nannofossil claystones (Rögl and Hochuli, 1976). Hence, when the SAF was located north of Hole 325, cold subantarctic surface water (equivalent to modern CSW) bathed the site and diatoms flourished. As the front migrated southward, warm subantarctic surface water (equivalent to modern SASW) bathed the site and high-latitude calcareous nannofossils and planktic foraminifera flourished, along with bolboforms.

The late Early Miocene (Zone N6-N7, 19-17 Ma) was a time of relative warmth around the Antarctic (Shackleton and Kennett, 1975; Kennett, 1977) interspersed with several glacial events (e.g. Mi1b at c. 18 Ma; Wright et al., 1992). The appearance of bolboforms in Hole 325 may be linked to the southward migration of the AAPFZ during this warmer period (Kennett and Kennett, 1990) which ended just before Mi3 at c. 13.7 Ma (Wright et al., 1992). The cooling and expansion of the polar zone by the Late Miocene is marked by IRD in Hole 322, north of Hole 325, signalling the arrival of the SAF (Tucholke et al., 1976). Hole 325 continues to

record Antarctic assemblage diatoms above the claystones (Leg 35 Shipboard Scientific Party, 1976).

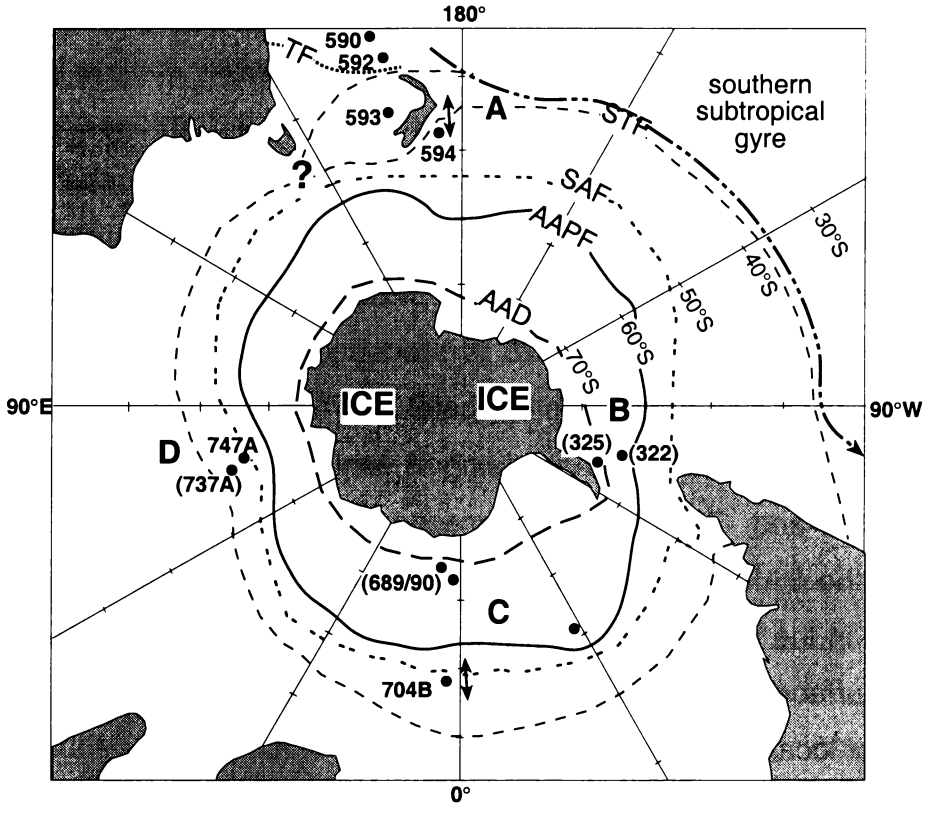


Figure 11 Late Middle to Late Miocene (from c. 16 Ma) Southern Ocean frontal structure. Bolboforms present in Holes 590B, 592-594A, 704B (unpub.), and 747A. Landmass configuration of New Zealand at this time may result in two branches of the STF (like the modern Indian Ocean, see Belkin and Gordon, 1996). Sedimentological changes at Kerguelen Plateau sites suggest major front migrations: in Hole 737A (north of Hole 747A) the change from upper Oligocene nanno chalk, to mid Miocene nanno/diatom ooze, to upper Miocene (c. 6.3 Ma) subantarctic diatom ooze (Zachos et al., 1992) is inferred to reflect northwards migration of the SAF. During the uppermost Miocene-earliest Pliocene (c. 5.8 Ma) the Hole 737A sediments contain temperate water diatoms, and Hole 747A sediments consist of foraminiferal- and diatom-bearing nanno ooze with bolboforms (Mackensen, 1992; Zachos et al., 1992), inferred to indicate southwards migration of the SAF over the site.

Region C - Maud Rise

Palaeogene and Neogene records

Isotopically-derived SSPTs determined for Maud Rise sites indicate that surface waters were never colder than 8-9°C during the Palaeocene and early Eocene and reached maximum values of 15-18°C, suggesting Antarctic sea ice was not being formed (Stott et al., 1990). This temperature range (c. 9-18°C) is very similar to the modern CSTW (Fig. 2), indicating the SSPTs at Maud Rise during the Palaeocene-earliest Eocene were probably cool subtropical (Fig. 4). By the Early Eocene (c. 53 Ma) SSPTs start to cool, recording decreased seasonality (Stott et al., 1990), and

the first occurrence of bolboforms in the Middle Eocene (c. 44 Ma; Kennett and Kennett, 1990) coincides with significant surface-water cooling events between 52-36 Ma. The largest numbers of *Bolboforma* occur in upper Eocene sediments which have taken on a polar character (Stott et al., 1990) and contain subantarctic radiolarians (Lazarus and Caulet, 1993), suggesting they lay south of a proto-STF (Fig. 5). Large numbers of bolboforms coincide with large numbers of radiolarians which points to surface-water palaeoproductivity fluctuations, the bolboforms occurring in larger numbers when the surface waters were cooler and more nutrient-rich (Diester-Haass, 1992). Kennett and Kennett (1990) suggested that the last occurrence of bolboforms on Maud Rise was related to Southern Ocean surface waters becoming too cold for them, rather than due to their extinction.

Fluctuations between siliceous and calcareous sedimentation were established by Late Eocene, inferred to reflect cyclical migration of a proto-AAPF across Maud Rise (Leg 113 Shipboard Scientific Party, 1988a; 1988b; O'Connell, 1990). There was a marked increase in biosiliceous sedimentation (both radiolarians and diatoms) by latest Eocene (Barker et al., 1988; Thomas et al., 1990) indicating sites where probably located south of the proto-AAPF. In the modern ocean the SAF marks the northern boundary of the diatom belt (Burckle and Cirilli, 1987), and diatomaceous sediments record its possible formation in the late Oligocene between the AAPF and SAF (Nelson, 1996), establishing essentially modern oceanic conditions (e.g. Heath, 1985; Belkin and Gordon, 1996). However, as diatom sedimentation is reported at Maud Rise from the latest Eocene-Early Oligocene this suggests either an earlier time of formation of SAF, at least in the South Atlantic, or that the AAPF marked this biosiliceous boundary until the SAF became established. Low sedimentation rates since the Eocene indicate these sites have been located away from the high productivity biogenic belt associated with the AAPFZ (Barker et al., 1988). Isotopic analysis of Maud Rise sediments led Kennett and Stott (1990) to conclude that the generation of high-latitude cool intermediate waters (either proto-AAIW or Southern Component Intermediate Water, SCIW) occurred at this time. If this was the case, then the subduction of cold antarctic surface waters to form SCIW necessitates the presence of an oceanic front. In the modern ocean AAIW is generated at the AAPF, and so it is inferred that this front has existed in some form since the late Eocene (Fig. 5).

During latest Eocene-Early Oligocene, Maud Rise SSPTs cooled to 2-5°C (Stott et al., 1990) and there was a change from subantarctic to antarctic radiolarian species (Lazarus and Caulet, 1993), along with the earliest record of IRD (Barker et al., 1988) marking the formation of sea ice. The last occurrence of bolboforms in uppermost Eocene sediments (Kennett and Kennett, 1990) precedes lower Oligocene diatomaceous sedimentation (O'Connell, 1990) defining the diatom belt, between the AAPF (or pSAF) and the northern limit of Antarctic sea ice (Fig. 7) as found in the modern ocean. Alternation of nannofossil oozes and diatom-bearing nannofossil oozes until the middle upper Miocene in Hole 690B is interpreted to represent repeated migration of a front over the site (Leg 113 Shipboard Scientific Party, 1988b) (Fig. 9). Diatomaceous sedimentation continued at Maud Rise without any carbonate accumulation until the Pleistocene, when in Hole 689B a calcareous component returned in the form of sinistral *Neogloboquadrina pachyderma* and a few calcareous nannofossils (Kennett and Kennett, 1990). The presence of calcareous sediments is most likely related to the Weddell Polynya and slightly warmer surface waters within the Weddell Gyre, rather than to southward migration of the AAPF or pSAF. The upper Neogene record of continuous diatomaceous sedimentation indicates the Maud Rise sites remained within or south of, the diatom belt (Fig. 12).

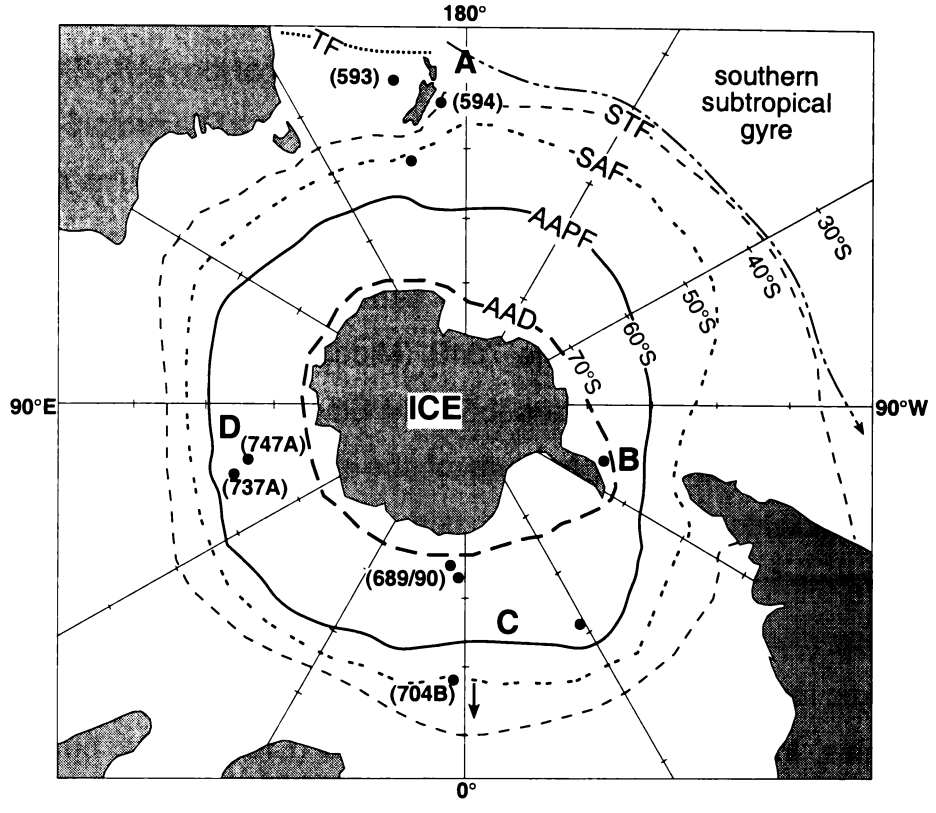


Figure 12 Early to Late Pliocene (from c. 5 Ma) Southern Ocean frontal structure. No bolboforms reported from any sites. The presence of IRD and foraminifera-bearing diatom ooze in Holes 737A and 747A (Baldauf and Barron, 1991; Bohrmann and Ehrmann, 1991) is inferred to indicate northwards migration of the SAF over these sites.

Region C - South Atlantic

Palaeogene and Neogene records

The South Atlantic records come from Site 699 just south of the modern AAPF, and Site 704, between the STF and AAPF (Leg 114 Shipboard Scientific Party, 1988a, 1988b). The Quaternary sedimentary record of alternating siliceous and calcareous sedimentation suggest Site 704 is located close to the SAF Other South Atlantic sites contain warm planktic foraminiferal faunas from Palaeocene to Early Eocene (Nocchi et al., 1991). During Zone P11 (c. 46-44 Ma) the faunas changed, but still represented 'warm temperate' conditions (Nocchi et al., 1991). Middle upper Eocene sediments in Hole 699A comprise nannofossil ooze containing bolboforms, which by lower Oligocene include increasing amounts of biosiliceous sediment in which bolboforms are rare (Spiegler, 1991). The change from calcareous to biosiliceous sedimentation in Hole 699A suggests a front, possibly the proto-SAF (Fig. 7), was close to and/or migrated across the site (Leg 114 Shipboard Scientific Party, 1988a; Westall and Fenner, 1991). It is possible that due to the reduced

ocean thermal gradient a proto-SAF did not exist during the Eocene and this sediment boundary may reflect the position of the AAPF itself. The earliest evidence of IRD, used to indicate proximity to the northern margin of the AAPFZ in Hole 699A, occurs at c. 23.5 Ma (Allen and Warnke, 1991) (Fig. 10). The proto-SAF remained close to the site throughout the Neogene (Fig. 11), with another pulse of IRD at 10.7 Ma (Allen and Warnke, 1991).

The oldest sediments cored in Hole 704B (Middle Eocene) are calcareous and reflect relatively warm surface waters (Leg 114 Shipboard Scientific Party, 1988b), suggesting the site was probably north of the proto-STF (Fig. 5). Nannofossil assemblages indicate surface waters had cooled considerably by the Early Oligocene, warmed slightly in the Late Oligocene, and cooled again by the Middle Miocene (Crux, 1991). During Zone P22-N4 (Late Oligocene-Early Miocene) South Atlantic planktic foraminiferal diversity increase along the with the presence of low-latitude species, indicating an increase in SSPTs (Crux, 1991), but subsequent species changes were associated with cooling later in the Early Miocene (Müller et al., 1991). Rare early Oligocene appearance of bolboforms at this site (Spiegler, 1991) coincides with cooler conditions and may reflect the close proximity of the proto-SAF (Fig. 7).

Müller et al. (1991) reported Site 704 to be north of the SAF from 9.8-6.4 Ma (Fig. 11). Prior to c. 9 Ma, the microfossil assemblages and calcareous-dominated sediments are consistent with a position in warm subantarctic surface waters between the SAF and STF (Müller et al., 1991). A large decrease in carbonate productivity between 8.45 and 8.2 Ma (324-318 mbsf), associated with an increase in diatomaceous sediment, is taken to indicate significant cooling of the surface waters, and close proximity of the high-silica productivity zone and the SAF (Müller et al., 1991). Upper Miocene bolboforms are found in Hole 704B sediments from c. 438-258 mbsf (114-704B-47-4, 100 cm to 704B-26-1, 100 cm; D. Spiegler, pers. comm., unpublished data), co-incident with an c. 1.6°C (0.4 ‰ increase in benthic $\delta^{18}O$) drop in bottom-water temperatures (Müller et al., 1991) and indicative of further cooling and intensification of circum-antarctic circulation. Bolboforms disappear just before planktic foraminiferal $\delta^{18}O$ values indicate significant warming of surface waters at c. 6.5 Ma, supported by the presence of temperate and low-

latitude diatom and silicoflagellate assemblages (Froelich et al., 1991). This suggests that the STF migrated southward over Site 704 (Fig. 11). Pujol and Bourrouilh (1991) reported that coiling direction changes in *Neogloboquadrina pachyderma* indicate Site 704 was closer to the STF in the Late Miocene but closer to the AAPFZ in the Late Pliocene and Quaternary. The earliest IRD in Hole 704B occurs at c. 4.2 Ma, further indicating the site was close to the northern edge of the AAPFZ at this time (Allen and Warnke, 1991).

Within the four Palaeogene *Bolboforma* Zones in the South Atlantic holes (Fig. 3), up to 10 *Bolboforma* species are recorded (Spiegler, 1991). This compares with only 5 species in the three equivalent zones at Maud Rise (Kennett and Kennett, 1990). This may indicate more favourable palaeoceanographic conditions existed for bolboforms in the South Atlantic, and that the Maud Rise locality was close to the southern limit of their ecological range.

Region D - Central Kerguelen Plateau

The modern location of all Leg 120 sites is 500-900 km south of the AAPF (Schlich and Wise, 1992), with bolboforms recovered from Holes 747A, 748B, 749B, 750A (one sample only), and 751A (three samples only) (Mackensen and Spiegler, 1992). Bolboforms were not as common in sediments from Hole 749B as 748B, but exhibit a similar record in terms of species and zonation (Mackensen and Spiegler, 1992). To simplify palaeoceanographic reconstructions, details of the Palaeogene species reported from Holes 748B and 749B, and of the Neogene species from Hole 747B are used here.

Palaeogene record

During the latest Cretaceous-earliest Palaeocene there was sharply reduced bioproductivity at c. 55°S at the southern end of Broken Ridge, northern Kerguelen Plateau (Rea et al., 1990). In the Middle Eocene (c. 42 Ma) the southern margin of Broken Ridge was uplifted about 2.5 km as a result of intra-plateau rifting between the ridge and Kerguelen Plateau (Schlich and Wise, 1992), which must have had a major impact on palaeocirculation. Lazarus and Caulet (1993) reported no provincialisation of warm-water radiolarians in Early Eocene times from the southern Indian Ocean (Crozet Basin), but a dramatic change to a subantarctic assemblage

in the Middle Eocene of Hole 748B, to an antarctic assemblage in upper Eocene-lower Oligocene sediments. Both planktic and benthic foraminiferal $\delta^{18}O$ records from Hole 748B exhibit significant enrichment (0.6-1.0‰ planktic and 1.2‰ benthic) in the uppermost Eocene to lowermost Oligocene records (Zachos et al., 1992). Associated with this change in $\delta^{18}O$ is a dramatic increase in cold-water nannofossil species, a decrease in carbonate accumulation, an increase in biosiliceous sediment, a shift of 0.7‰ (from 0.71‰ to 1.4 ‰) in benthic $\delta^{13}C$ values, and the appearance of IRD at c. 117-115 mbsf (Breza and Wise, 1992; Zachos et al., 1992). Similar $\delta^{18}O$ enrichment is reported from Site 744, south of 748B (Salamy and Zachos, 1999), suggesting it was a regional phenomenon.

Together these changes indicate there was significant cooling of both surface and intermediate waters which may support the migration of first the proto-STF, then the AAPF, northwards over the site (Figs. 6 and 7). The increase in the benthic $\delta^{13}C$ values is not evident in the planktic record, suggesting a change in chemistry at the source of the intermediate waters bathing the site. Specifically, this could indicate that the source of the intermediate waters was getting closer to the site, resulting in waters bathing the site being younger and more nutrient-depleted (Zachos et al., 1992). As the front generating SCIW/AAIW is the AAPF, this suggests it migrated northwards at this time (Fig. 7).

Bolboforma are reported in Hole 748B from 180.6-111.3 mbsf, in middle Eocene to lower Oligocene sediments (Mackensen and Spiegler, 1992). Their presence coincides with a cooling trend in the $\delta^{18}O$ record starting at c. 170 mbsf, c. 46-44 Ma (Zachos et al., 1992). Prior to appearance of IRD (c. 116 mbsf) and biosiliceous sedimentation (Breza and Wise, 1992), which are taken to indicate arrival of the proto-SAF, the site would have been located between the STF and proto-SAF (Fig. 7). The $\delta^{18}O$ values remain heavy after the isotope shift, indicating the site stayed within the cool subantarctic zone. The rare occurrence of bolboforms after the earliest Oligocene IRD event, and their absence in the rest of the core from 4 m above the IRD (still Early Oligocene), further support the site being located south of the proto-SAF (Fig. 9).

Neogene record

Late Miocene-Early Pliocene (c. 10-4 Ma) bolboforms are reported from Hole 747A on Central Kerguelen Plateau, north of Sites 748 and 749 (Mackensen and Spiegler, 1992). They were found from 66-29.5 mbsf, with the zonation extending from the *Bolboforma compressispinosa* Zone to the *Bolboforma intermedia* Zone (Fig. 3). This is the same zonation as in Leg 90 holes (Grützmacher, 1993; Crundwell et al., 1997) and in Hole 704B (D. Spiegler, pers. comm., 1998 unpublished data). The upper Miocene sediments of Hole 747A from 60-34.3 mbsf are foraminifera- and diatom-bearing nannofossil ooze, while the Plio-Pleistocene sediments through to the sea bed change to foraminifera-bearing diatom ooze (Leg 120 Shipboard Scientific Party, 1989). As for other sites, the presence of diatom ooze is taken to indicate proximity of the SAF, marking the northern margin of the AAPFZ (Burckle and Cirilli, 1987). Upper Miocene nannofossil ooze suggests Hole 747A was at this time located north of the AAPFZ, with the change to diatom ooze representing northward migration of the SAF over the site (Fig. 11) where it has remained throughout the Plio-Pleistocene. The overall surface-water temperatures derived from the radiolarian assemblage suggest the site has been south of the AAPF for much of the Neogene, but subantarctic radiolarian species are common in the uppermost Miocene-lowermost Pliocene sediments indicating slightly warmer conditions (Leg 120 Shipboard Scientific Party, 1989). This slight warming of surface waters occurs at the same time as the bolboforms appear and is taken to reflect southward migration of the SAF over the site (Fig. 12). Return of cooler surface waters during the middle Pliocene is indicated by minor amounts of IRD in the upper 20 m of the hole (Leg 120 Shipboard Scientific Party, 1989) which suggests that by this time the fronts had migrated northwards again.

As Site 747 is currently south of the AAPF, it may be possible to track the continued northward migration of the AAPF using the sediment compositional changes linked to oceanic fronts north of this site. The only site north of Site 747 with sufficient core recovery is Site 737 on Northern Kerguelen Plateau which sits within the modern AAPFZ (Baldauf and Barron, 1991), but south of the AAPF. In Hole 737A the transition from upper Miocene nannofossil ooze to diatom ooze occurs at 245 mbsf, at approximately 6.3 Ma (Baldauf and Barron, 1991; Bohrmann and Ehrmann, 1991). This probably marks migration of the SAF over Site 737 at this time (Fig. 11).

However, between 263-157 mbsf (150 mbsf = c. 5.8 Ma) the cool-water diatom assemblage also includes warm-temperate diatoms, typical of low-mid latitudes (Baldauf and Barron, 1991). Above this depth level the Pliocene assemblage is again representative of the Southern Ocean (Baldauf and Barron, 1991). Given the complicated nature of the modern AAPF structure in this part of the southern Indian Ocean (Belkin and Gordon, 1996), it would appear that the frontal structure did not reach something approaching the modern situation until the Pliocene (Fig. 12).

DISCUSSION

Pulsed nature of *Bolboforma* records

The pulsed nature of the *Bolboforma* record in Hole 593 (Crundwell et al., 1997) and at Maud Rise (Kennett and Kennett, 1990) suggests an intermittent bloom or period of stable conditions followed by very rapid changes in environmental conditions within a few or several 1000 years. Kennett and Kennett (1990) suggested that although there are only five *Bolboforma* species in some of the Maud Rise samples, the number of specimens (up to 55% by wt of the >63 μm size fraction) indicated there were large blooms, and that the low calculated flux rates in other samples was suggestive of intermittent rather than continuous productivity. Bolboforms in some Hole 593 samples make up to c. 10% of the >150 μm fraction (by vol.). The occurrence of single species 'assemblages' in most upper Miocene samples from Hole 593 (Crundwell et al., 1997) may reflect some form of environmental stress resulting in bolboform blooms with the tests being transported away from the source population. Single species assemblages are also reported from the North Atlantic (Poag and Karowe, 1986). This lack of species diversity with large numbers of specimens is characteristic of high-latitude marine ecology (Kennett and Kennett, 1990). The bolboform diversity appears to decline both towards the tropics (e.g. Leg 90 sites from c. 12 to 4 species) and towards Antarctica, south of the AAPFZ.

Subsurface watermass emplacement of *Bolboforma* at Southwest Pacific sites

In Southern Ocean sediments the presence of bolboforms generally coincides with indicators of subantarctic conditions. However, this is not always the case as in the Southwest Pacific (Region A) Palaeogene sediments from Holes 277, 592, and 593, and the Neogene sediments from Holes 590B, 592, and 593.

As Hole 592 contains both Eocene bolboforms and tropical radiolarians, whereas Hole 593 only contains bolboforms, suggests conditions at Site 592 were warmer than at Site 593. Caulet (1986) makes the observation that these warm-water radiolarians probably arrived at Site 592 via flow in a southern subtropical gyre. The absence of radiolarians in Hole 593 could indicate that this subtropical flow did not reach as far south as this site. As the thermal gradient through the Tasman Sea increased in the Late Eocene, with subsequent front formation as inferred by Murphy and Kennett (1986), the partitioning of Tasman surface waters appears to have prevented further radiolarian-containing tropical waters from entering the region, indicated by the absence of this group from the remaining sediments in Hole 592.

The absence of radiolarians in Hole 593 indicates the bolboforms did not arrive via subtropical gyre flow. Equally, when Early Oligocene SSPTs warm at Site 593 (and cooling at Site 277 further south) (Murphy and Kennett, 1986) bolboforms disappear from Site 593 (Grützmacher, 1993). The most likely mechanism is that the bolboforms arrived in the Tasman Sea via a subsurface watermass.

In Hole 590B the presence of very small numbers of bolboforms in upper Miocene sediments coincides with a c. 3°C cooling of surface waters, but with calculated SSPTs still c. 20°C (Kennett, 1986). The cool subtropical/temperate foraminiferal assemblage in Hole 593 (Jenkins and Srinivasan, 1986) associated with the bolboforms indicates that this site (and Sites 592 and 590 to the north) remained north of the STF throughout the Neogene. Despite the bolboforms being associated with both subtropical SSPTs (Hole 590B) and temperate foraminiferal assemblages (Holes 592 and 593), they are always associated with some evidence for cooling of surface waters in the Southwest Pacific.

If bolboforms are pelagic (Spiegler and Erlenkeuser, 2001) and lived to the south of the STF in subantarctic surface waters, as appears to be the case at the other Southern Ocean sites, what might account for their apparent cool subtropical association in the Tasman Sea? There are several possibilities, including: (a) bolboforms in this region are not restricted to subantarctic surface waters; or (b) they have arrived in the region via a subsurface watermass, likely the SCMW (Southern Component Mode Water) or SCIW (Southern Component Intermediate Water); or

(c) other regions north of the STF have not been sampled at sufficient resolution to show up detailed palaeoceanographic conditions associated with the bolboforms; or (d) there is a lack of suitable sites above the CCD, north of the STF in regions away from the Tasman Sea where carbonate sediments can accumulate.

Outside the Tasman Sea region, bolboforms are only associated with subantarctic conditions. The only site which has good evidence for the STF migrating across it is Hole 704B in the South Atlantic. Here bolboforms disappear from sediments when cool subtropical surface waters bathe the site, and return when the STF migrates northwards and reintroduces subantarctic surface waters over the site (Westall and Fenner, 1991). This strongly suggests that the bolboforms are restricted to warm subantarctic surface waters and, consequently that of the options given above, subsurface transport best explains their presence at sites north of the STF. The modern STF is a very effective barrier to surface-water transfer across it (Chiswell, 1994), effectively necessitating a subsurface mechanism for transfer. The other mechanism for surface waters to get across the STF is via large, mesoscale eddies which have been reported along this front (Leg 181 Shipboard Scientific Party, 1999), but these would not result in long distance transfer of surface waters.

In the southern hemisphere, non-tropical regions where calcareous sediments can accumulate above the CCD and north of the SAF appear to be limited to Lord Howe Rise in the Tasman Sea, Campbell Plateau, the northern margin of the South Australia Basin (Leg 182), and parts of the South Atlantic (e.g., Site 704). So areas which might record SCIW *Bolboforma* transport away from the Southern Ocean are limited. One possibility could be ODP cores along the ocean ridges as they are occasionally shallow enough to accumulate calcareous sediments. Two areas in the Southwest Pacific which are bathed by modern AAIW and from which *Bolboforma* have recently been reported are Campbell Plateau (Site 1123; Leg 181 Shipboard Scientific Party, 1999; M. Crundwell, pers. comm., 2000 unpublished data) and South Tasman Rise (Leg 189 sites; J. Kennett, pers. comm., 2000). Many previous investigations in these areas (Leg 90 and Leg 29) did not recognise *Bolboforma* in the sediments, and that could well reflect a lack of awareness of this microfossil group rather than their absence.

Bipolar nature of *Bolboforma* distribution

Bolboforms are reported in Tertiary sediments from the North Atlantic and in northern hemisphere onshore drill sites where they exhibit a similar biozonation to that of the Southern Ocean cores (Fig. 3). As the oldest known bolboforms occur in Hole 277, south of New Zealand this suggests there must have been some mechanism to disperse the bolboforms into northern hemisphere high latitudes from high southern latitudes. The tropical oceans are formidable barriers to cool-water microfossils and transport across the ocean fronts is unlikely (Darling et al., 2000). However, using the bipolar distribution of planktic foraminifera, Darling et al. (2000) demonstrated that it was possible for cool-water specimens (and therefore their genes) to reach the opposite polar region via upwelling systems and cool subsurface boundary currents. It is possible that a similar scenario could apply to the bolboforms, especially if the transport mechanism is the SCIW, the forerunner of the modern AAIW. This watermass travels northwards along the western margin of the Atlantic and into the Caribbean Sea where it gets mixed into the regional watermasses (Tomczak and Godfrey, 1994). This certainly mirrors the *Bolboforma* distribution as it is presently known, with both Palaeogene and Neogene sites occurring along the east coast of North America (Spiegler and von Daniels, 1991). In the South Atlantic there are few areas where carbonate sediments are preserved, hence sites with bolboforms are somewhat limited. The eastern Atlantic distribution is less clearly defined, with mostly Neogene sites in the central and eastern North Atlantic and onshore Europe (Spiegler and von Daniels, 1991). The global distribution of bolboforms between the SAF and its northern hemisphere equivalent may reflect the pathways of AAIW or its equivalent predecessor, but further investigation is beyond the scope of this paper.

Neogene oceanic gateways and Tasman Sea palaeoceanography

Both the Indonesian and Panama gateways were open to deep-water flow during the early Middle Miocene (Hamilton, 1979; Duque-Caro, 1990; Burton et al., 1997) resulting in largely uninterrupted westward-flowing equatorial surface currents, equivalent to the modern Southern and Northern Equatorial Currents (Kennett et al., 1985). Any return flow as an Equatorial Undercurrent would have been weaker due to the lower equator-to-pole thermal gradients, with a resultant reduction in strength of both the trade winds and the westerlies.

From the Middle Miocene onwards flow through the Indonesian gateway became more and more restricted due to continental collision with the northwards-moving Australian plate (Hamilton, 1979). As a result, equatorial flow was no longer able to pass through the Indonesian archipelago in the same volume as before (Kennett et al., 1985). The equatorial water is likely to have 'backed up' north of Papua New Guinea to initiate the Western Pacific Warm Pool, to then be deflected in western boundary currents and as equatorial return flow (Kennett et al., 1985; Jenkins, 1992). Consequently, increased flow within the proto-East Australian Current (EAC) is inferred, as it is the western boundary current linked to the subtropical gyre (Tomczak and Godfrey, 1994). Given that flow along the Tasman Front is directly linked to the EAC (Heath, 1985), it is assumed that this front did not exist in anything like its modern form prior to this increase in flow when surface watermasses in the Tasman Sea would have been less partitioned. This may account for the reported difficulty in determining which planktic foraminiferal biozonation scheme, warm or cool subtropical, is most appropriate for use with Tasman Sea samples, as the Neogene microfossil assemblages in both the warm and cool regions lack certain characteristic species at this time (e.g. Jenkins and Srinivasan, 1986; Leg 90 Shipboard Scientific Party, 1986a; 1986b).

In Hole 208 (equivalent to Site 588 - northern Lord Howe Rise) there is a significant change in the planktic foraminiferal population in the Middle Miocene, where temperate species begin to dominate over tropical ones (Kennett and Srinivasan, 1984). In Hole 206 (equivalent to Sites 590 and 591) this also occurs as the assemblage becomes dominated by temperate species, but with some rare but persistent tropical elements (Kennett and Srinivasan, 1984). In the southern Tasman Sea any subtropical elements in the planktic foraminiferal assemblage disappear from Hole 593 at the same time as the Late Miocene last occurrence of bolboforms (Crundwell, in prep.). The changes in planktic foraminiferal assemblage dominance indicate a general cooling of surface waters in the Tasman Sea. In addition, the latitudinal position of the changes is taken to reflect partitioning of the Tasman Sea by deflection of warmer waters along the Tasman Front due to invigorated EAC flow. As there is no evidence for radical changes in circulation in the southern Tasman Sea (no major unconformities or changes in sediment type) it is assumed that AAIW continued to flow into the Tasman Sea throughout the

remaining Neogene, so the absence of bolboforms is more likely to be due to bolboform ecology than to a lack of preservation.

A few sites containing *Bolboforma* are reported west of the Panama region during the Middle Miocene (Spiegler and von Daniels, 1991). Uplift in this region, starting c. 16 Ma, began to restrict the gateway but not actually close it (Duque-Caro, 1990). By c. 12 Ma the restriction was affecting the surface-water circulation (Mullins and Neumann, 1979; Lyle et al., 1995). These 'tropical' bolboforms either indicate this group is tolerant of warm surface waters, and appear to have been able to cross oceanic fronts, or more likely they arrived via a subsurface watermass as discussed previously.

Circum-Antarctic Palaeogene *Bolboforma* distribution

Similarity of the bolboform and other microfossil biostratigraphies throughout the Eocene and Oligocene at sites around Antarctica is suggestive of some sort of circum-Antarctic connection. There was a shallow opening of the Tasmanian gateway prior to c. 33-31 Ma (Jenkins, 1974; 1993a; Leg 189 Shipboard Scientific Party, 2001) allowing flow between the Indian and Pacific Oceans, and once the Drake gateway opened by the Late Oligocene (Barker and Burrell, 1977; Lawver et al., 1992) full ACC development was possible. However, the bolboform distribution is "circum-antarctic" prior to both these gateways opening, and assuming this group is pelagic and restricted to subantarctic waters, the distribution needs consideration. One possible early connection between the Pacific, South Atlantic, and Indian Oceans might have been via a West Antarctic Seaway (WAS). The development of the West Antarctic Ice Sheet is inferred to have occurred in the Late Miocene (Kennett et al., 1975), so prior to this, the area now covered in sea ice was presumably ice free, at least in summer (Fig. 9). Therefore surface-water flow through the archipelago could have been possible, providing a circum-antarctic marine connection between the three oceans (Figs 5 and 7).

The recording by Cande et al. (2000) of rifting along the Balleny fracture zone to link the West Antarctic rift system with the Alpine Fault in New Zealand added impetus to the idea of the existence of a possible WAS. The rifting is linked to initiation of uplift along the Transantarctic Mountains after c. 55 Ma, and was terminated by c.

27 Ma (Cande et al., 2000). This suggests the WAS could have existed from Early Eocene to Late Oligocene (Lawver and Gahagan, 1998) and would have enabled ACC-like connections to exist in the Southern Ocean. By the Late Oligocene the main Southern Ocean gateways were opening as the WAS was closing. Large unconformities in the lower Oligocene of Hole 277 and in the Kerguelen Plateau holes might possibly related to this pre-ACC flow. Once the Tasmanian gateway opened, a proto-ACC flow would have been possible via the WAS rather than through Drake gateway. Although such a proto-ACC flow is unlikely to have extended to the depths of the modern ACC, the forcing of large volumes of water through a shallow gap is likely to have generated swift currents and the potential for sediment erosion. The upper Oligocene unconformity in the Bellinghausen Basin in Hole 325 (Leg 35 Shipboard Scientific Party, 1976) could reflect the scour caused by the change in position of the proto-ACC circulation from the WAS to the Drake gateway, by the Late Oligocene.

CONCLUSIONS

Bolboforma represent an enigmatic group of marine microfossils which appear to have the potential to advance understanding of Cenozoic Southern Ocean biostratigraphy and palaeoceanography. In particular, distribution of *Bolboforma* species in Southern Ocean cores can be linked to warm subantarctic surface waters bounded by the Subtropical Front and Subantarctic Front.

The oldest record of *Bolboforma* to date, is in the lower Eocene of Hole 277 on Campbell Plateau, south of New Zealand (Grützmacher, 1993) (Fig. 3). They are then not reported again until the middle Eocene, and then in three areas: the Southwest Pacific (Region A), Maud Rise/South Atlantic (Region C), and Kerguelen Plateau (Region D). The Palaeogene circum-antarctic distribution and biostratigraphy of the bolboforms suggest some connection existed between the South Atlantic, Indian, and Pacific Ocean systems at higher latitudes prior to full opening of both the Tasmanian and Drake gateways by c. 25 Ma.

A possible link via a West Antarctic seaway linking Ross Sea with Weddell Sea during the Early Eocene to Late Oligocene is invoked (Fig. 9). Initiation of partial circum-antarctic flow in Southern Ocean sediments is often marked by a lower

Oligocene unconformity inferred to be associated with the opening of the Tasmanian gateway (e.g. Leg 21, Kennett et al., 1972; Kennett et al., 1975). In Bellinghausen Basin (Hole 325; Region B), a significant unconformity is dated as Late Oligocene/ Early Miocene and has been associated with opening of the Drake gateway (Leg 35 Shipboard Scientific Party, 1976). Full Antarctic Circumpolar Current development was not possible until both the Tasmanian and Drake gateways were fully open to circum-antarctic circulation by c. 25 Ma, yet large Early Oligocene unconformities exist in many holes prior to this. If 'proto-Antarctic Circumpolar Current' flow through a West Antarctic Seaway was possible, it may account for these unconformities.

The highest bolboform diversity at Maud Rise, Kerguelen Plateau, and Campbell Plateau occurs concurrently with significant cooling of isotopically-derived Late Eocene-Early Oligocene sea surface palaeotemperatures to values of 8.5-6°C, similar to those characterising modern subantarctic surface waters, south of the Subtropical Front. However, the upper Eocene-lower Oligocene bolboforms from Southwest Pacific sediments (Region A) are associated with cool subtropical sea surface palaeotemperatures and subtropical microfauna/flora, unlike the truly Southern Ocean sites where the bolboforms are associated with subantarctic conditions.

By middle Oligocene, surface-water conditions at both Maud Rise and southern South Atlantic sites had cooled sufficiently to force migration of bolboforms northward of these sites, as indicated by the onset of diatomaceous sedimentation linked to the proto-Subantarctic Front (Figs. 7 and 8). There are no reports, to date, of upper Oligocene to uppermost lower Miocene bolboforms in any Southern Hemisphere sites, except in Bellinghausen Basin (Region B), where a few bolboforms are present that are possibly linked to latest Early Miocene warming, after which the site cooled again to antarctic conditions and bolboforms disappear.

In the Late Miocene the absence of bolboforms in northern Tasman Sea sediments, the limited numbers in central Tasman Sea sites, and the increased occurrence and numbers of species in more southern sites reinforce the suggestion that they have a preference for cooler surface-water temperatures (Fig. 11). However, unlike the

Southern Ocean sites, the bolboforms co-exist with temperate or cool subtropical microfossil assemblages, north of the Subtropical Front.

The anomalous association of bolboforms with cool subtropical microfossil assemblages in the Southwest Pacific through the Cenozoic is suggested to be the result of their entrainment into Southern Component Intermediate Water which transported them northwards from their original surface-water, subantarctic growth habitat south of the Subtropical Front, into the Tasman Sea, where the tests settled out into the Challenger Plateau sediments.

The bipolar distribution of bolboforms may also be linked to intermediate depth transport in the Southern Component Intermediate Water from the Southern Ocean to the North Atlantic. Consequently where other proxies indicate other than subantarctic conditions its it likely that subsurface transport of bolboforms has occurred. As a result bolboforms can be used to recognise Southern Ocean subtropical and subantarctic frontal zones, but caution is needed as the subsurface transport in intermediate waters (i.e. the Southern Component Intermediate Water/ Antarctic Intermediate Water) can introduce them into warmer zones which do not reflect the original subantarctic conditions preferred by the group.

The upper Miocene-lowermost Pliocene *Bolboforma* record from Kerguelen Plateau (Region D) assists with unravelling the complicated frontal structure associated with this platform (Fig. 12). The last occurrence of bolboforms in the Southwest Pacific at c. 8 Ma corresponds with reorganisation of Southern Hemisphere circulation as a consequence of restriction of both the Indonesian and Panama gateways.

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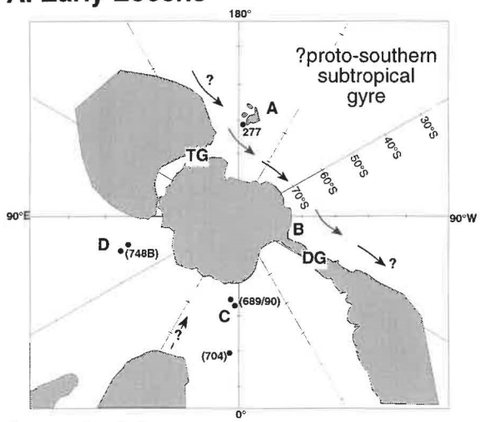
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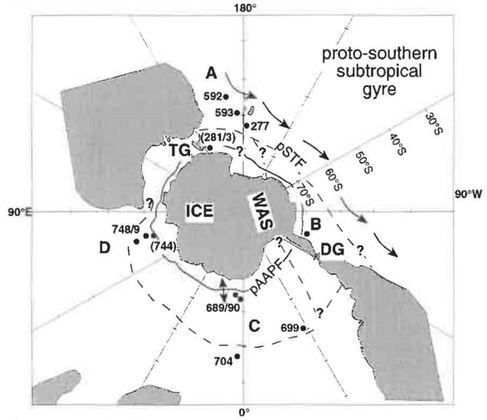
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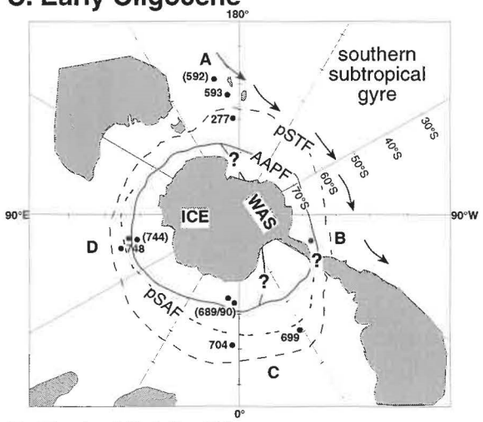
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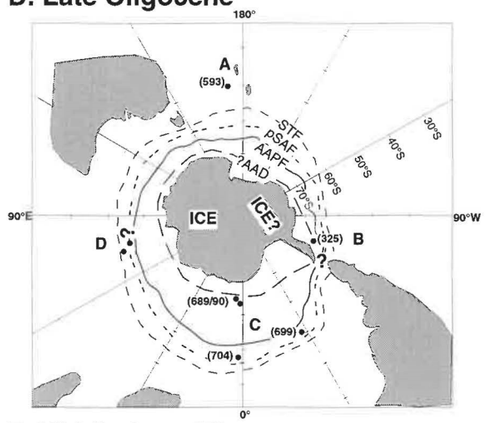
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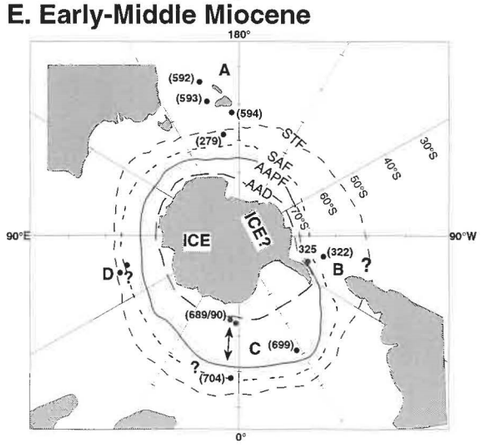
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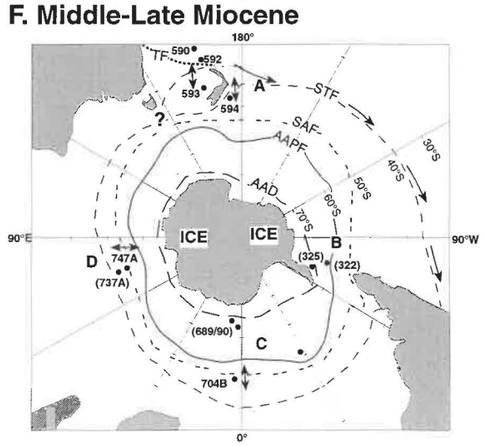
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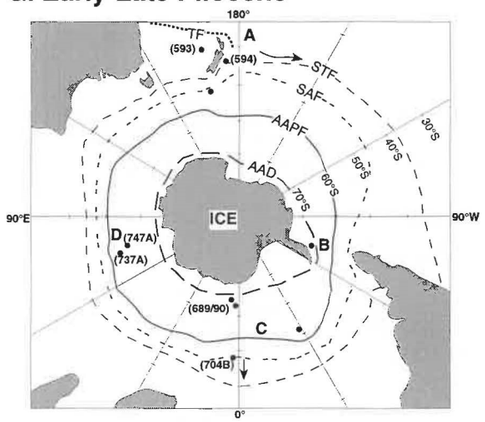
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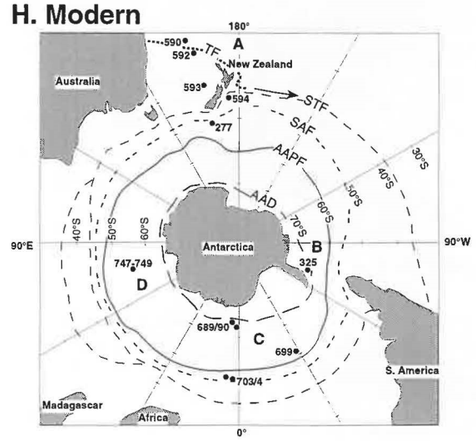
F. Middle-Late Miocene



G. Early-Late Pliocene

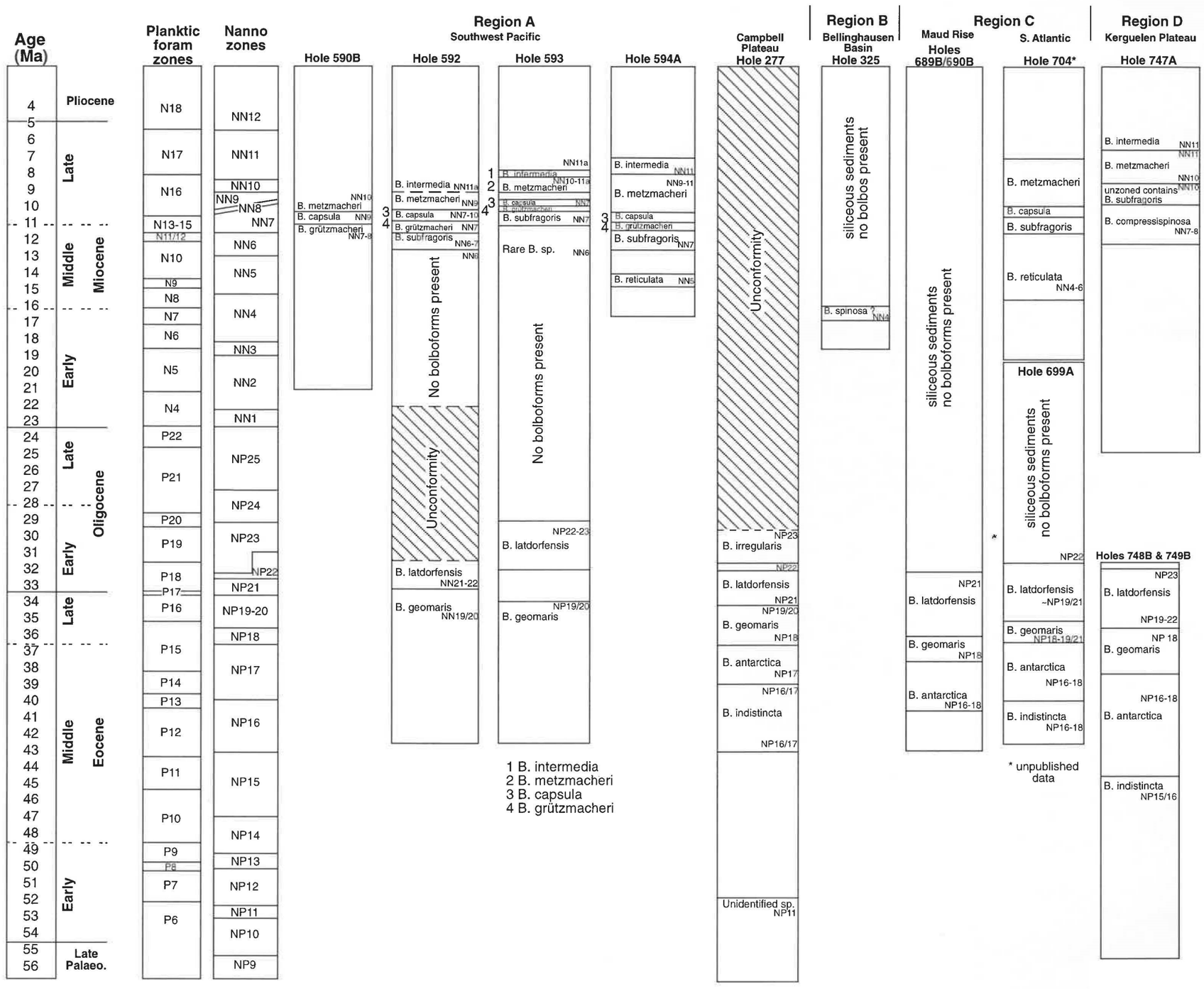


H. Modern



Chapter 5

Figures: 1, 4, 5, 7, 8, 10, 11 and 12



Chapter 5

Figure 3. Southern Ocean Bolboforma biostratigraphy correlated with calcareous nannofossil and planktic foraminiferal biostratigrahy for the region (after Rögl and hochuli, 1976; Kennett and Kennett, 1990; Spiegler, 1991 and unpublished data; Mackensen and Spiegler, 1992; Grützmacher, 1993; Berggren et al., 1995 and Crundwell et al., 1997)

Chapter 6

Using Wavelet Analysis For Investigating Palaeoclimate: Is It An Improvement Over Spectral Analysis?

Having once elaborated the basic features of the present terrestrial climate, we would be in a position to explore and describe the climates of ancient times...The new theory would thus enable us to go beyond the range of direct observation.

M. Milankovitch (1941)

Using Wavelet analysis for investigating palaeoclimate: Is it an improvement over spectral analysis?

ABSTRACT

Data from Southwest Pacific DSDP Site 593 are used to illustrate the application of Wavelet analysis to proxy climatic data. Wavelet analysis can produce global averaged variance versus period or frequency plots comparable to Fourier analysis periodograms. However, Wavelet analysis has the additional ability to assess the changes in variance at a range of periods or scales over time, or with depth for up core data. This provides additional information about the behaviour of the proxy climatic indicators that may assist with interpretation of irregularly sampled data, and data affected by differential compaction and losses due to erosion and poor core retrieval.

INTRODUCTION

Milutin Milankovitch (1941) recognised mathematical patterns in the orbital parameters of the Earth and that these may have an affect on Earth's climate. These patterns implied cyclical changes over time periods of 20-400 ky. Climate data spanning multiple cycles are needed to demonstrate the existence of such cycles. It was not until the 1970s that sufficiently long and detailed chronologies could be established using ocean cores. Only then could the orbital patterns be applied to Cenozoic climatic change records.

Milankovitch climate oscillations have been inferred to cause considerable climatic variability (Imbrie and Kipp, 1971; Imbrie et al., 1984) as they operate by changing the seasonal distribution of insolation reaching the Earth (House, 1995). The main cycles are precession, obliquity and eccentricity that can combine to give quite complex patterns. These cycles affect the outer atmosphere and the amount of heat energy reaching the Earth's surface and may therefore affect the freezing/thawing rate of any ice accumulation as well as sea level, climatic regimes and associated erosion/weathering processes and hence sedimentation rates in the ocean systems. The three orbital frequencies vary in relation to the equator (House, 1995).

The precession frequencies (19-23 ky) are related to the precession of the equinoxes and the movement of the perihelion (House, 1995). As the Earth spins, the axis is wobbling in a circle. Although the axis appears to point to the same position in the galaxy (currently Polaris, the North Star), it is actually slowly changing its position, or precessing which takes c. 19-23 ky. This results in the seasons occurring at different points along the Earth's orbit. Currently the perihelion occurs in January during the southern summer, but in c. 11.5 ky from now it will occur in June. As it approaches a June perihelion, the global temperature decreases.

The obliquity of the ecliptic refers to the Earth's axis which reaches a minimum tilt of 21.5° and a maximum of 24.4°, with the change taking c. 41 ky (House, 1995). Changing the tilt angle alters the seasonal contrast and the meridional insolation gradient, which affects ocean circulation, with a reduction in contrast leading to global cooling.

The eccentricity orbital parameter (100 ky and 400 ky) changes the Earth's orbit from almost circular to more ellipsoid (House, 1995). This alters the amount of insolation received, with the modern Earth receiving 7% more solar radiation during perihelion than aphelion, but this can increase to c. 30% at the extreme of the ellipse (House, 1995). Hence seasonal variation is greater when the orbit is more eccentric, even if the Earth is further from the Sun.

FINDING THE CYCLES — FOURIER AND WAVELET ANALYSIS

Many time series in the Earth sciences contain dominant quasi-periodic signals that vary in both amplitude and frequency over long periods of time. Various numerical techniques have been developed to extract information about the characteristics of the forcing cycles that generate the observed signals. This paper will consider just two of these techniques: Fourier analysis and Wavelet analysis.

Fourier series are sums of sine and cosine waves, which can be used to approximate almost any time series, no matter how angular and irregular (Hubbard, 1996; Middleton, 2000). Fourier analysis involves determining the best-fit Fourier series by calculating the appropriate amplitudes of the component waves at fixed frequencies or periods. The result is often presented as the contribution made by each wave to the total variance, since the variance at any frequency is equal to the amplitude squared, in a plot of variance versus frequency known as a periodogram. Fourier analysis normally utilises equally spaced data, and is quicker to perform if the number of data points is a power of two. However, it is possible to undertake Fourier analysis on time series where the length is not a power of two, or are irregularly spaced (Press et al., 1989).

One difficulty with Fourier analysis is that the best-fit amplitude applies to the entire time series. This may not always be appropriate. Considering climatic data for example, quasi-periodic cycles such as El Nino Southern Oscillation (ENSO), North Atlantic Oscillation (NAO) and Interdecadal Pacific Oscillation (IPO) do not always influence weather patterns with the same strength (Goring and Bell, 1999; Kulkarni, 2000; Lau and Weng, 1995; Torrence and Compo, 1998). Therefore, any proxy indicators of weather (and climate) will reflect both the quasi-periodicity of the forcing phenomena and the strength of their interactions. A Fourier analysis assumes that

the nature of the interaction between the forcing phenomena and the proxy indicators remains constant over time.

DSDP Site 593 (1068 m water depth) is located in the Southern Tasman Sea on Challenger Plateau, an extension of the Lord Howe Rise (Figure 1). Previous studies on cores in the region have demonstrated the palaeoceanographic potential of sediments from the Challenger Plateau because of the relatively complete sediment accumulation through the Cenozoic (Kennett et al., 1975; Kennet and von der Borch, 1986). The core sections used comprise in excess of 80% carbonate sediment, dominated by calcareous nannofossils and planktic foraminifera, with small amounts of benthic foraminifera. The planktic component (nannos and forams) was sourced from Cool Subtropical Water where the major input is from the East Australian Current, via the Tasman Current (Fig. 1). The sea-floor sediments are bathed by Antarctic Intermediate Water, and probably have done so through the Neogene (see Chapter 3) and so the benthic forams have been influenced by cold, southern high-latitude water. The mud component of these sediments is composed mainly of calcareous nannofossils and minor amounts of terrigenous clays and juvenile foraminifera, so that this textural fraction is dominated by surface-water signals, and post-depositional changes on the sea floor.

The climate-proxy parameters in Hole 593 (Fig. 2) suggest that the magnitude of forcing oscillations may vary through the core, particularly for the planktic $\delta^{18}O$, which shows a reduction in the apparent amplitude of the oscillations with increasing depth. A Fourier analysis of these data provides a good approximation of the time series (Fig. 3). With the appropriate phase lags, the unsmoothed periodogram can be used to regenerate the original time series. However, most of the observed peaks in the periodogram are not statistically significant, and may not represent real oscillations. Further, it is expected that this core should display Milankovitch forcing. Although energy is present at 2.5 and 10-10.4 cycles per Ma (corresponding to 400 ky and 96-100 ky Milankovitch cycles), the periodogram is dominated by frequencies of less than 1 cycle per Ma. These frequencies are needed to reproduce the observed variation in the amplitudes of apparent oscillations in planktic values with depth, but do they represent real quasi-periodic forcing? If cycles at long periods are an artefact of the data analysis, the variance at shorter periods associated with

real cycles will be reduced as Fourier analysis partitions the total variance across all periods.

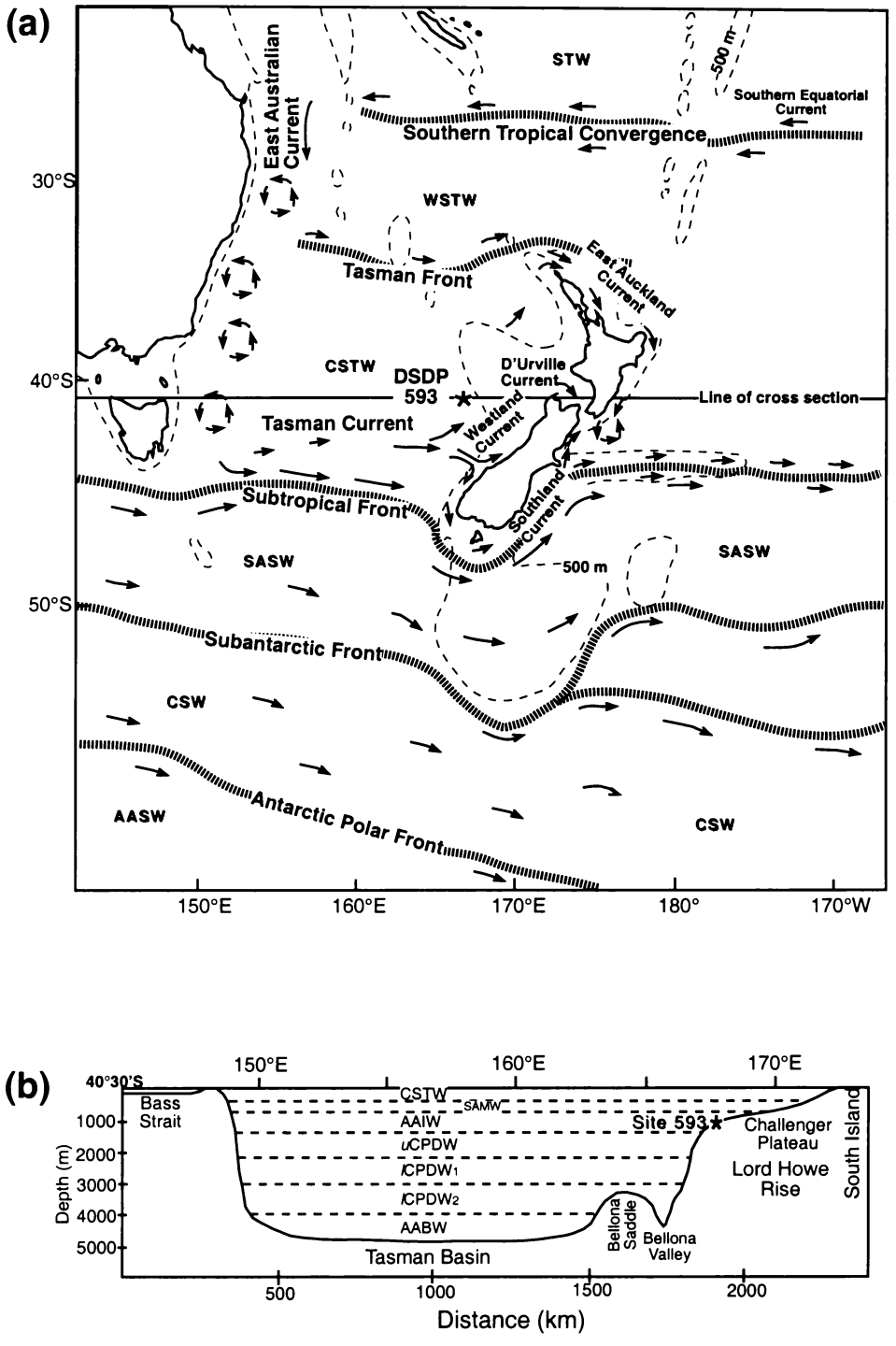


Figure 1 (a) Map showing the location of DSDP Site 593 in southern Tasman Sea, and the main surface watermasses, currents and oceanic fronts of the region. STW = Subtropical Water, WSTW = Warm Subtropical Water, CSTW = Cool Subtropical Water, SASW = Subantarctic Surface Water, CSW = Circumpolar Subantarctic Water; (b) Schematic cross section of the Tasman Basin at 40°30'S, showing the bathymetric position of Site 593 (40°30'S, 167°40'E) in 1068 m water depth, physiographical features of the basin and the watermasses found in the Tasman Sea; CSTW = Cool Subtropical Water; SAMW = Subantarctic Mode Water; AAIW = Antarctic Intermediate Water; uCPDW = upper Circumpolar Deep Water; lCPDW = lower Circumpolar Deep Water; AABW = Antarctic Bottom Water. (After Wyrtki, 1961; Wyrtki, 1962; Rodman and Gordon, 1982; Drewry, 1983; Heath, 1985)

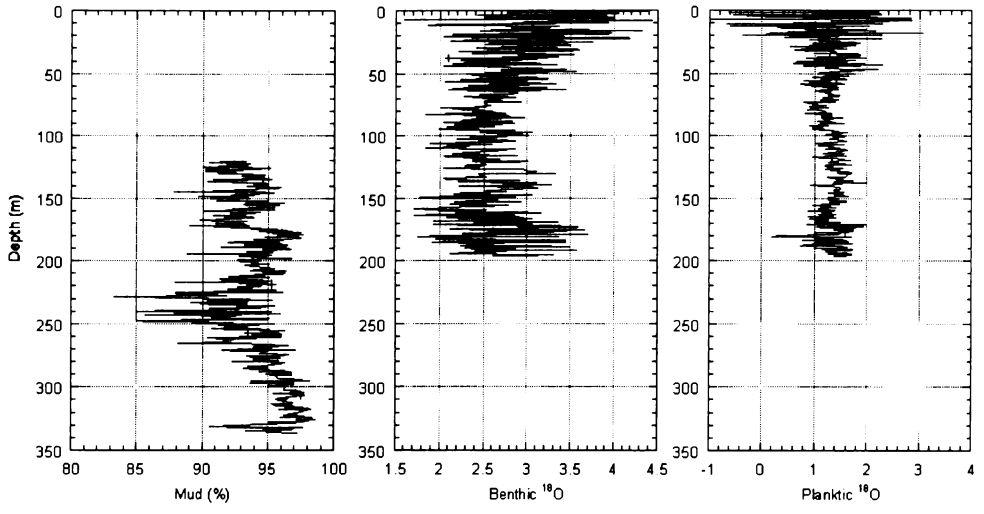


Figure 2 Data from Hole 593 used to illustrate the application of Wavelet analysis. Depth is measured relative to the sea floor, and mud % is cumulative. The depth data were converted to ages by assuming linear sedimentation rates between key dated samples (Chapter 2, Table 1).

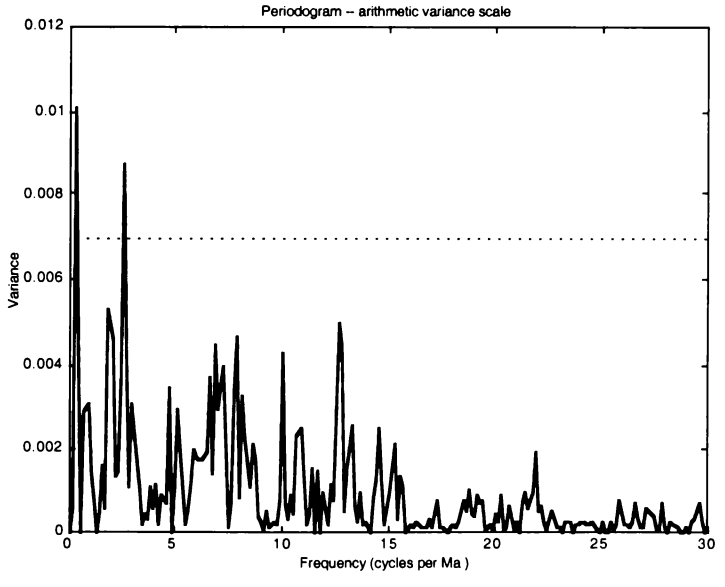


Figure 3 Unsmoothed periodogram determined by Fourier analysis from Hole 593 planktic $\delta^{18}O$ data. The dashed line corresponds to the 95% confidence level. Milankovitch forcing is expected to produce peaks at 2.5, 10.0-10.4, 23.3 and 45.5 cycles per Ma. Only the peak at 2.5 cycles per my (400 ky) is statistically significant. The 45.5 cycles per my peak is completely lost in noise and so the periodogram is truncated at 30 cycles per my.

An approach to dealing with this problem would be to subdivide the timeseries into small sections or windows and perform separate Fourier analyses on each window, converting the time series into a sequence of periodograms. However, the lowest

frequency (longest period) oscillation that can be detected by Fourier analysis depends on the length of the time series analysed. Therefore, by subdividing the time series, a limit is imposed on the oscillations that can be detected. The method could be improved if different window sizes were employed for each frequency band (scale) of interest: small windows for high frequency oscillations; and large windows for low-frequency oscillations.

This is essentially what Wavelet analysis does, although it goes a step further and also can combine non-cosine wave types to estimate the behaviour of the time series. Wavelet analysis provides estimates of the amplitude (variance) for each frequency considered at each time interval of the time series. Hence, instead of displaying the variance in frequency space (periodogram), a Wavelet analysis displays variance in time space. Since three variables are involved (time, frequency and variance) there are various ways of displaying the results. We have found that a contour plot of variance on a frequency versus time grid is the most useful, but taking averaged slices along frequency bands is also useful. Summing the variance over time produces a smoothed estimate of the global variance versus frequency, which is essentially the same as the periodogram produced by Fourier analysis for the same time series (Fig. 4).

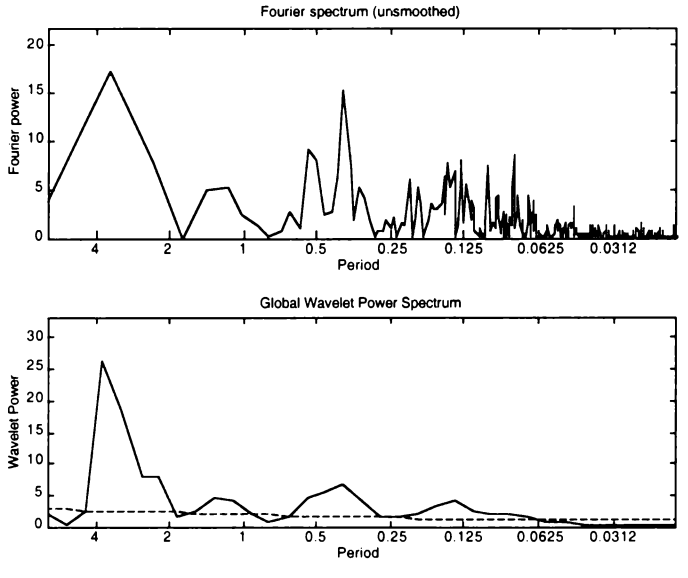


Figure 4 Comparison between Fourier analysis periodogram (plotted as variance against period) and the cumulative Wavelet variance versus period (global Wavelet power spectrum). The periodogram has not been smoothed, whereas the wavelet analysis results in a smoothed spectrum. However, the results are very similar, except for the absence of variance at very long periods (>4 my) in the Wavelet results.

MATLAB GRAPHICAL USER INTERFACE (GUI)

In order to facilitate Wavelet analysis, a GUI was developed (Fig. 5) that undertook any necessary resampling of core data before calling the Wavelet analysis routines developed by Torrence and Compo (1998). Resampling is used to adjust the data to a constant spacing and is not necessary for Wavelet analysis but is required for Fourier analysis. The statistical significance tests of Torrence and Compo (1998) also assume constant data spacing. To remind the user of the data characteristics, the *Check data* button determines basic statistics for the selected data. The statistics include the number of data pairs, the minima and maxima of the data pairs, and minimum, mean and maximum spacing of the depth or age variable.

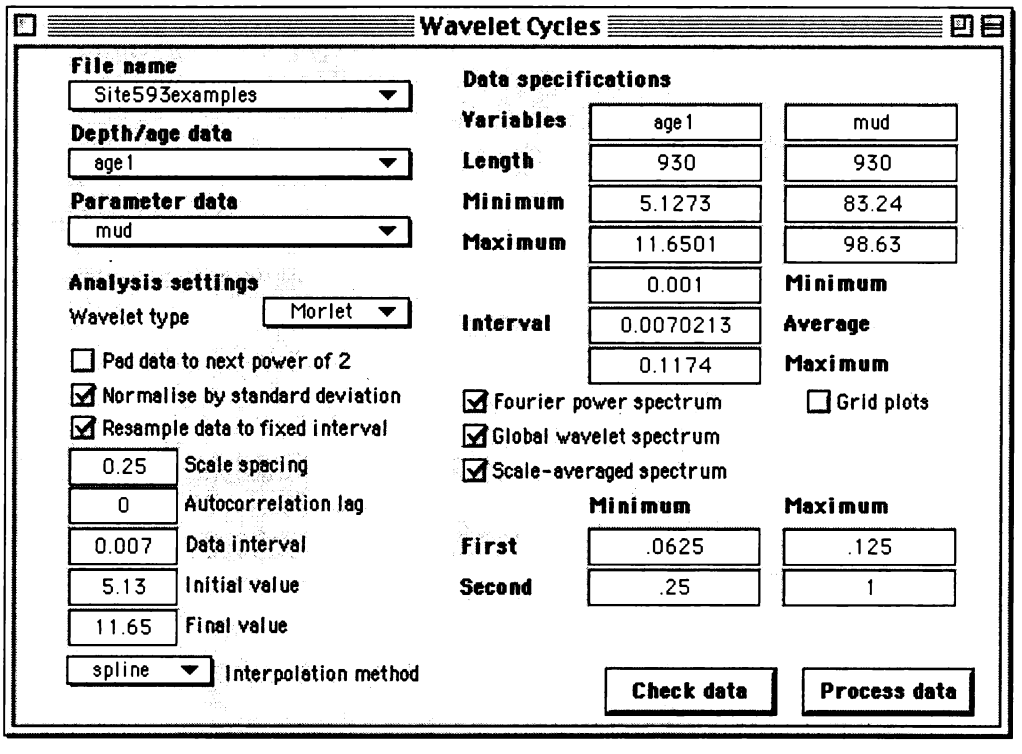


Figure 5 Matlab GUI used to facilitate Wavelet analysis of core data. The GUI is used to select mat files containing the data from a pop-up menu of mat files in the current directory. When a file is selected, the GUI then provides access to the data in the file via two data pop-up menus.

The number of data points need not equal a power of 2. Matlab can undertake Fourier and Wavelet analysis of data series of any length. However, Fourier analyses of time series with a length equal to a power of two are faster, so the time series can be padded with zeros to increase the length to the next power of two. Undertaking analyses on a PowerMac G3 did not reveal any advantage in undertaking padding.

The time series data are normalised by first subtracting the mean as recommended for Fourier analysis (Middleton, 2000). The GUI allows further normalisation by the standard deviation of the data, so that the observations become the distance in standard deviations from zero (Torrence and Compo, 1998). This is comparable to standardising a univariate parameter to a scaled normal variable for statistical analysis (Swan and Sandilands, 1995) and removes scale effects from observations, making it easier to compare different parameters from the same core. The data are resampled by specifying start and end points, and a required spacing. Interpolation can be undertaken using nearest neighbour, linear, spline or cubic schemes. For the Hole 593 data (Fig. 2), resampling has little effect on the results since there are only a few gaps that require interpolation. For most analyses, resampling is undertaken using the average time or depth interval and linear interpolation. Higher order interpolation techniques are available, but these can generate spurious data spikes. Unlike Fourier analysis, data outliers as illustrated below affect wavelet analysis. Therefore, interpolation needs to be undertaken with caution.

The GUI always undertakes a Wavelet analysis and plots the contoured variance and original time series. Optional output includes a Fourier analysis periodogram, modified to plot variance against period, and global and scale-averaged Wavelet spectra (similar to periodograms).

WAVELETS INTERPRETATION AND DISCUSSION

A comparison between the Fourier periodogram and the global Wavelet power spectrum for planktic $\delta^{18}O$ data (Fig. 4) shows a similar distribution of variance, except at long periods. Fourier analysis determines statistically significant variance at periods longer than 4 Ma (<0.25 cycles per Ma), while wavelet analysis does not. This suggests that aliasing has affected the Fourier analysis, reducing the significance of cycles at Milankovitch periods.

Figure 6 shows the normalised data and contoured variance distribution with age for all three data sets. For planktic $\delta^{18}O$, wavelet analysis highlights the higher variance that exists at shorter periods for sediments younger than 1 Ma and around 1.5-2.5

Ma compared to the rest of the core. This is not evident in the Fourier periodogram (Fig. 3), although it is suggested by the time series data (Fig. 2).

Two other parameters from core 593 have also been included (Fig. 6) for comparison. Time series data for benthic $\delta^{18}O$ doesn't show the same obvious variation in the magnitude of oscillations with increasing age evident in the planktic $\delta^{18}O$ (Fig. 2). However, wavelet analysis indicates that there are underlying oscillations in variance that display some features in common with the planktic $\delta^{18}O$ (Fig. 6). In particular, there is increased variance for sediments younger than c. 1 Ma, and the variance tends to decline with increasing age, until c. 5.5 Ma. Then benthic $\delta^{18}O$ displays increasing variance in contrast to planktic $\delta^{18}O$.

The % mud data do not completely span the same age range as the planktic and benthic $\delta^{18}O$ data, although there is an overlap from c. 5-7 Ma. The % mud content has an underlying decreasing trend with decreasing age (Fig. 2), which has not been removed for this analysis. The Wavelet analysis indicates that variance tends to increase with age (Fig. 6).

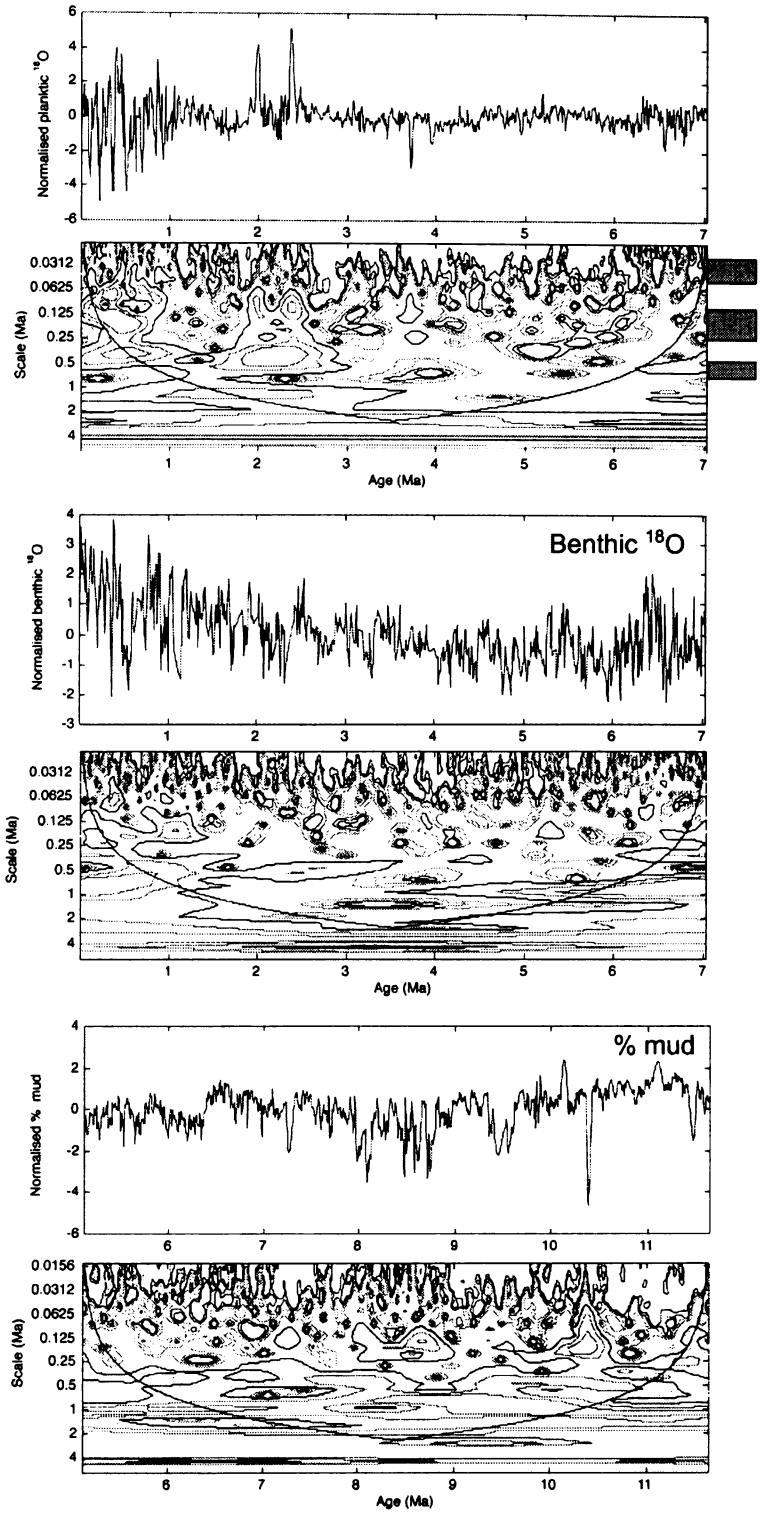


Figure 6 Wavelet analysis results for planktic $\delta^{18}O$, benthic $\delta^{18}O$ and % mud measurements from Hole 593. The upper plot in each pair is the input data normalised by standard deviation, and the lower is the contoured variance gridded by scale (Ma) and age down core. The solid curve on the contour plot represents the 95% significance level, with contoured areas above the curve being statistically distinguishable from noise. The correspondence between variance at short periods (<0.5 Ma) and the variability of the original core with age is clear. The scale bands corresponding to Milankovitch orbital forcing are indicated by shaded bars to the right of the planktic $\delta^{18}O$ contoured variance plot. Note that the % mud data plotted in the lower pair span a different age range from the planktic and benthic $\delta^{18}O$ isotope data, although there is almost 2 Ma overlap between 5 and 7 Ma.

It can be difficult to visualise the patterns displayed in variance contour plots such as those in Fig. 6. An alternative method of visualising the results is to take a slice along a scale band, providing a time series of average variance at a specific scale or narrow range of scales. This has been done for the Milankovitch periods at the scales indicated by the shaded bars in Fig. 6. Three bands corresponding to periods of 19-41 ky, 96-100 ky and 400 ky have been treated in this way (Figs. 7-9).

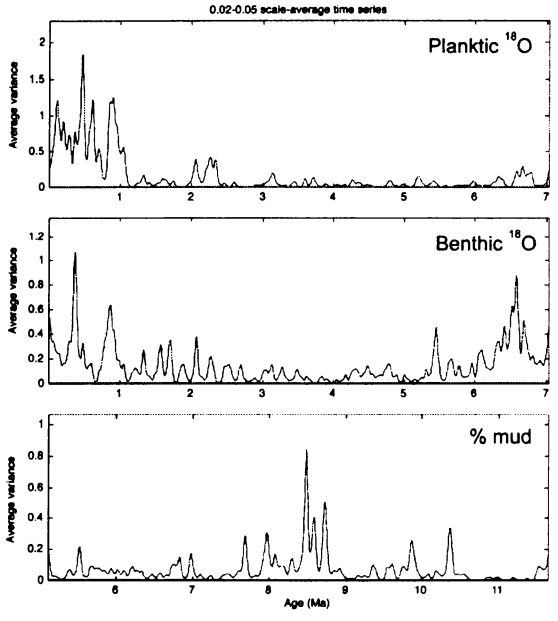


Figure 7 Average Wavelet variance for planktic $\delta^{18}O$, benthic $\delta^{18}O$ and % mud at the 0.02-0.05 Ma scale band. This includes the 19-23 ky and 41 ky Milankovitch orbital forcing cycles. The resolution of the Hole 593 data is insufficient to adequately separate these cycles by either Fourier or Wavelet analysis. Note that the % mud data plotted in the lower plot span a different age range from the planktic and benthic $\delta^{18}O$ isotope data, although there is almost 2 my overlap between 5 and 7 Ma. The horizontal line near the bottom of each plot represents the 95% significance level.

A general comparison between Figs. 7 to 9 shows that the plots are more detailed as the scale decreases, which corresponds to the structure evident in Fig. 6. Further, within any particular dataset, the behaviour at all Milankovitch periods is similar, indicating a consistent response. However, there are differences between the three parameters considered. Oscillations in planktic $\delta^{18}O$ are well developed at 19-41 ky Milankovitch periods for the youngest 1 Ma of the core, and less so for older parts of the core. This is also evident for the 96-100 ky cycle, where the magnitude of variance peaks decreases systematically with increasing age. For the longer period 400 ky, variance is notably higher for the last 3 Ma of the record, although it does appear to be increasing around 7 Ma.

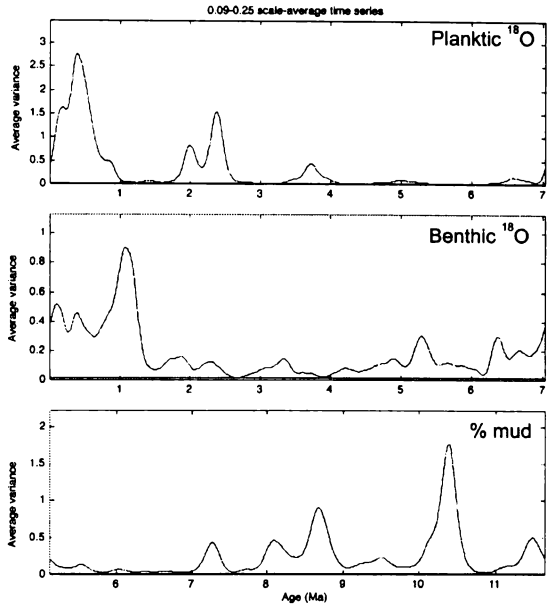


Figure 8 Average wavelet variance for planktic $\delta^{18}O$, benthic $\delta^{18}O$ and % mud at the 0.09-0.25 Ma scale band. This includes the 96-100 ky Milankovitch orbital forcing cycle(s). Note that the % mud data plotted in the lower plot span a different age range from the planktic and benthic $\delta^{18}O$ isotope data, although there is almost 2 my overlap between 5 and 7 Ma. The horizontal line near the bottom of each plot represents the 95% significance level.

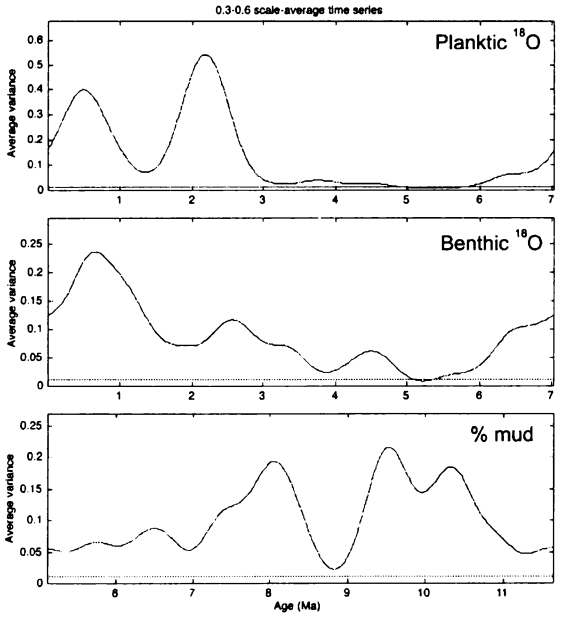


Figure 9 Average wavelet variance for planktic $\delta^{18}O$, benthic $\delta^{18}O$ and % mud at the 0.3-0.6 Ma scale band. This includes the 400 ky Milankovitch orbital forcing cycle. Note that the % mud data plotted in the lower plot span a different age range from the planktic and benthic $\delta^{18}O$ isotope data, although there is almost 2 my overlap between 5 and 7 Ma. The horizontal line near the bottom of each plot represents the 95% significance level.

The % mud data only partially overlap with the planktic and benthic $\delta^{18}O$ data. In the overlapped age range, the % mud appears similar in behaviour to planktic $\delta^{18}O$ at all Milankovitch periods. This is reasonable, since in Hole 593 the mud is largely

derived from planktic material and can be expected to reflect climatic changes influencing surface waters that would also affect planktic $\delta^{18}O$. If this is correct, the surface waters indicate strong 400 ky forcing from 0-3 Ma and 7-11 Ma, with reduced influence between 3 and 7 Ma.

The benthic $\delta^{18}O$ display a different behaviour, although there is still an increased response evident for all Milankovitch periods for ages less than 1 Ma. Apart from the differences in the magnitude of the variance peaks, the Wavelets results also provide information about their timing. Considering the 19-41 ky Milankovitch band, the timing of the variance peaks do not quite coincide between the planktic and benthic $\delta^{18}O$, with the benthic peaks tending to be slightly older. At longer Milankovitch periods a relationship between the timing of benthic and planktic $\delta^{18}O$ peaks is less clear. Nonetheless, the Wavelets results demonstrate that the benthic samples are responding differently to climate forcing than the data relating to surface waters. This was not apparent from Fourier analysis periodograms.

One potential problem that can occur is that Wavelet analysis is sensitive to rapid fluctuations or spikes in the data. The % mud data has one such spike at c. 10.3 Ma as shown in Fig. 6. This has resulted in an increase in variance across many scales around 10.3 Ma as shown by the contoured variance below (Fig. 6). Figures 7 and 8 show that this spike is also associated with peaks in the variance in the 19-41 ky and 96-100 ky Milankovitch bands. The spike may result from the use of non-linear interpolation techniques, be a data error, or a real rapid transition. An advantage of wavelet analysis is that the presence of a spike and its effects are readily apparent from the results included in Fig. 6. It would not have been evident in Fourier analysis results.

Wavelet analysis is capable of dealing with irregularly spaced data, and can also identify changes in variance caused by variations in sedimentation rate and sediment compaction (Prokoph and Barthelmes, 1996). The method is also suitable for identifying breaks in the time series caused by erosion or sediment loss during core retrieval (Prokoph and Agterberg, 1999). Therefore, the method has the potential to further improve the interpretation of core data. At this stage, these

capabilities have not been included in our GUI but are being considered as future extensions.

CONCLUSIONS

Wavelet analysis has proved to be a useful tool for visualising the temporal variability of quasi-periodic cycles from DSDP Hole 593 oxygen isotopic and textural data sets. It can be applied to any parameter that varies with age or depth down core, and provides more information than supplied by standard Fourier analysis techniques. The Wavelet technique may be extended to deal with irregularly sampled data, and data affected by differential compaction and losses due to erosion and/or poor core recovery.

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Chapter 7

Neogene Palaeoceanographic Synthesis For The Southern Tasman Sea Based On DSDP Site 593

In parts of East Antarctica, West Antarctica is east, in others west. This of course depends on if you are in east East Antarctica or west. However, if you are in west West Antarctica, East Antarctica is west unless you want to go to west East Antarctica, in which case it is east. The same holds for east West Antarctica only in reverse, except that if you want to go to west East Antarctica, you still go east.

No wonder we don't know what we found!

Dennis E. Hayes (1975) Leg 28

Neogene palaeoceanographic synthesis for the southern Tasman Sea based on DSDP Site 593

This synthesis chapter summarises and interrelates several of the main findings of this study of the Neogene palaeoceanographic record from Hole 593 in the southern Tasman Sea. Climate change and its effects on ocean circulation can only be monitored in ancient sediments using proxy parameters, and a multi-proxy approach has been taken in the analysis of Neogene sediments (c. 19-0 Ma) from Hole 593, which includes: sediment texture and composition; planktic and benthic foraminiferal oxygen and carbon isotopes; and bolboform biostratigraphy.

OCEANOGRAPHIC SETTING

DSDP Site 593 is located on the southern margin of the Challenger Plateau (40°30.47'S, 167°40.47'E) in 1068 m of water (Kennett and von der Borch, 1986b) (Fig. 1). The site lies c. 400 km north of the modern Subtropical Front (STF) in cool-subtropical surface water (CSTW). The Tasman Front to the north and the STF to the south of the site tend to isolate the surface circulation from the Pacific as well as the Southern Ocean. The surface watermasses extend to depths of c. 400 m, below which lie northward-flowing Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW), derived from the cooling and sinking of Subantarctic and Antarctic Surface Waters, respectively. Neogene equivalent subsurface watermasses are referred to as Southern Component waters, but the surface watermass remains CSTW largely because of the apparent similarity between the proxy data derived in this study and the modern parameters.

Because of northwards plate movement, Site 593 was located further south than its modern position during the Miocene (Kennett and von der Borch, 1986b), and the palaeocirculation patterns in the Southwest Pacific Ocean and Tasman Sea were influenced by slightly different continental configurations (Kennett et al., 1985). The palaeolatitudinal position and intensity of the oceanographic fronts have also changed, reaching modern relative positions by the Late Miocene (Nelson and Cooke, 2001). Both the Indonesian and Panama Gateways were open during the Middle Miocene (Hamilton, 1979; Duque-Caro, 1990; Burton et al., 1997), resulting

in largely uninterrupted westward-flowing equatorial surface currents (equivalent to the modern Southern and Northern Equatorial Currents) (Kennett et al., 1985). Any return flow as an equatorial undercurrent would have been weaker due to the reduced equator-to-pole thermal gradients and resultant reduction in wind strengths, and the volume and strength of western boundary currents (East Australian Current and Kuroshio) would also have been reduced compared with modern circulation (Kennett et al., 1985).

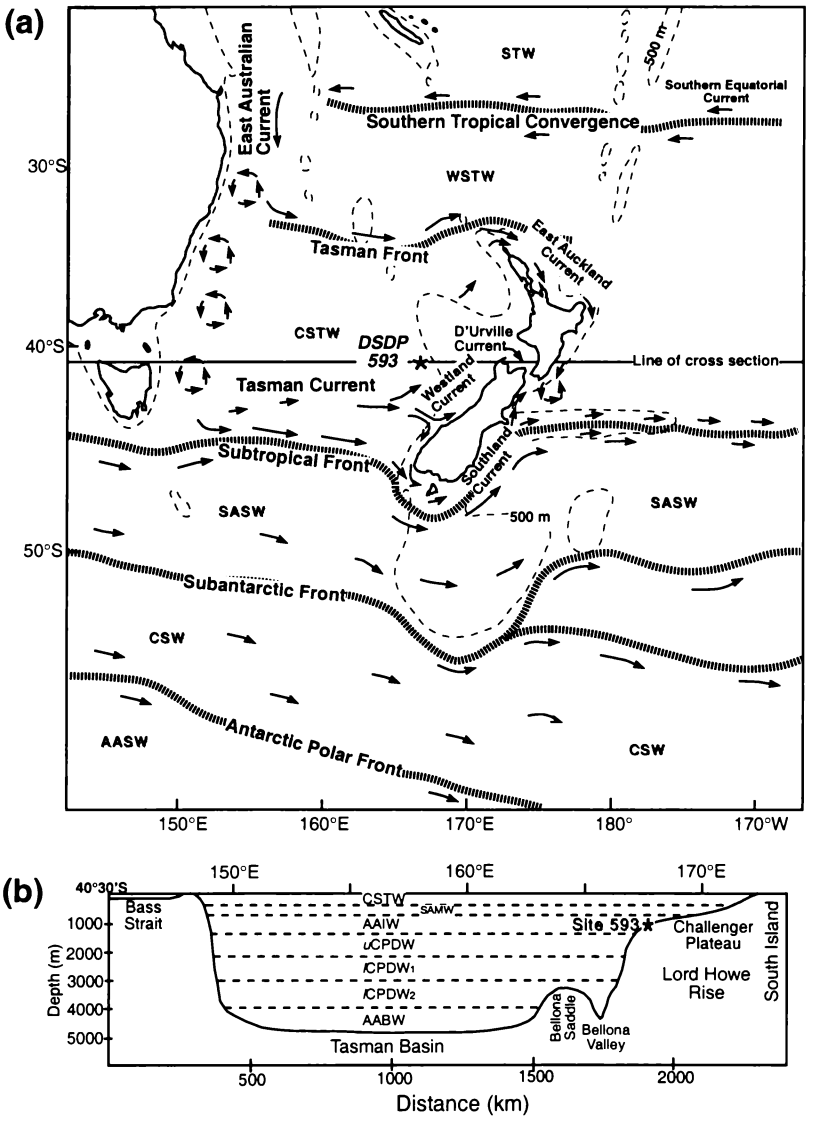


Figure 1 (a) Tasman Sea regional oceanography illustrating the location of Site 593 and its position relative to New Zealand and Australia, and main surface watermasses, currents and oceanic fronts of the region. (After Heath, 1985; Kennett and von der Borch, 1986a; Carter et al., 1998). (b) Schematic cross-section of the Tasman Basin at 40°30'S, showing the bathymetric position of Site 593 (40°30'S, 167°40'E) in 1068 m water depth, physiographical features of the basin and the watermasses found in the Tasman Sea; STW = Subtropical Water, WSTW = Warm Subtropical Water; CSTW = Cool Subtropical Water; SASW = Subantarctic Surface Water; CSW = Circumpolar Surface Water; AASW = Antarctic Surface Water; SAMW = Subantarctic Mode Water; AAIW = Antarctic Intermediate Water; uCPDW = upper Circumpolar Deep Water; lCPDW = lower Circumpolar Deep Water; AABW = Antarctic Bottom Water. (After Wyrtki, 1961, 1962; Rodman and Gordon, 1982; Drewry, 1983; Heath, 1985).

LITHOLOGIC CHARACTERISTICS

The Early Miocene to Early Pliocene sediments from Hole 593 comprise mainly nannofossil ooze, with the younger Plio-Quaternary sediments changing to foraminifera-bearing nannofossil ooze (Fig. 2) (Nelson, 1986), detailed in Chapter 2.

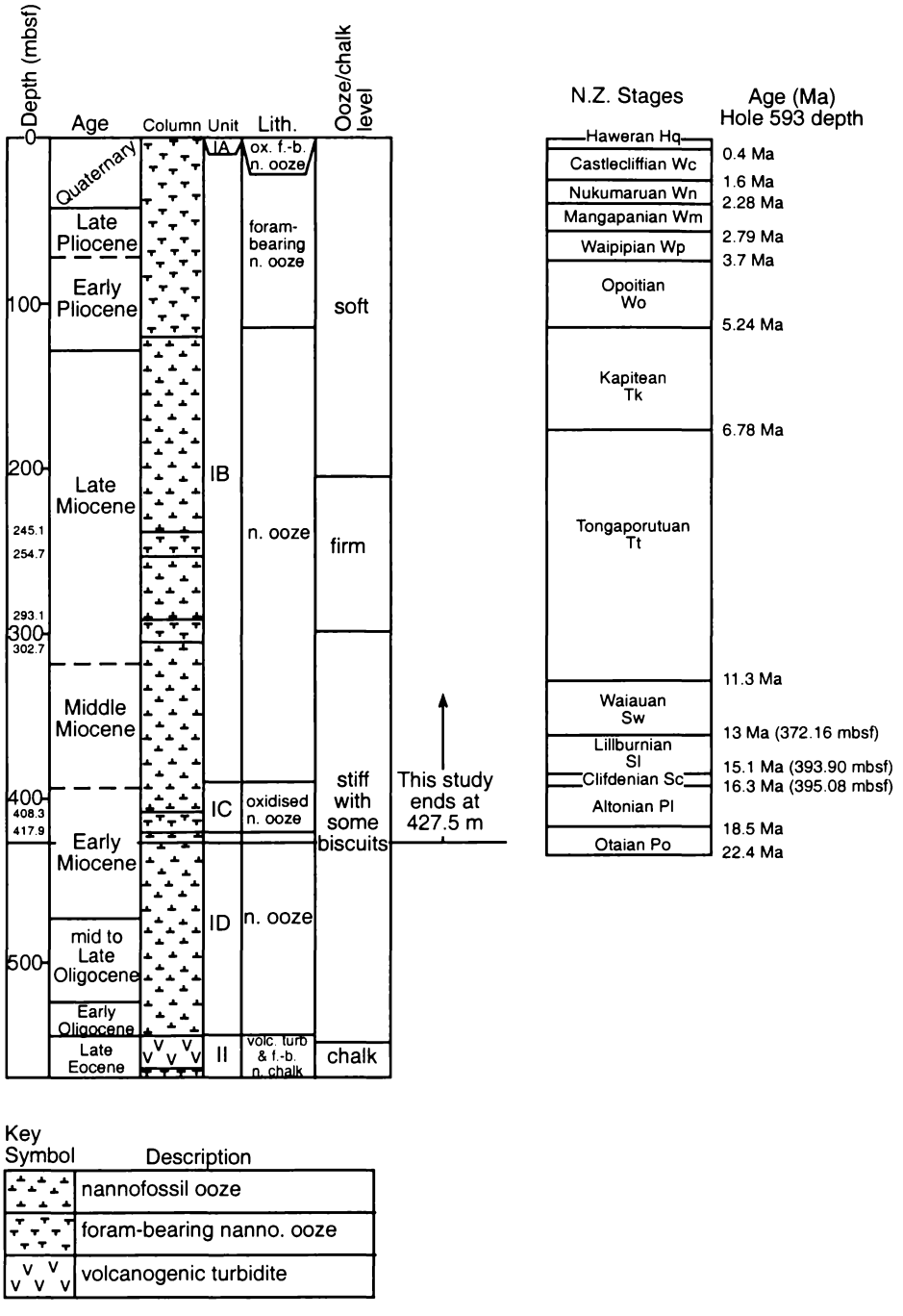


Figure 2 General Site 593 stratigraphy, unit IA-D = ooze, unit II = volcanogenic turbidites, after Nelson (1986). Three core sections in the Early to Late Miocene are foraminifera-bearing nannofossil ooze, and their depths are noted. New Zealand Stages and ages are slightly different to those ages in the Leg 90 core log due to the lack of dating control in the high-carbonate sediments. The absolute ages of the New Zealand Stages are after Morgans et al. (1996) with some modifications of the Pliocene stage values following Kamp et al. (in prep.).

The carbonate content of the Miocene and Pliocene sections from Hole 593 exceeds 90% (Fig. 3a), but this drops to >75% in the Early Pliocene to Quaternary sections (Mycke et al., 1986; C. Nelson, unpublished data). The persistently high carbonate content demonstrates that the site has remained well above the CCD and lysocline throughout the Neogene (Kennett and von der Borch, 1986b), whose depths today are >4200 m and 3600 m, respectively in the western Tasman Sea (Martínez, 1994).

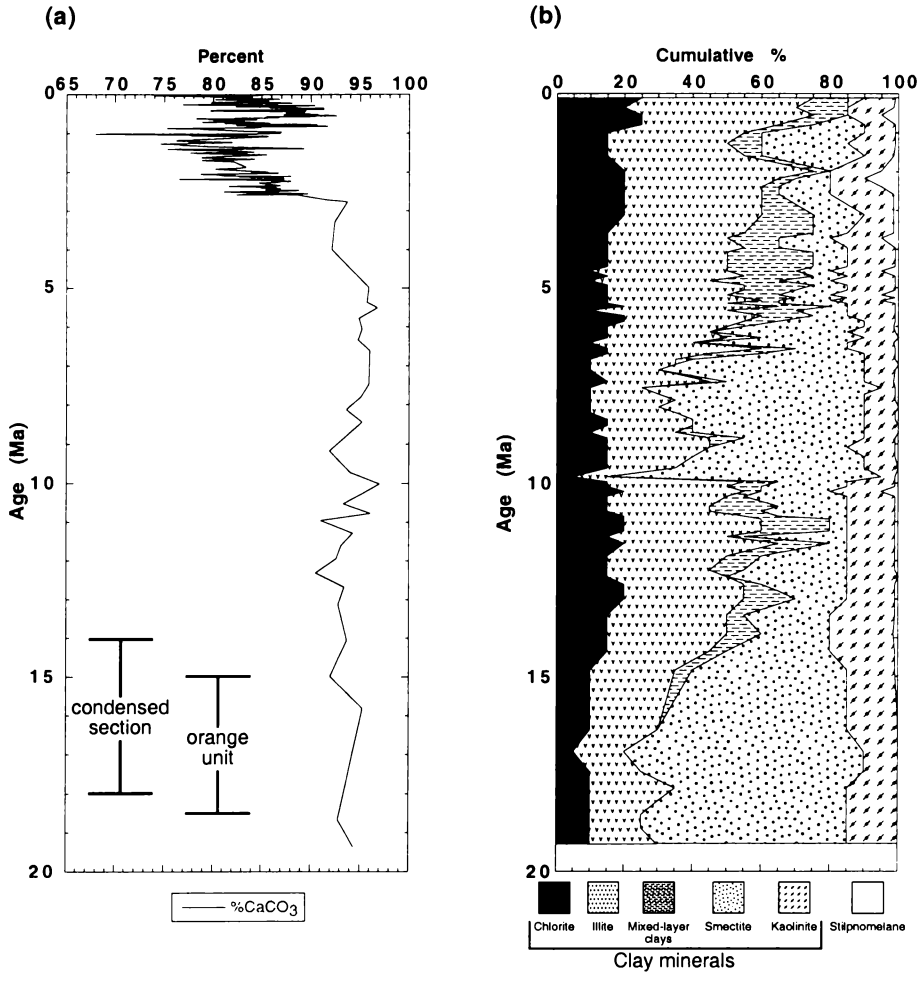


Figure 3 (a) Carbonate content of the Neogene section of Hole 593 sediments. (After Mycke et al., 1986; C. Nelson, unpublished data). (b) Composition of the clay fraction through the Neogene section of Hole 593 where the chemically mature clays (smectite and kaolinite) are considered indicative of chemical weathering on land, and the chemically immature clays (illite and chlorite) of physical weathering (Robert et al., 1986). The small amount of stilpnomelane is inferred to originate from weathered South Island Mesozoic metamorphic terranes, transported to Hole 593 via ocean currents (Robert et al., 1986).

The non-carbonate contribution to the mud consists mainly of clay minerals (Fig. 3b) with minor quartz, feldspar, pyrite and glass shards (Nelson, 1986; Robert et al., 1986). The terrigenous component comprises <10% of the Hole 593 sediments throughout the Miocene and Early Pliocene (Fig. 3a). From c. 3 Ma onwards the

terrigenous component increases to a maximum of 20-25%, as the carbonate content decreases, mainly due to the presence of tephra and onland-derived clays.

STRATIGRAPHY

This study of the Early Miocene to Holocene record at Site 593, from the Otaian to Haweran New Zealand Stages (c. 19-0 Ma), uses samples with a temporal resolution of c. 3-20 ky per sample. Sedimentation rates through the record typically fall within 20-60 m/Ma (Fig. 4). However, the interval between c.18-14 Ma has rates of <10 m/Ma and represents a condensed section.

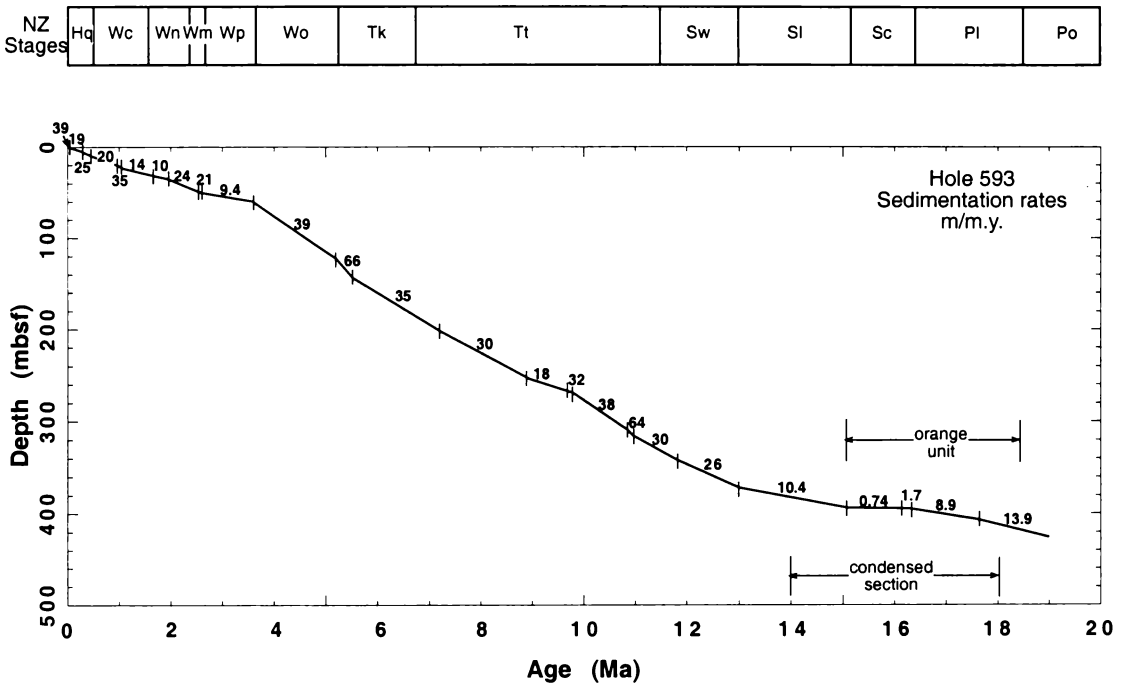


Figure 4 Hole 593 sedimentation rates calculated using the events in Table 1. New Zealand Stages defined in Fig. 2.

Table 1. Hole 593 stratigraphic tie-points and sedimentation rates used in this study.

Event	Depth (mbsf)	Age (Ma)	Approx. Sedn. Rate (m/Ma)
Radiocarbon date [a]	0.07	0.0069	
			39
Radiocarbon date [a]	0.31	0.013	
			19
FAD *Emiliania huxleyi* [a]	5.07	0.268	
			25
LAD *Pseudoemiliania lacunosa* [a]	9.91	0.458	
			20
Brunhes/Matuyama [b]	16.30	0.78	
			20
Top Jaramillo [b]	20.70	0.99	
			35
Base Jaramillo [b]	23.50	1.07	
			14
Top Olduvai [b]	33.33	1.77	
			10
Base Olduvai [b]	35.65	1.95	
			24
Isotope stage 100 [c]	49	2.53	
			21
Isotope stage 104 [c]	50.1	2.58	
			10
Base Gauss [b]	59.9	3.58	
			40
FAD *Globorotalia punticulata* [d]	123.04	5.19	
			66
FAD *Globorotalia sphericomiozea* [d]	143.72	5.51	
			35
FAD *Amorolithus primus* [e]	203.42	7.24	
			30
LO *Globoquidrina dehiscens* [d]	254.38	8.95	
			18
Top Tukemokihi Coiling Zone [d]	269.07	9.78	
			34
Base Tukemokihi Coiling Zone [d]	270.72	9.85	
			38
Top Kaiti Coiling Zone [d]	309.20	10.85	
			64
Base Kaiti Coiling Zone [d]	315.25	10.95	
			30
NN6/NN7 boundary [e]	341.16	11.8	
			26
LO *Fohsella peripheroronda* [f]	372.16	13.0	
			10
FCO *Orbulina suturalis* [f]	393.90	15.1	
			1
FO *Praeorbulina circularis* [f]	394.57	16.0	
			2
FO *Praeorbulina curva* [f]	395.08	16.3	
			9
FO *Globorotalia miozea* [f]	406.65	17.6	
			14
FO *Globorotalia praescitula* [f]	426.10	19	

[a] Determined using Nelson et al. (1986) and Dudley and Nelson (1989)

[b] Palaeomagnetic dates updated after Dudley and Nelson (1989), Berggren et al. (1995a; 1995b)

[c] After Naish (1996) following Shackleton et al. (1995)

[d] Dates determined by Crundwell (in prep.)

[e] After Lohman (1986) and Raffi et al. (1995)

[f] After Elkington (2000) - notice condensed zone

LO = Last occurrence, FCO = First common occurrence, FO = First occurrence, FAD = First appearance datum, LAD = Last appearance datum

TEXTURE

Compared with many textural studies of deep-sea sediments where the dominant component is terrigenous, the Hole 593 sediments are carbonate pelagic oozes and this results in textural analysis of biologically generated sediment grains, not often attempted. The late Early to Middle Miocene sediments from Hole 593 contain >75% mud (clay and silt), and this increases to >80% after c. 14.5 Ma through the Middle to Late Miocene (Fig. 5a). The extreme variability of the Pliocene to Holocene textural data, in part a reflection of the sample processing (Appendix B), is also a reflection of genuine textural change as recorded in the core log (Fig. 2). This change, from nannofossil ooze in the older section, to foraminifera-bearing nannofossil ooze at c. 120 m (5 Ma), is maintained through to the sea floor (Leg 90 Shipboard Scientific Party, 1986) and is reflected in the much increased sand content of samples. The general background sand content for the entire record is near 10%, with several Miocene intervals (e.g., 19-14.5 Ma and 9.5-8 Ma) exhibiting values up to 25%. After 5 Ma there is also a significant increase in the content of sand in samples (up to around 50%) associated with large amplitude fluctuations. Sediments younger than 2.5 Ma exhibit the greatest textural fluctuations, with up to 60% sand in some samples (Fig. 5b). The main control on sediment texture through the Neogene in Hole 593 is interpreted to be due to current winnowing; any significant contributions from palaeoproductivity, dissolution, bioturbation or diagenesis have all been discounted in this study. Specifically, using the 0.25 ϕ data set, it has been determined that it is the fine silt- to coarse clay-sized grains (3-13 μm, 6.25-8.25 ϕ) which were preferentially removed during winnowing episodes (Chapter 2, Fig. 9 page 100).

Compositionally, the sand fraction from 19-4 Ma consists mainly of adult foraminifera, with negligible quantities of terrigenous material. From about 4 Ma through to the Holocene sea floor sediments, several tephra layers (recorded as volcanic ash in the core log) have been noted (Leg 90 Shipboard Scientific Party, 1986; Head and Nelson, 1994), and certainly account for the large sand spikes in the record at this time (e.g., sample 593-3-5-80 at c. 1 Ma with some 80% sand, Fig. 5a). The smoothing function removes these single point extremes (Fig. 5b) and the smoothed data are interpreted as being reasonable, processing aside. The mud

fraction is composed of nannofossil placoliths and fragments, and minor amounts of clay minerals (Leg 90 Shipboard Scientific Party, 1986; Chapter 2). The missing winnowed grain size range can only consist of coccolith placoliths, and it is that plate-like shape which is proposed to be the reason for their removal from the sediments, rather than the finer grains which are less-hydrodynamically prone to winnowing.

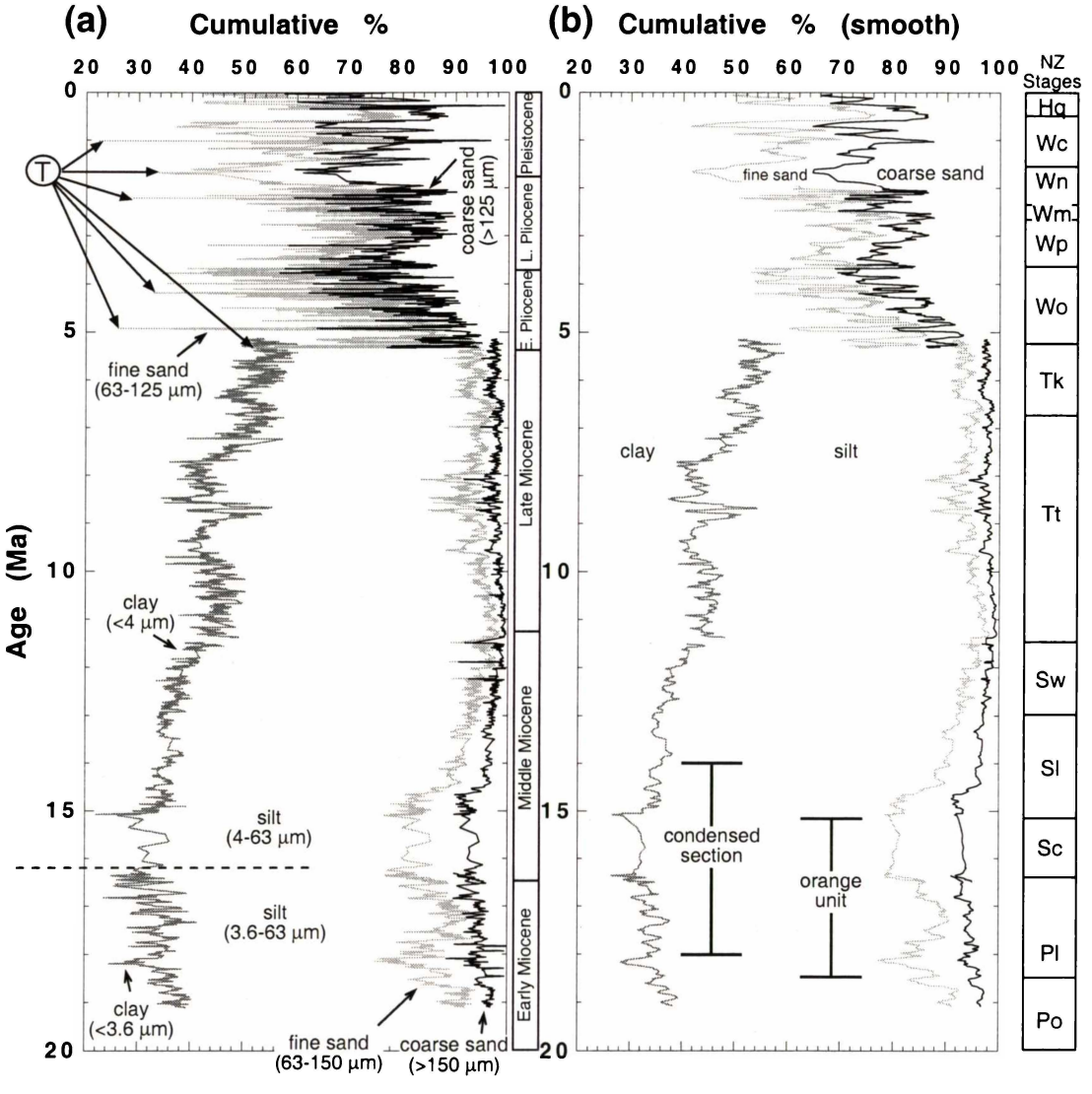


Figure 5 (a) Hole 593 raw bulk texture data, with several tephra layers (T) marked which contribute to greater variability in the younger part of the hole. (b) Smoothed texture data, with the Early Miocene increased sand content corresponding with the condensed section and extremely well oxidised 'orange unit'. Note that the cumulative % axis is shown only down to 20%, and that for some samples between c. 19-15 Ma the clay/silt boundary uses 3.6 µm, rather than the standard 4.00 µm value. NZ Stages defined in Fig. 2. A colour A3 version of this figure is provided at the end of the chapter.

Extreme winnowing through the condensed section (c. 18-14 Ma) is evident in the reduced silt content associated with increased sand content (Fig. 5). The associated 'orange unit' (c. 18.5-15 Ma) supports the contention that invigorated

Southern Component Intermediate Water (SCIW) circulation in the southern Tasman Sea occurred through the late Early Miocene to early Middle Miocene, bringing with it highly-oxygenated water. The increase in sand content associated with decreased silt over the intervals c. 19-14.5 Ma, 8.9-8.6 Ma and 5-0 Ma suggests these times represent accentuated bottom current activity and increased SCIW flow velocity. However, persistently strong SCIW flow can be ruled out because of the relatively uninterrupted sediment accumulation throughout the Neogene at the site. The cause of the invigoration has been linked not only to glacial cooling, but to increased wind strength associated with the greater meridional thermal gradient due to the cooling.

ISOTOPES

Benthic $\delta^{18}O$ curves

Particularly notable features of the benthic $\delta^{18}O$ record include the recognition of Miocene glacial Zones Mi1b, Mi1c and Mi2 (Scott et al., 1994), as well as Mi3 to Mi6, and a general trend to heavier values after 6.5 Ma (Fig. 6b). An obvious feature of the glacial development of the SCIW is the step-wise increase in benthic $\delta^{18}O$ through Zones Mi2 to Mi5 (Chapter 3, Fig. 8 page 159), a feature not recognised in the Deep Water records. In addition, the interval from c. 5 to 3.8 Ma when the amplitude of the benthic $\delta^{18}O$ fluctuations is less than the Late Miocene and Quaternary sections on either side, and the whole interval records lighter $\delta^{18}O$ values than the Holocene guideline (2.55‰), is identified as the Early Pliocene warm period, reported also from other oceanic sites (e.g., Crowley, 1991; Kennett and Hodell, 1993; Denton, 1995; Shackleton, 1995; Raymo et al., 1996; Bart, 2001). From 3.5 to 0 Ma the benthic record enriches by over 1.0 ‰ and exhibits much of this enrichment between 2 and 1 Ma, with larger amplitude changes from c. 1.4 Ma, interpreted to be a consequence of Northern Hemisphere ice volume increases associated with extreme interglacial to glacial palaeoclimate changes (Head and Nelson, 1994; Nelson et al., 1994).

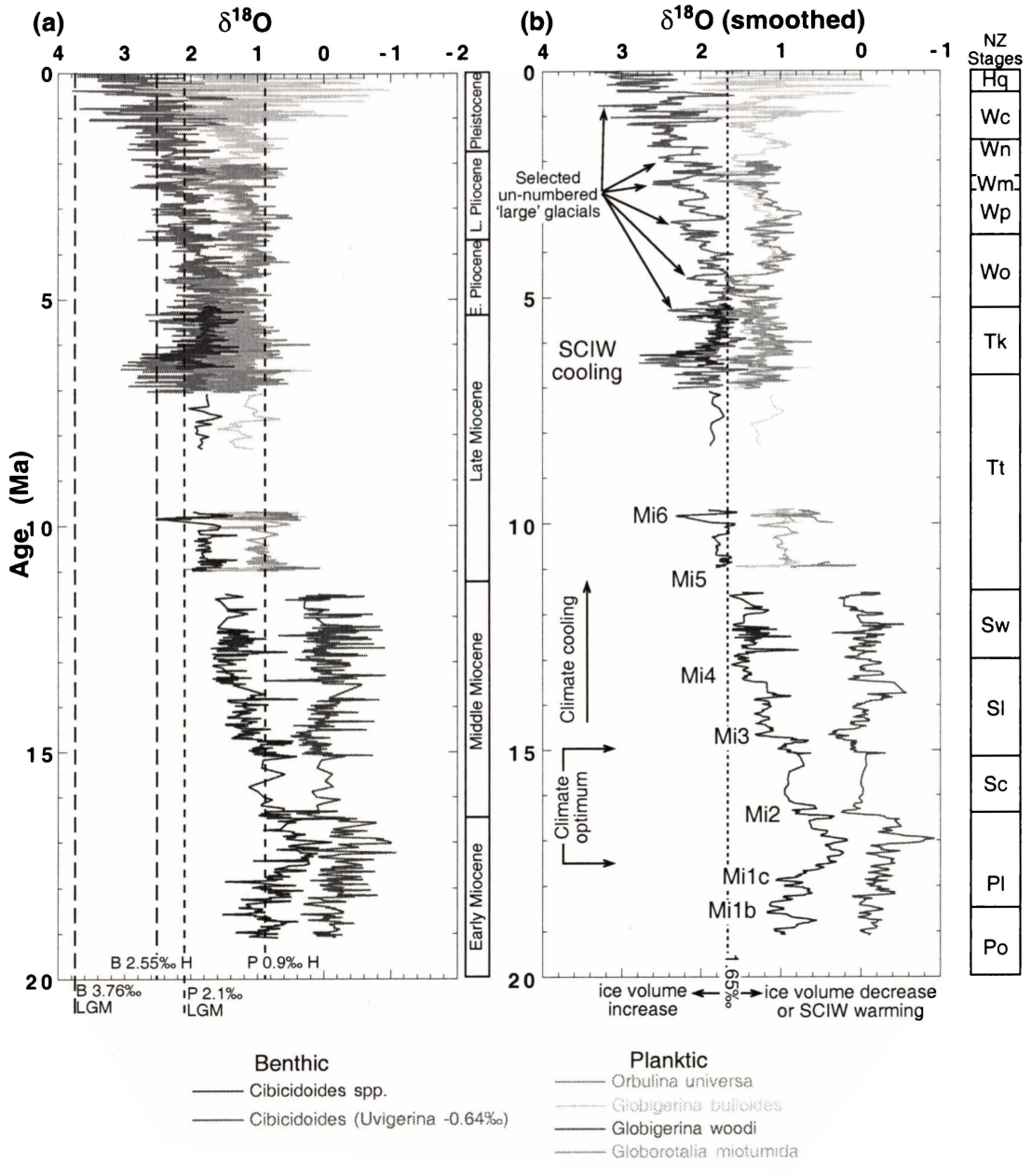


Figure 6 (a) Hole 593 Neogene raw $\delta^{18}O$ data, with Holocene (H) and Last Glacial Maximum (LGM) values marked for comparison. (b) Smoothed $\delta^{18}O$ data, with the glacial Zones Mi1b to Mi6, Southern Component Intermediate Water (SCIW) cooling event, and several un-numbered glacials identified. Values heavier than 1.65‰ are inferred to reflect active ice volume increase. NZ Stages see Fig. 2. A colour A3 version of this figure is provided at the end of the chapter.

Planktic $\delta^{18}O$ curves

Notable features again include definition of glacial Zones Mi1b, Mi1c and Mi2 (Scott et al., 1994), and Mi3 to Mi6. Identification of the Mi Zones as glacials is only possible by using both the benthic and planktic records, as ice volume changes affect the whole water column. In previous studies planktic Zone Mi4 (Miller et al., 1991; Wright and Miller, 1992) has not been easily recognised, but is evident in the

Hole 593 $\delta^{18}O$ record (Fig. 6b). Moreover, the generally good covariance between the benthic and planktic records after Mi6 supports the notion that the southern Tasman Sea has recorded the global ice volume signal, without any significant local effects swamping it. The *Globorotalia miotumida* $\delta^{18}O$ record is interpreted as a mode water signal during the Miocene, specifically Southern Component Mode Water (SCMW). During the SCIW cooling event, warming in all three planktic records is evident (Fig. 6b, see also Fig. 8), indicating that this divergence cannot be due to large ice volume changes. This suggests that while the planktic records do pick up the ice volume signal they are also recording localised variation, particularly since most of the *Globigerina bulloides* record is heavier (colder) than the Holocene value of 0.9‰, but lighter (warmer) than that of the LGM at 2.1‰ which represents maximum ice volume.

Benthic $\delta^{13}C$ curves

Globally recognised Early to Middle Miocene Carbon Maxima (CM) events CM1 to CM7 are identified in the benthic $\delta^{13}C$ record (Fig. 7b). In combination, CM1 to CM6 comprise the Monterey Excursion, with some of the individual events co-occurring with Mi Zones. In addition, three Late Miocene carbon maxima have been recognised, labelled CMX to Z, one of which, CMX, co-occurs with glacial Zone Mi4, not previously noted from other sites. The Late Miocene (7-6.5 Ma) shift to lighter $\delta^{13}C$ values, the so-called Messinian Carbon Shift (MCS) is evident in all the records (Fig. 7b). While this event is linked to palaeoceanographic changes in the Mediterranean and North Atlantic, its effects on the global carbon cycle are also clearly evident in the Southwest Pacific Ocean system.

Planktic $\delta^{13}C$ curves

The lack of any significant $\delta^{13}C$ offset between the planktic *Globigerina woodi* and benthic *Cibicidoides* spp. $\delta^{13}C$ records is interpreted to indicate vital effect fractionation in *Globigerina woodi.* Upwelling which would bring low $\delta^{13}C$ water to the surface can be ruled out using the $\delta^{18}O$ records, as upwelled water should be cold and the *Globigerina woodi* values do not indicate cooling (Fig. 7). Overall, both the *Orbulina universa* and *Globigerina bulloides* records exhibit decreasing $\delta^{13}C$ values from the Late Miocene to Pliocene, and Holocene, respectively (Fig. 7a). This is interpreted as a reflection of the global trend to lighter values as carbon was

partitioned between ocean sediments and the atmosphere. The extreme amplitude variation exhibited by *Globigerina bulloides* through the Plio-Quaternary is interpreted as due to the tendency of this species to migrate vertically through the water column following nutrients (Nelson et al., 1994). The offsets of the planktic carbon isotope curves support the contention that *Globorotalia miotumida* was a deep-dwelling planktic species, as it exhibits lighter $\delta^{13}C$ values than the other planktic species (Fig. 7b).

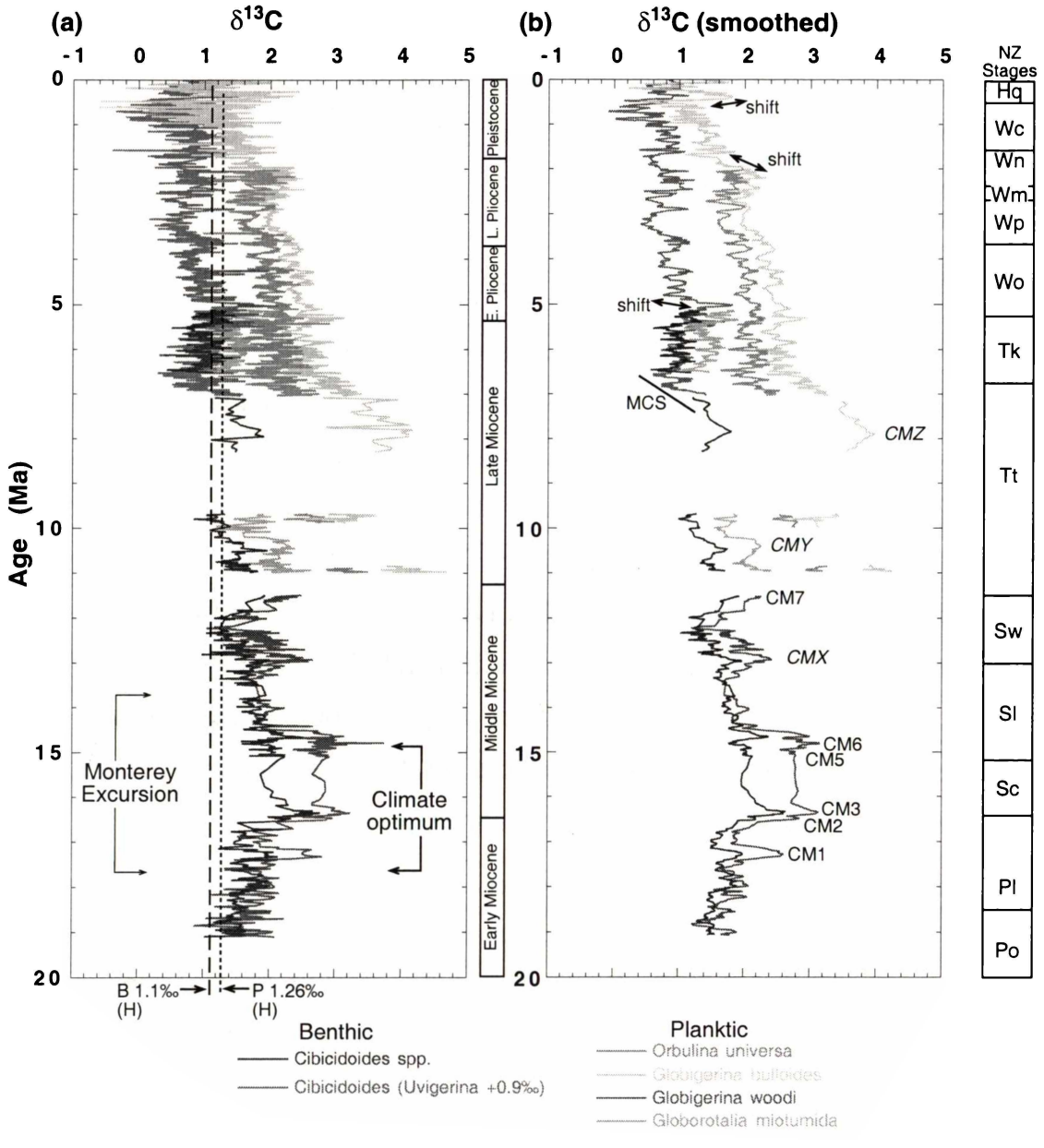


Figure 7 (a) Hole 593 Neogene raw $\delta^{13}C$ data, with Holocene benthic and planktic values (H) included for comparison. The interval of enriched values 17.5-13.5 Ma is identified as the Monterey Excursion. (b) Smoothed $\delta^{13}C$ data, with the carbon maxima CM1-7 identified. Additional Middle to Late Miocene carbon maxima, labelled CMX to Z, are also noted, along with the Messinian Carbon Shift (MCS) and several Pliocene to Holocene un-numbered carbon shifts. NZ Stages detailed in Fig. 2. A colour A3 version is provided at the end of the chapter.

SEAWATER $\delta^{18}O_W$ vs ICE VOLUME

For any time other than the Holocene, palaeotemperature calculations are critically dependent on estimating the mean isotopic composition of seawater ($\delta^{18}O_w$), which cannot be measured directly. With the exception of average modern and ice free values of c. -0.28‰ and -1.2‰$_{VPDB}$ respectively, or c. 0‰ and c. -0.93‰$_{VSMOW}$ (using the correction between these two standards of -0.27‰, see Hut, 1987), there are no absolute controls on $\delta^{18}O_w$ estimates. Hence, one of the most difficult aspects of calculating the ice volume contribution to the Miocene oxygen isotope values is to know the global ice budget during that time. Ice volume changes will affect both the calcite and seawater $\delta^{18}O$ values. Many attempts have used either modern $\delta^{18}O_w$ values (which will overestimate Miocene ice and underestimate the water temperature), or the ice free value (which will do the opposite). As a compromise, in this study global mean estimates of $\delta^{18}O_w$ values have been determined for time slices through the Miocene-Holocene based on the time intervals of Feary et al. (1991). Also the modern $\delta^{18}O_w$ values for the Tasman Sea have been used as end points rather than the commonly used modern average global values (Table 5).

Table 5. Estimated $\delta^{18}O_w$ values since the Early Miocene that have been used in palaeotemperature calculations. Age model after Feary et al. (1991); modern measured $\delta^{18}O_{wVSMOW}$ values provide endpoints, which estimated Neogene values must reach at some point in time. The benthic age model is slightly different to the planktic one because the SCIW $\delta^{18}O_{wVSMOW}$ is required to make less change though the Neogene, from the initial starting point.

Time interval (Ma)	$\delta^{18}O_{wVSMOW}$	$\delta^{18}O_{wVPDB}$
Benthic – intermediate water		
22-16	-0.83	-1.1
16-12	-0.63	-0.9
12-5.2	-0.43	-0.7
5.2-4.3	-0.37	-0.64
4.3-0	-0.3	-0.57
Planktic – cool subtropical surface waters		
22-16	-0.83	-1.1
16-12	-0.63	-0.9
12-6.2	-0.43	-0.7
6.2-4.3	-0.225	-0.495
4.3-3.4	-0.02	-0.29
3.4-1.6	0.185	-0.008
1.6-0	0.39	0.12

During glacials, the ice volume adjustments will slightly overestimate the watermass cooling, as no additional correction to the $\delta^{18}O_w$ value is included to account for ice volume increases. On the other hand, during interglacials this calculation will slightly underestimate the watermass warming as any ice melting is not adjusted for in the $\delta^{18}O_w$ value.

A *Cibicidoides* $\delta^{18}O$ ice volume constraint value of 1.65‰ has been established for SCIW in the southern Tasman Sea (Chapter 3, page 165) and provides a guide to ice volume increase. Hence during the Neogene when intermediate depth *Cibicidoides* $\delta^{18}O$ is >1.65‰, it is likely there was additional ice volume increase on Antarctica. While the intermediate water has some capacity for cooling to increase the $\delta^{18}O$ value because it is warmer than the cold deep waters, the Hole 593 SCIW follows similar trends to those from deep water. The Hole 593 SCIW $\delta^{18}O$ record starts to reach $\delta^{18}O$ values >1.65‰ during glacial event Mi4, and definitely between events Mi4 and Mi5 (Fig. 6b). Prior to Mi4, fluctuations in the $\delta^{18}O$ values are attributed to decreasing SCIW temperature in addition to some ice volume changes. A similar situation occurs in the Deep Water records where the first glacial Zone to include values >1.8‰ (the deep water constraint value) is also Mi4, and events younger than Mi4 are consistently heavier than 1.8‰ (Fig. 8).

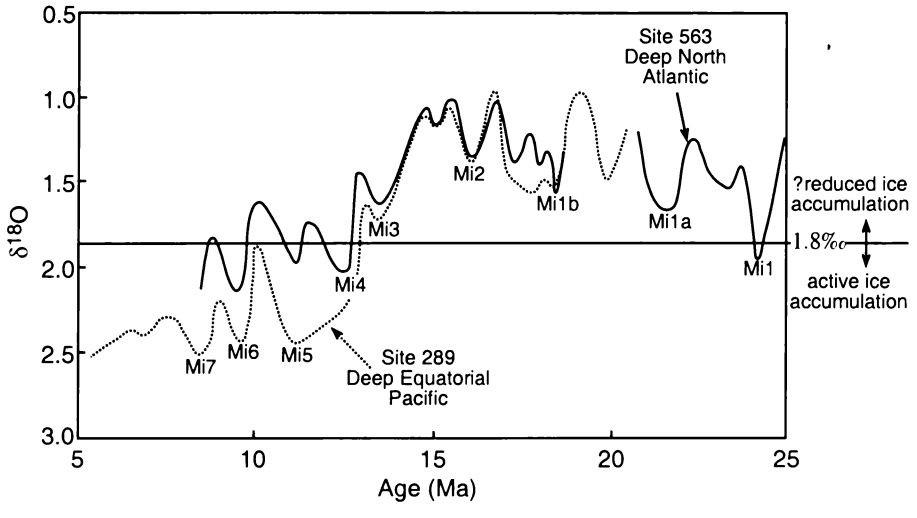


Figure 8 (a) *Cibicidoides* $\delta^{18}O$ Deep Water records from the North Atlantic and Equatorial Pacific illustrating the Mi Zones of Wright and Miller (1992); (b) smoothed data illustrating the general trends, with the 1.8‰ line representing the deep water *Cibicidoides* constraint value, where values heavier than 1.8‰ are inferred to reflect active Antarctic ice volume expansion rather than deep water cooling. Note how Deep Waters exceed 1.8‰ at the same time (Mi4) as the SCIW exceeds 1.65‰ (Fig. 6).

NEOGENE SOUTHERN TASMAN SEA PALAEOTEMPERATURES

The complete 19-0 Ma record (Fig. 9) exhibits a general cooling of SCIW over this interval, with accelerated cooling after c. 5 Ma. The latest Early Miocene to early Middle Miocene climate optimum has been recognised in many other $\delta^{18}O$ records and represents an interval of warmth punctuated by at least three (Mi1c, Mi2 and Mi3) glacial cycles. SCIW cooling of up to 3.5°C from 6.5-6.0 Ma does not appear to represent a large glacial event as all the planktic records warm slightly over this interval (Fig. 9). The SCIW palaeotemperatures consistently reach AAIW values after c. 4 Ma, which may in part be a reflection of the increasing global ice volume and cooling linked to the development of the Northern Hemisphere ice sheets. The *Globorotalia miotumida* SCMW record is generally slightly warmer than modern SAMW (8-9°C) but does exhibit some cooling over the Late Miocene interval, while the planktic CSTW records exhibit considerable temperature variability, but generally remain within the thermal range of modern CSTW of 10-17°C (Fig. 9).

As the warming and cooling of 'source waters' contribute to the thermal characteristics of a watermass, the cooling of the SCIW from >10°C during the Early-Middle Miocene climate optimum to around 8°C in the Late Miocene and cooler through the Plio-Pleistocene, must have involved cooling of the antarctic surface waters which subducted to form this watermass. Equally, the SCMW originated in the Southern Ocean, so the Late Miocene cooling of SCMW from 12°C to 9°C must also be related to cooling of Miocene subantarctic surface waters. Because the palaeotemperatures calculated for these subsurface watermasses did not cool by the same amount through the Late Miocene, with the mode water exhibiting greater cooling, the subantarctic region appears to have been subjected to greater cooling than the antarctic region closer to Antarctica. Once antarctic surface waters approach 0°C, there is very little capacity for cooling, except to freeze the water. Hence while the SCIW has some capacity to cool through the Neogene, the SCMW has a greater thermal capacity and can therefore cool more.

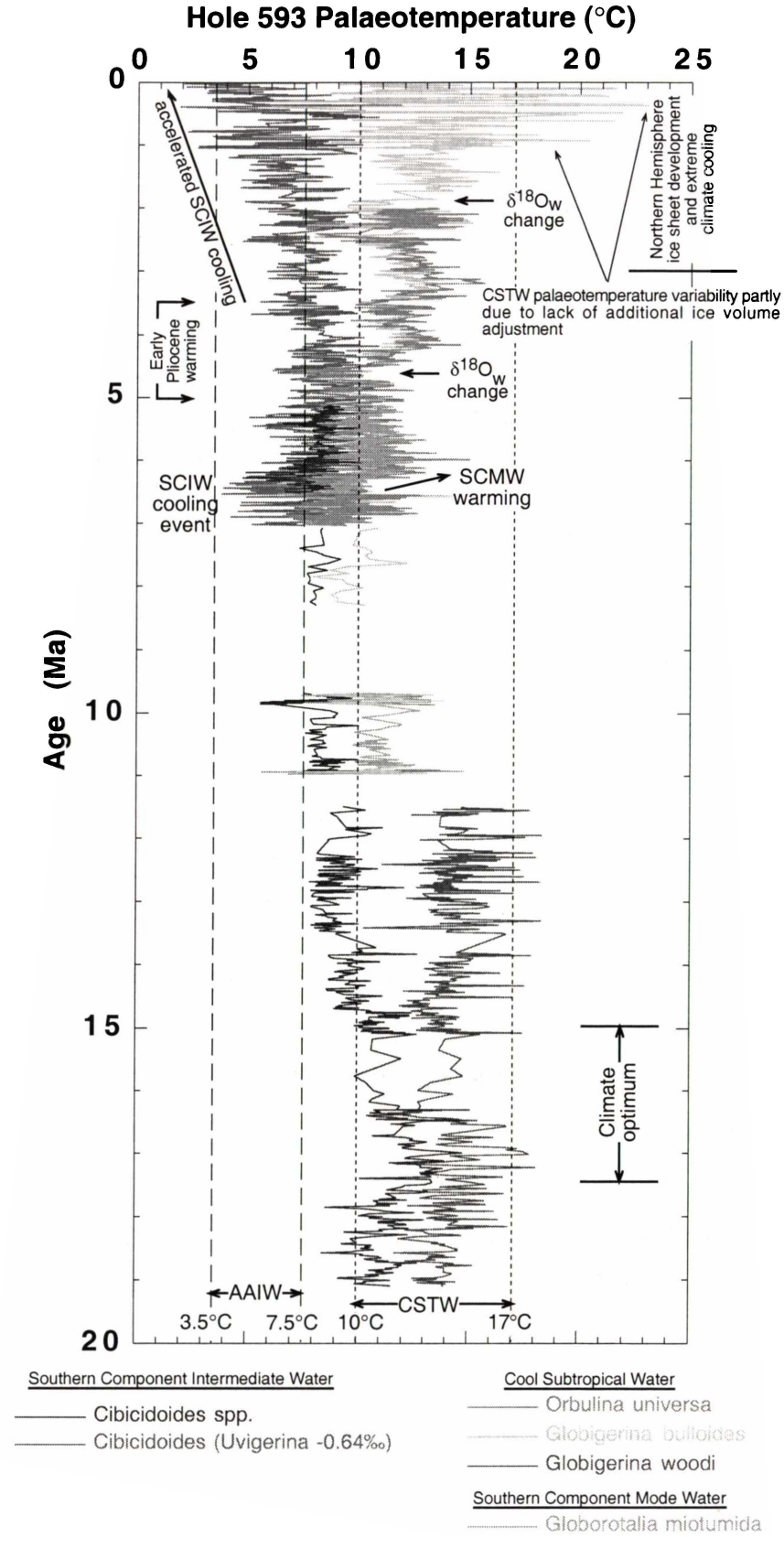


Figure 9 Palaeotemperature records for the intermediate (SCIW), mode (SCMW) and surface waters (CSTW) through the Neogene from Hole 593. Selected events illustrated. The range of modern Antarctic Intermediate Water (AAIW) and Cool Subtropical Water (CSTW) values are marked for comparison. An A3 colour version is provided at the end of the chapter. Climate optimum = interval of warmer climate associated with the Monterey Excursion (Fig. 7).

The Miocene was a time of major deep water circulation changes and phases of ice cap growth. During the early Middle Miocene in particular, there was intensified accumulation of ice on the East Antarctic Ice Sheet (EAIS) (Shackleton and Kennett, 1975; Kennett, 1986; Kennett and von der Borch, 1986b; Flower and Kennett, 1995) and the thermal structure of the ocean began to assume modern characteristics (Woodruff, 1985; Woodruff and Savin, 1989). Expansion of the EAIS is evident in Zones Mi1 to Mi4, with continued growth and the establishment of the West Antarctic Ice Sheet (WAIS) between about 10 and 7 Ma (Denton et al., 1990; Kennett, 1995), associated with Zones Mi5 and Mi6 (and Mi7, present in the Site 747A record (Fig. 10) but not in the Hole 593 data). In the previously established Deep Water records glacial Mi Zones are recognised as single points, and their ages determined based on the most extreme point in the particular part of the record. In Hole 593 Zones Mi1b, Mi1c, and Mi2 are indeed recognised as 'points' (Fig. 6), however, Zones Mi3, Mi4, and Mi5 step down to heavier values (Fig. 6 and Chapter 3, Fig. 8 page 159) and, although fluctuating, maintain the heavier values. As a consequence of this step-wise, plateau-like cooling in the Hole 593 SCIW, the absolute ages of Zones Mi3, Mi4, and Mi5 are ranges rather than single ages (Chapter 3, Table 4 page 157).

While the Middle Miocene cooling occurs in two steps, namely Mi3 and Mi4 (Miller et al., 1991), the plateau-like nature of the intermediate water Hole 593 record is not evident in the deep water benthic records (Fig. 8). The plateauing of the Hole 593 SCIW $\delta^{18}O$ is interpreted to reflect (1) ice volume increases with stabilisation of cooler SCIW temperatures after the initial glacial event, and (2) that intermediate waters are acting to a certain extent independently of the deep waters, even though both originate in the Southern Ocean. The co-occurrence of Late Miocene *Globorotalia miotumida* coiling zones and glacial Mi Zones supports the contention that oceanic system reorganisation of intermediate water and the permanent thermocline occurred during the glacials.

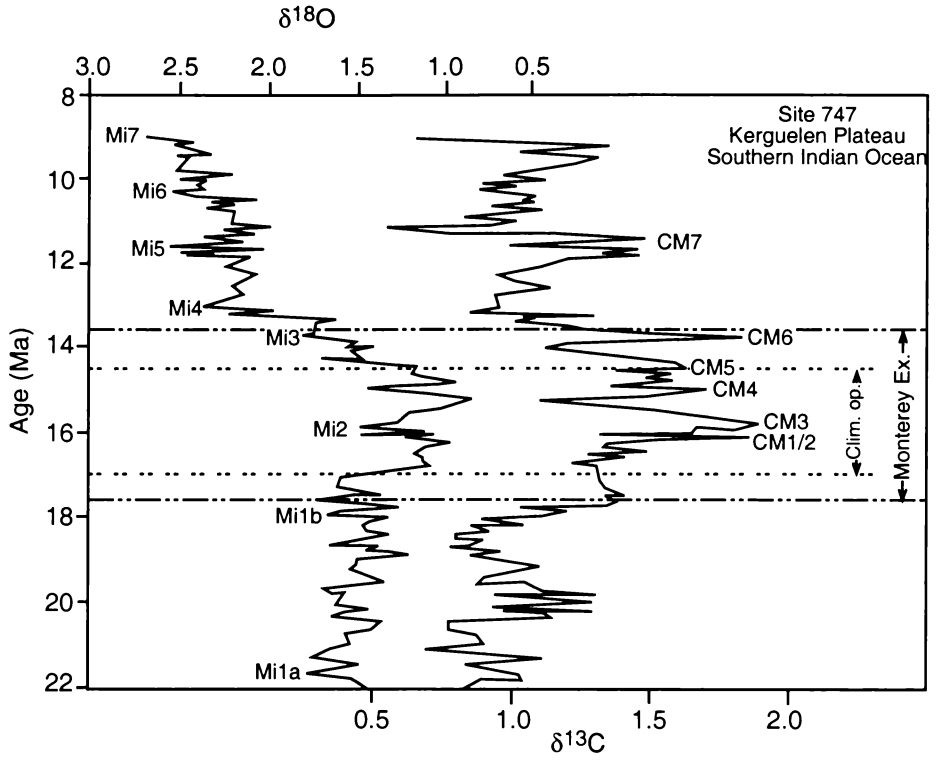


Figure 10 Isotope stratigraphy from Southern Ocean Site 747, Kerguelen Plateau, in which both glacial Mi Zones and CM carbon events have been identified. Clim. op. = climate optimum; Monterey Ex. = Monterey Excursion. After Wright and Miller (1992) and Woodruff & Savin (1991) with ages adjusted according to Hodell and Woodruff (1994).

LGM TO HOLOCENE ICE VOLUME CHANGES AS A CONTROL IN HOLE 593

Palaeotemperature calculations can either 'load' the ice volume component on to the $\delta^{18}O_w$ or onto the $\delta^{18}O_c$ if modern $\delta^{18}O_w$ values are used in the equations. While the estimated $\delta^{18}O_w$ values (Table 5) provide a mean watermass $\delta^{18}O_w$ value, if the global ice volume of extreme glacials is not removed then water temperature calculations result in excessively cold values. Reported $\delta^{18}O$ changes between Last Glacial Maximum (LGM) and Holocene foraminiferal calcite of 1.2‰ from several southern Tasman Sea core sites (Table 6), including Site 593, match the proposed ice volume component (1.2‰) of this palaeoclimatic transition (Chappell and Shackleton, 1986; Chappell et al., 1996). The value of 1.2‰ was derived by correlating dated and uplifted LGM and Holocene coral reefs on the Huon Peninsula, Papua New Guinea, with the $\delta^{18}O$ isotopic record from deep sea core V19-30. This value is reasonably close to that calculated by Fairbanks (1989) of 1.33‰, which represents the LGM to Holocene sealevel change of 121 m recorded

in Barbados, multiplied by the calculated rate of $\delta^{18}O$ change due to ice volume of 0.011 ‰/m of sea level change (i.e., 121x0.011 = 1.33‰).

Table 6. Mean benthic and planktic $\delta^{18}O$ values for LGM and Holocene Tasman Sea Site 593 (Nelson et al., 1994) and Pacific Ocean NZOI sites R657 and U939 (Neil, 1997) off eastern New Zealand. Southern Tasman Sea Site 593 and Northern Chatham Rise Site R657 both lie north of the STF in CSTW, whereas Site U939 lies south of the STF in SASW. Diff = difference between LGM and Holocene $\delta^{18}O$ values, where a value of 1.2‰ equals glacial ice volume. *G. bulloides* = *Globigerina bulloides.*

Core	Location	Holocene (benthic)	LGM	diff.	Holocene (planktic)	LGM	diff
		(*Uvigerina* sp.)			(*G. bulloides*)		
Site 593	Southern Tasman Sea	3.19	4.40	1.21	0.90	2.10	1.20
R657	Northern Chatham Rise	3.46	4.64	1.18	1.10	2.19	1.08
U939	Southern Chatham Rise	3.10	4.56	1.46	1.36	2.92	1.56

The lack of any temperature change between Holocene and LGM in the southern Tasman Sea (and northern Chatham Rise) indicates the CSTW was somehow insulated from the ocean response to LGM cooling (Nelson et al., 1994). As the LGM planktic values record only the ice volume difference of 1.2‰ this has been interpreted to reflect minimal cooling of the CSTW in the southern Tasman Sea during the LGM (Nelson et al., 1994). A possible mechanism is related to restriction of flow through the Indonesian gateway during the LGM and lowered sea level. In turn this is likely to have forced western Pacific 'warm pool' surface waters further eastwards to contribute a greater volume to the EAC, consequently warming the southern Tasman Sea surface waters (Nelson et al., 1994; this study).

The benthic $\delta^{18}O$ changes between LGM and Holocene samples also suggest minimal changes in the temperature of the AAIW between LGM and Holocene in the Tasman Sea. In part this may have been due to the restricted circulation in the Tasman Sea, with somewhat slow 'flushing-out' of deeper waters. Also a possibility is the blocking action of expanded warm EAC flow (which does extend to intermediate depths in the modern Tasman Sea) feeding into the southern Tasman Sea, restricting SCIW inflow from the south. The above discussion indicates that the Tasman Basin was thermally isolated from the large surface and intermediate water temperature changes reported from other southwest Pacific sites during a major glacial to interglacial climate transition (Nelson et al., 1994; Neil, 1997; Weaver et al., 1997; Weaver et al., 1998). Applying this same kind of model to the older parts

of the Hole 593 records may account for the Neogene CSTW palaeotemperatures remaining within the range of the modern watermass (Fig. 9).

OCEANIC VENTILATION DURING THE NEOGENE BASED ON HOLE 593

Increased ventilation of intermediate waters is evident in the Hole 593 carbon curves by convergence of the planktic and benthic records from the Late Miocene onwards (Fig. 7b). In general, the greater the similarity in value between benthic and planktic carbon curves, the closer a site is likely to be to the area of deepwater formation (Duplessy et al., 1988). However, the lack of any real difference between the benthic *Cibicidoides* and planktic *Globigerina woodi* records is not interpreted as ventilation, but as vital effect fractionation in the *Globigerina woodi* $\delta^{13}C$ values. This makes for limited interpretation of the record and requires an additional planktic $\delta^{13}C$ record for comparison. During the Late Miocene the distance of Site 593 from the source of SCIW probably did not change very much. This is because despite the Neogene increase in Antarctic ice volume causing the position of the Antarctic Polar Front (the 'source' of AAIW/SCIW) to migrate northward (Nelson and Cooke, 2001), plate tectonic movement also carried the Challenger Plateau northward. Therefore the converging trend shown by these curves (Fig. 7b) suggests an increase in the ventilation of the southern Tasman Sea over Site 593 through the Late Miocene to Holocene. After 3.0 Ma, there appears to be a clear link between increased ventilation and decreasing AAIW temperature (Figs. 7 and 9). Not because of vertical mixing but because the SCIW was well ventilated at source. Duplessy et al. (1988) reported greater ventilation of intermediate water in the North Pacific during the LGM. Lynch-Stieglitz et al. (1994) suggested that due to a diminished contribution of NIIW and resultant increase in the contribution of Antarctic Surface Water, last glacial AAIW would be fresher, cooler and better ventilated than modern AAIW. The data from Site 593 suggest this may have been the case since c. 6.0 Ma (Figs. 6 and 7). The higher than expected SCIW $\delta^{13}C$ absolute values through the Neogene indicate this watermass has been well ventilated through most of this interval, which is linked to ocean-atmosphere exchange along the AAPF. Hence the increased Neogene ventilation of the southern Tasman Sea is likely to be due to increased flow of SCIW/AAIW (evident

in the texture data) bringing relatively young (surface) water to Site 593, and not due to upwelling.

MONTEREY EXCURSION AND MESSINIAN CARBON SHIFT IN HOLE 593

Broecker and Denton (1989) make the point that the nature of climate changes during the Quaternary (rapid, global and near-synchronous) cannot be explained by the conventional Milankovitch-ice sheet links. Milankovitch-induced seasonal changes will influence water vapour transport, which will in turn affect ocean circulation, but will not influence circulation on an annual basis (Broecker and Denton, 1989). Broecker and Denton (1989) suggested that the most likely cause for global climate change (primarily recorded in the $\delta^{18}O$ signal, but also affecting $\delta^{13}C$) is the massive reorganisation of the ocean-atmosphere system from one stable state to another, and that as the ocean and atmosphere are tied together in a non-linear manner so the whole system is susceptible to abrupt mode switches.

Both the latest Early Miocene Monterey Excursion and the Late Miocene Messinian Carbon Shift represent a switch from one oceanic steady state to another, and both are evident in the Hole 593 carbon records (Fig. 7). In Hole 593 the Monterey Excursion is dated at c. 18-14 Ma and the Messinian Carbon Shift has been dated at 7.15-6.45 Ma, comparable with other dated records of these events.

BOLBOFORMS FROM HOLE 593: POSSIBLE TRANSPORT MECHANISMS

The unexpected finding of *Bolboforma* in the Late Miocene Hole 593 sediments and the subsequent investigation of their Cenozoic distribution in Southern Ocean drill sites led to these enigmatic planktic microfossils being linked to warm subantarctic surface waters (Chapter 5). With surface transfer across oceanic fronts highly unlikely, their arrival at Site 593 north of the STF is inferred to have been via subsurface flow in either the SCMW or, more likely, the SCIW. Because the oldest specimens at c. 53 Ma occur in the southern Campbell Plateau Hole 277, origin in the Southern Ocean is inferred. Moreover, bolboforms have been found in the North Atlantic and more global subsurface transport is inferred to account for this distribution because these planktic microfossils are unlikely to have crossed over the

numerous oceanic fronts between the Southern Ocean and the North Atlantic (cf. Darling et al., 2000).

WAVELET ANALYSIS

In previous palaeoceanographic studies, climate proxy data sets have been used to demonstrate cyclical climate changes using Fourier analysis. The Hole 593 proxy-records were expected to contain cyclic changes at Milankovitch orbital frequencies, but when this technique was applied to the Late Miocene textural and latest Miocene to Holocene oxygen isotopic records from Hole 593, most of the observed peaks in the periodograms were not statistically significant (Chapter 6, Fig. 3 page 288). This is explained by the Fourier technique applying a best-fit amplitude to the entire time series, which in Hole 593 varies in magnitude (the fluctuating amplitudes mentioned above). Wavelet analysis provides estimates of the amplitude for each frequency at each time interval of the time series. Wavelets has demonstrated that the Hole 593 climate-proxy data do contain genuine orbital frequency-controlled changes. Wavelets has potential to generate good time series analysis even when data are affected by quasi-periodic cycles or poor core recovery, a situation Fourier analysis does not cope with well.

CONTROLS ON PALAEOCEANOGRAPHIC CHANGES

A comprehensive summary of selected global Neogene palaeoceanographic events has been compiled in Fig. 11.

Age (Ma)	Hiatus (1 & 10)	Sediments	Tectonics & Gateways	Panama Gateway PG	Faunal & Floral changes	$\delta^{18}O$ & Ice	$\delta^{13}C$ & palaeocirculation	DSDP Site 593
1					* Dramatic increase in SSTs over Queensland Plateau @ c. 2 Ma (14)		* Pleistocene variations in NCW - low flux during glaicals, high during interglacials (3)	* Increase in stilpnomelane @ c. 2.0 Ma related to erosion of Southern Alps (25)
2						* Northern Hemisphere glaciation @ 3-2.5 Ma (4 & 8)		* Marked decrease in carbonate content @ c. 2.5 Ma (26)
3	3.2 NH 8 3.7	* Marked increase in sedimentation in North Atlantic @ c. 4 Ma (3).		* Tectonic closure of PG by 3.5 Ma (6).		* Increase in Northern Hemisphere glaciation @ 3.2 Ma (3)	* Relatively high NCW production @ 4-3 Ma, then decrease @ 3.0 Ma (3)	
4		* Modern pattern of world sediment distribution established (1).		* Complete closure of PG @ 3.7-3.1 Ma; sea level drop and climate cooling (12).		* Drawdown of CO_2 resulting in cooling & glaciation & subsequent increased in palaeoproductivity adding to this (4)		
5	4.7 NH 7 5.2		* Isolation of Mediterranean (1).	* Very restricted shallow water connection across PG @ 6.3-3.7 Ma, sea level rise; warming (12).				
6	6.0 NH 6		* Uplift at Gibraltar (1).	* By c. 6 Ma bottom waters completely isolated between Caribbean and Pacific (16).	* Increased provincialism of diatoms (1)		* WAIS established @ c. 6.5 Ma based on $\delta^{13}C$ (1 & 6)	* Palliser Coiling Zone @ c. 5.9-5.8 Ma (27)
7	7.0	* Silica increases in Indian Ocean, further reduction in North Atlantic (1)	* Gulf Stream reaches modern config. @ 8-6 Ma (sufficient deflection due to closing PG) (6 & 19).	* Panama Strait deepens to >200 m @ c. 6 Ma - Caribbean benthic forams show Pacific affinity (6).		* IRD in central Arctic = seasonal sea ice (31)	* Deep water circulation pattern similar to modern using $\delta^{13}C$ @ 7.0 Ma (11)	
		* Dropstones/IRD in North Atlantic @ c. 7 Ma (20)	* Uplift of Andes with increased weathering and nutrient supply to Pacific Ocean @ c. 8 Ma (4).	* Restricted shallow water connection across PG @ 7.0-6.3 Ma; sea level drop; climate cooling (12).	* High productivity event in eastern equatorial Pacific 8-4.5 Ma (5)		* Minor reduction in NCW production @ 7.0 Ma (3)	* Messinian Carbon Shift @ c. 7.0-6.5 Ma (30)
8	8.0 NH 5 8.6		* Intensification of Asian monsoon @ 8 Ma results in greater weathering of Himalayan Plateau & increased nutrient supply (4) & ? of silica.	* Earliest record of terrestrial fauna crossing Central American Isthmus @ 9.3-8.0 Ma (12)	* Biogeographic ocean barrier formed by Central American archipelago by 8 Ma (6)		* High NCW fluxes @ 7.5-5.3 Ma based on $\delta^{13}C$ (11)	* LAD *Bolboforma* @ c. 8.0 Ma (27)
9				* Abrupt rise in CCD @ 10 Ma in eastern equatorial Pacific prob. due to restriction of NCW flow through PG (5).		* Intermittent Arctic glacials from 10 Ma (31)	* NCW shutdown @ 8.9-8.0 Ma based on lack of difference in $\delta^{13}C$ between N. Atlantic, Pacific and Southern Oceans; minor reduction in production @ 9.0 Ma (11 & 3)	
	9.2	* Eastern equatorial Pacific 'Carbonate Crash' 10-9 Ma (5)				* West Antarctic Ice Sheet established by 10-8 Ma (23)	* High NCW fluxes @ 9.8-9.3 Ma based on $\delta^{13}C$ (11)	* Tukemokihi Coiling Zone @ 9.8-9.7 Ma (27)
10	NH 4				* Temperate SSTs on Queenland Plateau @ 10.4 Ma (14)			* Mi6 @ c. 9.9 Ma (30)
	10.5	* Change in hiatus forming mechanism @ c. 11 Ma (10)						* Kaiti Coiling Zone @ 10.95-10.85 Ma (27)
11				* Shallow water connection across PG @ 11.8-7.0 Ma; sea level rise; cool climate (12).	* Increased provincialism of all planktic groups @ 11 Ma (1)	* Possible start of glaciation on Greenland @ c. 11 Ma (20)		* Mi5 @ 11.5-11 Ma (30)
		* Silica increases in Pacific, disappears from mid latitude North Atlantic @ c. 11.2 Ma (1)	* Further restriction on Indonesian Gateway @ 12-11 Ma (2 & 23)					
12	11.8 NH 3	* Reduction in carbonate production 13-11 Ma in eastern equatorial Pacific (5)	* Difference between Atlantic & Pacific Nd content of sediments indicates closure of PG to deep waters by 12 Ma (15)	* Closing of intermediate water, and limited shallow water connection across PG @ 12.9-11.8 Ma; sea level drop; climate cooling (12).			* NCW production resumes @ 12.5 Ma (3)	
13	12.9	* Marked increase in sedimentation in North Atlantic @ c. 13 Ma (3)			* Extinction of remaining Palaeogene benthic foram fauna & high turnover of planktic forms increasing @ 13.5 Ma (8)			* End of Monterey Excursion @ 13.4 Ma (24, 7 & 30)
14						* $\delta^{18}O$ cooling event @ 14.8-14.1 Ma (8) = Mi3 & Mi4 (33)	* End of Monterey Carbon Excursion @ 13.5 Ma (8)	* Mi4 @ 13.4-12.3 Ma (24 & 30)
					* Evolutionary overturn in diatoms 14.9-12.4 Ma, with cool water forms increasing @ 13.5 Ma (8)	* Positive shift in $\delta^{18}O$ curve @ 15-13 Ma (9)		* Mi3 @ 14.7-13.8 Ma (24 & 30)
15			* Closure of Tethys seaway ending warm, saline deep flow to Southern Ocean @ 15-14 Ma (17, 18 & 7)	* Deflection of Gulf Stream due to restriction on PG @ 15-11 Ma (19).		* Initial growth of WAIS between 16-11 Ma (23)		* End of Orange unit @ 15.1-14.3 Ma (7, 24 & 30)
	15.1			* Intermediate & shallow water connection across PG @ 15.1-12.9 Ma; sea level rise; warming (12).	* Tropical faunas & SSTs on Queensland Plateau @ c. 15 Ma (14)	* Sea level drop after 16 Ma associated with EAIS build-up (9)	* NCW production reduced or eliminated @ 15 Ma (3)	* High $\delta^{13}C$ values after 15 Ma associated with increased production of oxygen-rich SCIW south of site (7, 24, & 30)
16	NH 2 16.1	* Major enrichment of silica in Pacific & Indian Oceans and decine in Atlantic - 'Silica Switch' @ c. 16 Ma (1 & 21); may not be signifcant sediment compositional change (35)		* Uplift of PG @ 16.1-15.1 Ma & closing of deep water connection; sea level drop; climate cooling (12).	* Evolutionary turnover in benthic forams 17-14 Ma; SW Pacjfic faunal changes associated with $\delta^{18}O$ increases (8)	* Large increase in benthic foram $\delta^{18}O$ @ 16-12.5 Ma linked to EAIS growth and deep water cooling (8)	* Carbon shift corresponds with a change in Os distribution in sediments @ c. 16 Ma (9)	* Mi2 @ 16.3 Ma (24, 28 & 30)
17							* Start of Monterey Carbon Excursion @ 17.0 Ma (8)	* Condensed section/hiatus @ 16.5-15.1 Ma associated with SCIW production (7 & 30)
	17.2							* Textural changes = winnowing (30)
18	NH 1 18.2	* Enrichment of silica in equatorial Pacific, reduction in Caribbean @ c. 18.0 Ma (21)	* Collision of Africa and Europe @ c. 18 Ma, i.e., start closure of Tethys (1)		* Major evolutionary change in radiolarians @ c. 17.5 Ma (1)			* Start of Orange unit; benthic forams typical of oxygen-rich waters @ c. 17 Ma (7, 24, & 29)
								* Start of Monterey Excursion @ 17.4 Ma (24 & 30)
19								* Mi1c @ c. 17.8 Ma (24 & 28)
					* Development of provincialism in coccoliths @ c. 19.0 Ma (1)		* Start of Monterey Carbon Excursion @ 19.5 Ma (9)	* Mi1b @ 18.4 Ma (24, 28 & 30)
	19.5	* Marked increase in sedimentaion in North Atlantic @ c. 19 Ma (3)	* Himalayan uplift and erosion @ 20-17 Ma corresponds with Sr curve & causes drawdown of CO_2 (9)				* Initial interval of NCW production @ 20-15 Ma, peaking around 17 Ma (3 & 34)	
20	NH 1a 20.5						* No Northern Component Water production prior to 20 Ma (3)	
21					* Increased diversity & planktic foram evolution of Neogene fauna @ c. 21.0 Ma (1)			
22								
	22.5		* Deep water opening of Tasmanian and Drake gateways by Late Oligocene c. 26 Ma (22 & 34); poss. earlier c. 32 Ma (13 & 32)					
23	PH 23.0			* Deep water connection through PG @ 23.7-16.2 Ma; climate 'warm' with high sea level (12).			* ACC development between 25-17 Ma (13 & 34)	
24			* Tasmanian Gateway open to surface waters 31-33 Ma (37)			* EAIS establishment by Early Oligocene evident in IRD on Kerguelen Plateau (36)		

Figure 11 General global Neogene palaeocirculation and selected palaeoceanographic events which are inferred to impact on the southwest Pacific and Tasman Sea region. Some specific features of the Site 593 record are included, and details are discussed in other chapters. Numbers in brackets refer to references below. IRD = ice rafted debris; PG = Panama gateway; NH = Neogene hiatus; EAIS = East Antarctic Ice Sheet; WAIS = West Antarctic Ice Sheet; NCW = Northern Component Water; SCIW = Southern Component Intermediate Water; SSTs = sea surface temperatures; Nd = neodymium; Sr = strontium; Os = osmium.

1 Keller and Barron (1983)
2 Kennett and von der Borch (1986b)
3 Wright and Miller (1996)
4 Filippelli (1997)
5 Lyle et al. (1995)
6 Collins et al. (1996)
7 Flower and Kennett (1995)
8 Flower and Kennett (1994a)
9 Raymo (1994)
10 Keller and Barron (1987)
11 Wright et al. (1991)
12 Duque-Caro (1990)
13 Nelson and Cooke (2001)
14 Isern et al. (1993)
15 Burton et al. (1997)
16 McDougall (1996)
17 Kennett and Stott (1990)
18 Woodruff and Savin (1989)
19 Mullins and Neumann (1979)
20 Helland and Holmes (1997)
21 Leinen (1979)
22 Wright and Miller (1993)
23 Kennett and Barker (1990)
24 Elkington (2000)
25 Robert et al. (1986)
26 Mycke et al. (1986)
27 Crundwell (in prep.)
28 Scott et al. (1994)
29 Boersma (1986)
30 This study
31 Frakes et al. (1992)
32 Lawver and Gahagan (1998)
33 Miller et al. (1991)
34 Billups et al. (2002)
35 Wright et al. (1992)
36 Zachos et al. (1992)
37 Leg 189 (2001)

Significance of tectonic gateways

Restriction of Indonesian gateway by 10 Ma

During the Early Miocene the Indonesian gateway was open, allowing surface and deeper waters to flow between the Pacific and Indian Oceans (Hamilton, 1979, 1988; Kroenke et al., 1993). By the Middle Miocene the gradual restriction of this gateway, due to the collision of Australia with southeast Asia, resulted in the 'piling up' of warm surface waters in the tropical western Pacific, dragged westwards by the trade winds (Kennett et al., 1985). This in turn established the Equatorial Undercurrent, the west to east return flow in the Pacific by c. 12-11 Ma (Burns and Andrews, 1973; van Andel et al., 1975). By the early Late Miocene (c. 10 Ma) the Indonesian gateway probably reached its modern configuration (Kennett et al., 1985) where the modern western Pacific 'warm pool' extends from the Philippines, along the equator eastwards to about 170°W, and southwards to the Solomon Islands at around 15°S) (Tomczak and Godfrey, 1994). Tectonic restriction of this gateway and establishment of a region of warm surface waters around the equator in the western Pacific would provide a mechanism for transporting the warmed water to the east of Papua New Guinea and linking it to the southward-flowing East

Australian Current (EAC) and the Tasman Sea, accentuated during times of lowered sea level. The Hole 593 planktic foraminiferal census data show a warm subtropical signature through the early Late Miocene section (>240 mbsf) (Crundwell, in prep.). This supports the contention that the partial closure of the Indonesian gateway and the resultant 'warm pool' formation pushed the warm subtropical surface waters southwards via the newly established/invigorated EAC into the southern Tasman Sea. The absence of the warm subtropical species after c. 8.8 Ma (Crundwell, in prep.) may be due to the establishment or strengthening of the Tasman Front (which is linked to the EAC), restricting the warm subtropical species to north of this front.

Closure of the Panama gateway and Greenland Ice Sheet development

Prior to the closure of the Panama gateway, low latitude Atlantic surface waters were probably not as saline and the open gateway restricted the development of the Gulf Stream, which in the modern North Atlantic transfers heat and salt to high latitudes (Broecker and Denton, 1989). While the Panama gateway was open, conveyer belt circulation in the Atlantic was not possible. Although the complete closure of the Panama gateway occurred with the uplift of the Isthmus by c. 3.5 Ma (Collins et al., 1996), partial closure and palaeoceanographic restriction occurred much earlier. The Panama gateway was restricting deep water flow by c. 15 Ma (Duque-Caro, 1990), and by c. 12 Ma there was no longer a deep water connection between the Pacific and Atlantic (Raymo, 1994; Burton et al., 1997). The eastern equatorial Pacific carbonate crash at c. 10 Ma has been linked to restriction of this gateway because the non-carbonate corrosive Northern Component Water which previously flowed into the Pacific Ocean, was replaced by carbonate-corrosive Southern Component Deep Water in the eastern Pacific basins (Lyle et al., 1995). The earliest land fauna crossing between North and South America occurred c. 9-8 Ma (Duque-Caro, 1990) and the gateway was an effective biogeographic barrier between the Pacific and Atlantic waters by 8 Ma (Collins et al., 1996). As a result of the partial closure of the Panama gateway, the deflection of the Gulf Stream occurred much earlier than the final uplift of the Isthmus. Partial deflection probably occurred when the deep water connection was closed, c. 15-11 Ma (Mullins and Neumann, 1979). Complete deflection occurred by c. 8 Ma (Collins et al., 1996) with the Gulf Stream reaching its modern configuration by c. 6 Ma (Mullins and Neumann, 1979). The deflection of the Gulf Stream would transport warm saline surface waters to the

North Atlantic (c. 8-6 Ma) with the likely result of initiating thermohaline circulation (the conveyer belt) in the Atlantic (see Broecker and Denton, 1989).

The oldest North Atlantic ice-rafted debris and dropstones are recorded from the Greenland margin (Site 918) at about 7.0 Ma, and have been interpreted to result from initial growth of Northern Hemisphere ice caps during the Late Miocene (Larsen et al., 1994). However, Helland and Holmes (1997) reported that the sediments below the dropstones in Hole 918 are also of glaciomarine origin and may be as old as c. 11 Ma. Glaciers would readily form in southeast Greenland due to the combination of high precipitation, the result of the Gulf Stream development, and topography, and that this region may have been the nucleation site for the ice cap rather than further north in Fennoscandia (Larsen et al., 1994). The timing of the partial deflection of the Gulf Stream from 15-11 Ma in combination with tectonic controls on Northern Component Water formation (Wright and Miller, 1996), and complete Gulf Stream deflection by 8 Ma, could account for the increased precipitation and ice sheet development on Greenland. By changing the dominant glacier formation from alpine to piedmont and increasing precipitation over Greenland, the resulting increase in snow, and ice advance would generate an ice sheet (Larsen et al., 1994).

Palaeoceanographic consequences for the southern Tasman Sea

While many of the various events detailed in Fig. 11 often did not directly affect the southern Tasman Sea, the consequences of many of them are evident in the Hole 593 data set. The palaeoceanographic connections between the restrictions on both the Indonesian and Panamanian gateways, deflection of the Gulf Stream, initiation of the Greenland ice cap, and initiation of the WAIS, all relate to the establishment of thermohaline conveyer belt circulation. Onland ice accumulation on Antarctica by the latest Eocene suggests regional temperatures below freezing for at least part of the year. Continued ice accumulation throughout the Oligocene, establishing the EAIS (Wise et al., 1991; Nelson and Cooke, 2001) and sea ice production around parts of Antarctica indicate freezing to sea level by this time, commencing thermohaline circulation (Kennett and Stott, 1990). Tectonic controls on, and isotopic evidence for, Northern Component Water point to production of this deep water starting by the Early Miocene (Wright and Miller, 1996; see also Fig. 11)

indicating cooling of the Arctic region. Once the Panama gateway restriction diverted the Northern Component Water into the South Atlantic (Duque-Caro, 1990; Lyle et al., 1995; Collins et al., 1996), a mechanism for transporting large amounts of heat to the Southern Ocean was established. Ocean currents transport about one third of the excess heat received at low latitudes towards the poles (Barry and Chorley, 1987). The consequence of this heat transfer via the deep waters was an increase in precipitation on the Antarctic continent (Prentice and Matthews, 1991; Kennett and Hodell, 1993), evident in the expansion of the EAIS through the Late Oligocene and Early Miocene. The glacial Zones Mi1 to Mi2 indicate fairly extreme climate change in the antarctic region because they occur within a general interval of climate warmth, known as the Miocene climate optimum (Fig. 12). Extreme climatic cooling and glaciation during the Miocene have been associated with invigorated circulation (e.g. McCave, 1984; McCave et al., 1995), and this invigoration is evident in the increased sand content from c. 18-14 Ma in the Hole 593 sediments (Fig. 5). Specifically, glacial Zones Mi1b, Mi1b, Mi2 and Mi3 all correspond with peaks of variably increased abundances of sand in the record (Fig. 12).

The Monterey Excursion (high $\delta^{13}C$ values) is associated with the climate optimum because this was a time of relatively high CO_2 levels in the atmosphere, resulting in 'greenhouse' conditions (Vincent and Berger, 1985; Berner, 1997). As the increased phytoplankton activity (evident in the large organic carbon deposits around the Pacific Rim, e.g., Flower and Kennett, 1993, 1994b) pulled CO_2 out of the atmosphere, the climate cooled, culminating in glacial Zone Mi3 at c. 14 Ma, and an enduring EAIS becoming established between c. 15.6 Ma and 13.8 Ma (Marchant and Denton, 1996). In addition, once the warm tropical waters forming the Gulf Stream had begun to deflect into the North Atlantic by about 8 Ma, the heat transfer from the tropics to high northern latitudes increased precipitation on Greenland and initiated ice accumulation there (Larsen et al., 1994). Climatic cooling of the North Atlantic region accelerated Northern Component Water production (Fig. 11) from c. 10-9 Ma (Wright and Miller, 1996), and with the circulation of Northern Component Water southwards this would in turn have accelerated ice accumulation on Antarctica. WAIS initiation is evident in glacial Zones Mi5 and Mi6, both recorded in Hole 593.

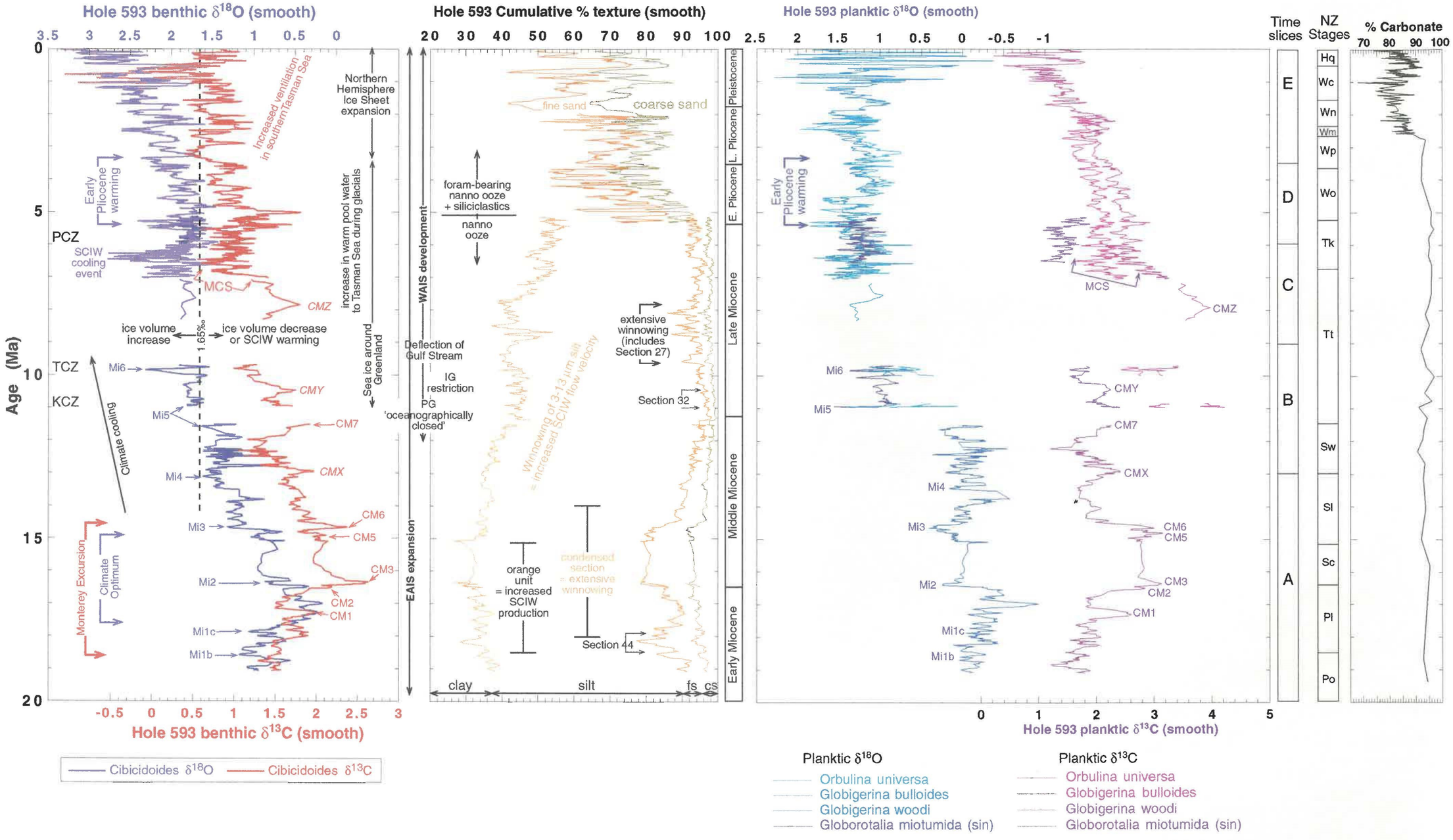

Hole 593 benthic δ18O (smooth)
Hole 593 Cumulative % texture (smooth)
Hole 593 planktic δ18O (smooth)
Time slices
NZ Stages
% Carbonate
Age (Ma)
Increased ventilation in southern Tasman Sea
Northern Hemisphere Ice Sheet expansion
Early Pliocene warming
PCZ
SCIW cooling event
MCS
CMZ
ice volume increase
ice volume decrease or SCIW warming
1.65‰
TCZ
KCZ
Mi6
CMY
Mi5
CM7
Mi4
CMX
CM6
Mi3
CM5
CM3
Mi2
CM2
CM1
Mi1c
Mi1b
Climate cooling
Monterey Excursion
Climate Optimum
increase in warm pool water to Tasman Sea during glacials
Sea ice around Greenland
WAIS development
EAIS expansion
Deflection of Gulf Stream
IG restriction
PG 'oceanographically closed'
fine sand
coarse sand
foram-bearing nanno ooze + siliciclastics
nanno ooze
Winnowing of 3-13 μm silt = increased SCIW flow velocity
extensive winnowing (includes Section 27)
Section 32
orange unit = increased SCIW production
condensed section = extensive winnowing
Section 44
clay
silt
fs
cs
Pleistocene
L. Pliocene
E. Pliocene
Late Miocene
Middle Miocene
Early Miocene
E
D
C
B
A
Hq
Wc
Wn
Wm
Wp
Wo
Tk
Tt
Sw
Sl
Sc
Pl
Po
Hole 593 benthic δ13C (smooth)
Hole 593 planktic δ13C (smooth)
Cibicidoides δ18O
Cibicidoides δ13C
Planktic δ18O
Orbulina universa
Globigerina bulloides
Globigerina woodi
Globorotalia miotumida (sin)
Planktic δ13C
Orbulina universa
Globigerina bulloides
Globigerina woodi
Globorotalia miotumida (sin)

Figure 12 Neogene palaeoceanographic proxy data from Hole 593, annotated with selected events linked to palaeoclimatic changes recorded in the data set. New Zealand stages are defined in Fig. 2. KCZ = Kaiti Coiling Zone; TCZ = Tukemokihi Coiling Zone; PCZ = Palliser Coiling Zone; MCS = Messinian Carbon Shift; PG = Panama gateway; IG = Indonesian gateway; EAIS = East Antarctic Ice Sheet; WAIS = West Antarctic Ice Sheet; SCIW = Southern Component Intermediate Water; fs = fine sand; cs = coarse sand. Core sections 27, 32 and 44 are singled out because these represent visual changes in texture recorded in the core log, and therefore represent intervals of persistent winnowing. Time slices as per this chapter.

Continued climatic cooling through the Late Miocene, with SCIW exhibiting extreme cooling (and possibly some ice volume increase) at c. 6.5 Ma, corresponds with the Messinian Carbon Shift (MCS) (Fig. 12) in the Hole 593 sediments, supporting the contention that this carbon event is in part linked to glacio-eustacy (Kastens, 1992; Hodell et al., 2001).

The cooling of the SCIW without the generation of large amounts of ice may reflect development of the Ross Ice Shelf producing cooled water during winter which contributes to the cooled antarctic surface water signal in the SCIW. However, as the SCIW cooling is not interpreted as glacial, the ice shelf is inferred to have melted during summer, which when combined with the winter waters would not record any ice volume increase in the $\delta^{18}O$ record, but would generate cooled SCIW.

Invigorated circulation continued through the Pliocene and Pleistocene in the southern Tasman Sea as evident in the lithological change to foraminifera-bearing nannofossil ooze through the top 120 m of core. This lithological change is interpreted to be associated with consistently faster SCIW flow rates winnowing the sediments, and is supported by convergence in the benthic and planktic $\delta^{13}C$ records, the result of greater ventilation of the subducted waters forming the SCIW.

NEOGENE PALAEOCEANOGRAPHIC TIME SLICES BASED ON HOLE 593

The Neogene palaeoclimate proxy records generated from Hole 593 have been divided up into five time slices illustrated on Fig. 12.

Time slice A: 19 to 13 Ma - for the first time most of the globally-recognised deep water palaeoclimate events have been recorded in intermediate waters. These include the glacial Zones Mi1b to Mi4, and the carbon maxima CM1 to 6 which in combination define the $\delta^{13}C$ Monterey Excursion. This time slice includes the

expansion of the East Antarctic Ice Sheet, the Miocene climate optimum, and extreme winnowing on the Challenger Plateau due to large volumes of Southern Component Intermediate Water production.

Time slice B: 13 to 9 Ma – includes glacial Zones Mi5 and Mi6, carbon maxima CMX, CM7 and CMY, and two *Globorotalia miotumida* coiling zones. This time slice includes palaeoceanographic closure of the Panama gateway, initial northwards deflection of the Gulf Stream, ice accumulation on Greenland with subsequent cooling of high northern latitudes, and initiation of the West Antarctic Ice Sheet.

Time slice C: 9 to 6 Ma – includes extensive winnowing from 9.5 to 8 Ma, the Messinian Carbon Shift from 7.0-6.5 Ma, extreme cooling of Southern Component Intermediate Water without a large ice volume change, and one *Globorotalia miotumida* coiling zone. This time slice includes full deflection of the Gulf Stream into the North Atlantic, sea ice around Greenland, and continued expansion of the West Antarctic Ice Sheet.

Time slice D: 6 to 3.5 Ma – includes recognition of the Early Pliocene warming event from 5-3.5 Ma and a textural change to increased sand content, possibly the result of delayed oceanic response to climate change. Closure of the Panama gateway was complete.

Time slice E: 3.5 to 0 Ma – accelerated winnowing of Challenger Plateau sediments associated with accelerated Southern Component Intermediate Water cooling, a reduction in the $\delta^{13}C$ gradient between Cool Subtropical Water and the watermasses below it because of increased ventilation of the southern Tasman Sea, and a significant increase in the amplitude of $\delta^{18}O$ fluctuation. The time slice includes establishment of the Northern Hemisphere Ice Sheets and their associated climatic cooling.

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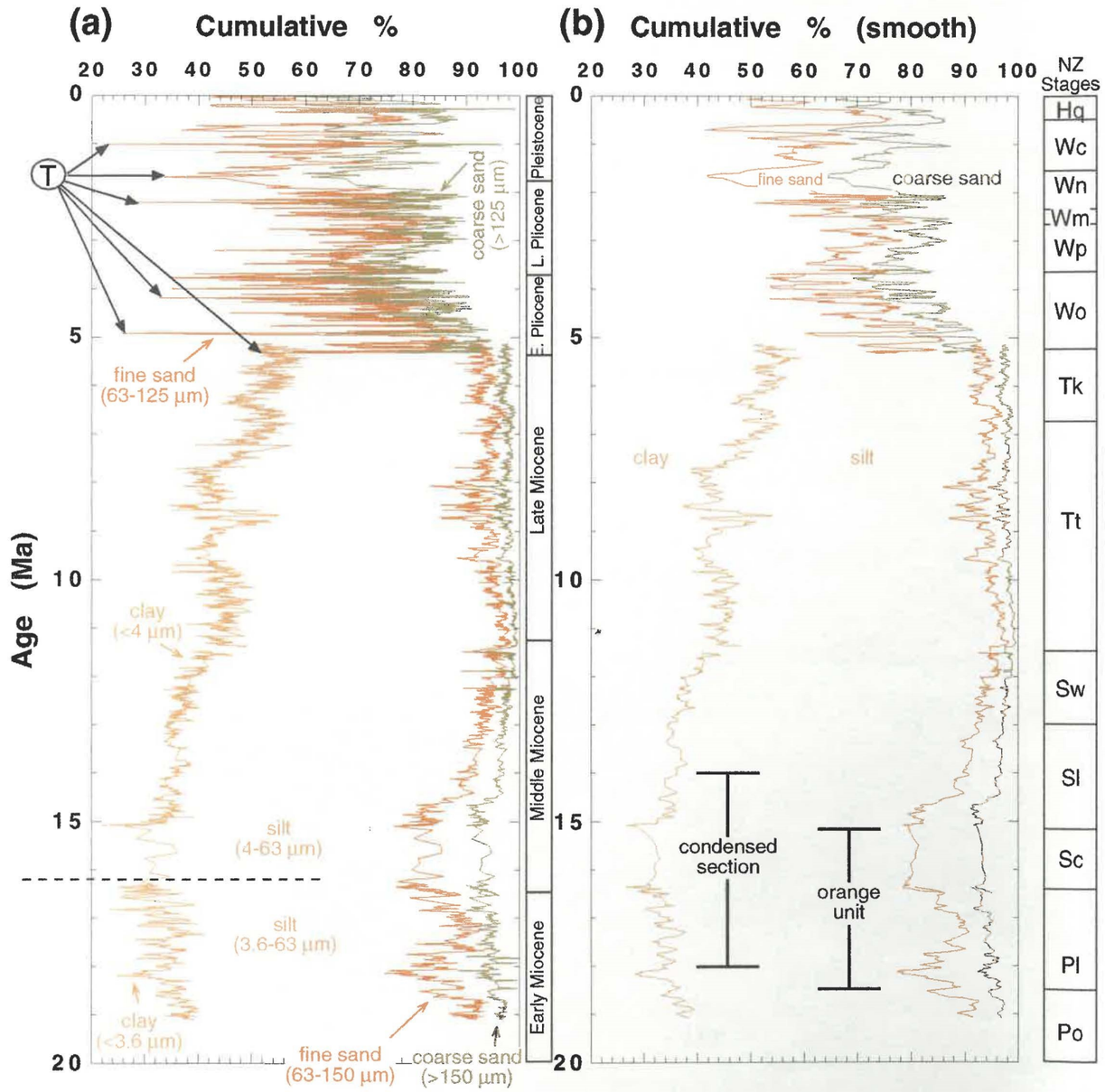
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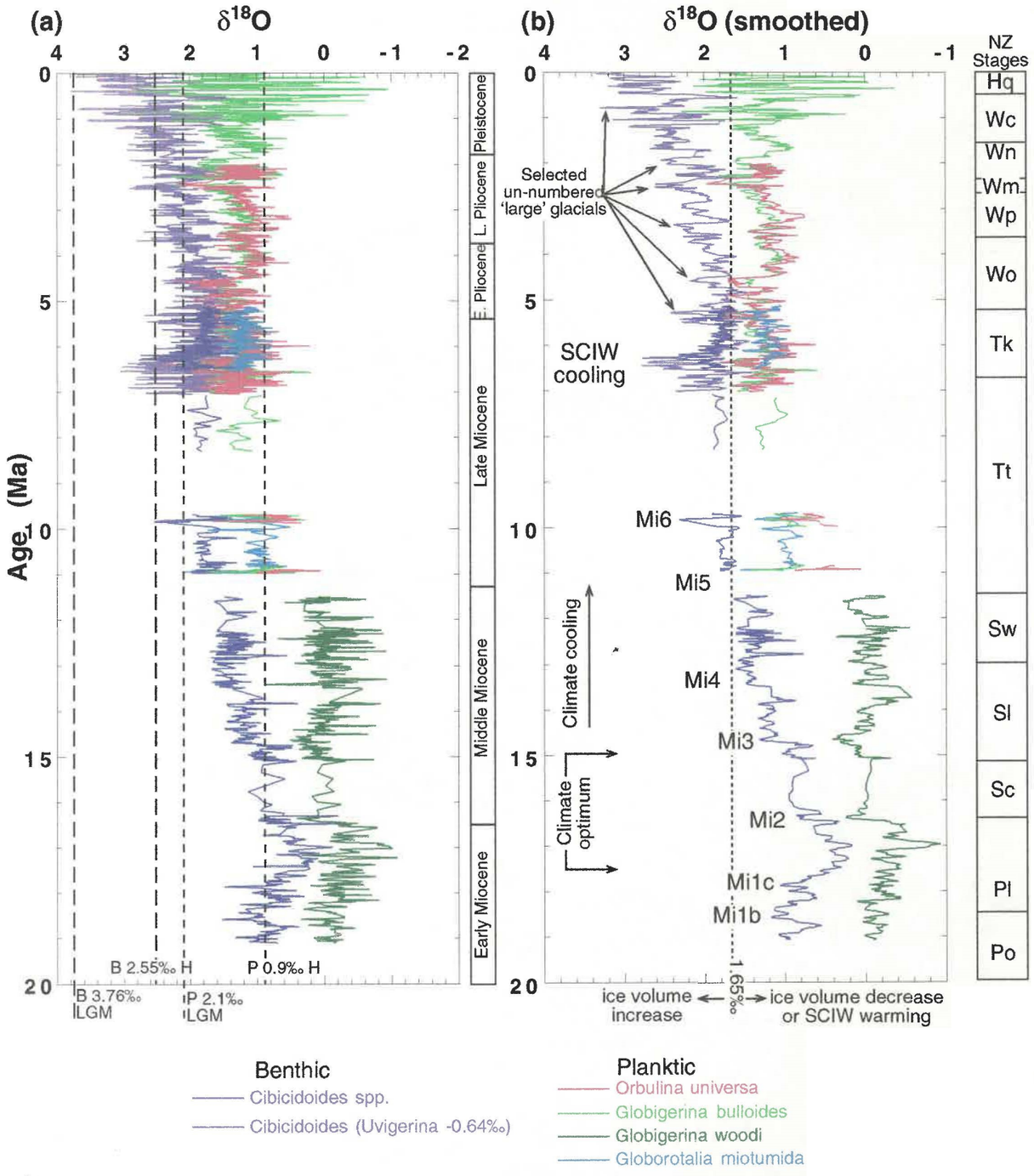
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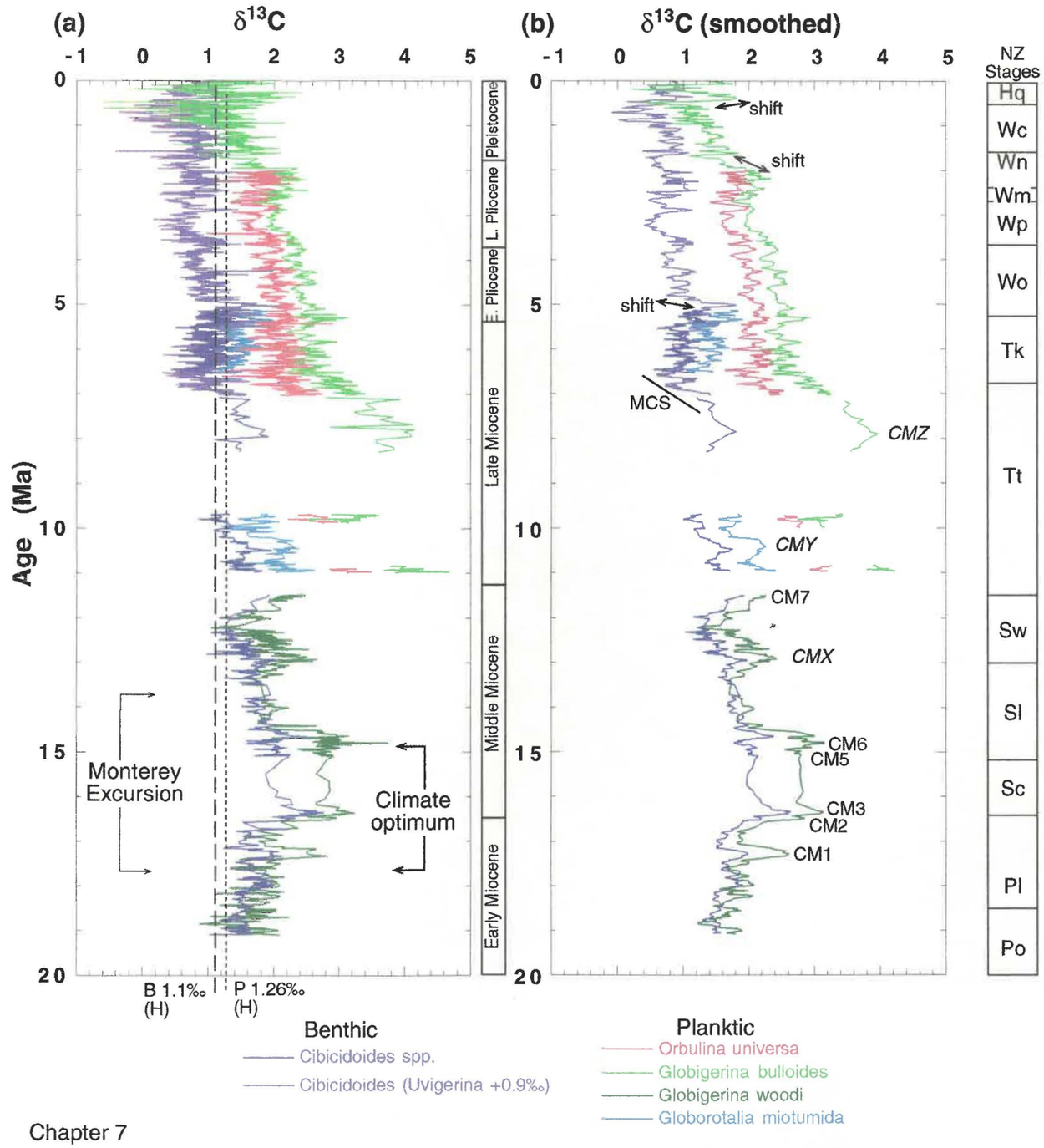
Chapter 7

Figure 5 (a) Hole 593 raw bulk texture data, with several tephra layers (T) marked which contribute to greater variability in the younger part of the hole. (b) Smoothed texture data, with the Early Miocene increased sand content corresponding with the condensed section and extremely well oxidised 'orange unit'. Note that the cumulative % axis is shown only down to 20%, and that for some samples between c. 19-15 Ma the clay/silt boundarys uses 3.6 µm, rather than the standard 4.00 µm value. NZ Stages defind in Fig. 2.



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Figure 6 (a) Hole 593 Neogene raw $\delta^{18}O$ data, with Holocene (H) and Last Glacial Maximum (LGM) values marked for comparison. (b) Smoothed $\delta^{18}O$ data, with the glacial Zones Mi1b to Mi6, Southern Component Intermediate Water (SCIW) cooling event, and several un-numbered glacials identified. Values heavier than 1.65‰ are inferred to reflect active ice volume increase. NZ Stages see Fig. 2.



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Figure 7. (a) Hole 593 Neogene raw $\delta^{13}C$ data, with Holocene (H) values marked for comparison. The interval of enriched values from 17.5-13.5 Ma is identified as the Monterey Excursion. (b) Smoothed $\delta^{13}C$ data, with the carbon maxima CM1-7 identified. Additional Middle to Late Miocene carbon maxima, labelled CMX to Z, are also noted, along with the Messinian Carbon Shift (MCS) and several Pliocene to Holocene un-numbered carbon shifts. Benthic and planktic Holocene (H) values are included for comparison. NZ Stages detailed in Fig. 2.

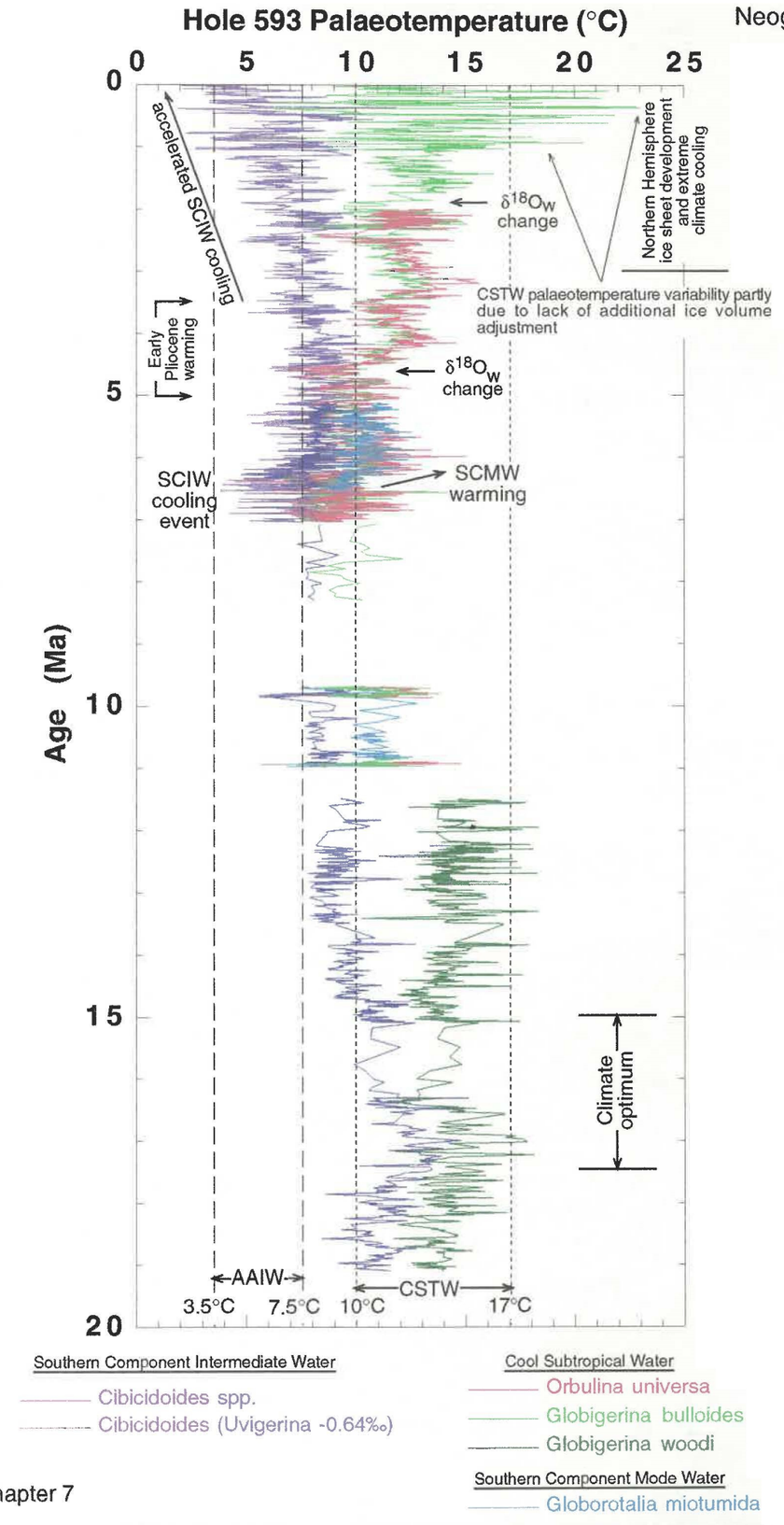


Figure 9 Palaeotemperature records for the intermediate (SCIW), mode (SCMW) and surface waters (CSTW) through the Neogene from Hole 593. Selected events illustrated. The range of modern Antarctic intermediate Water (AAIW) and Cool Subtropical Water (CSTW) values are marked for comparison. Climate optimum = interval of warmer climate associated with the Monterey Excursion (Fig. 7).

Glossary

Glossary

Abbreviation	Full description
Surface watermasses in latitudinal order: equator to pole	
PEW	Pacific Equatorial Water (warm, high salinity water; dragged eastwards via SEC)
SLW	Subtropical Lower Water
WSTW	Warm Subtropical Water
CSTW	Cool Subtropical Water (nutrient depleated)
WSPCW	Western South Pacific Central Water
BSW	Bass Strait Water
SASW	Subantarctic Surface Water
CSW	Circumpolar Subantarctic Water
AASW	Antarctic Surface Water
Subsurface Watermasses	
SAMW	Subantarctic Mode Water (originates along SAF)
AAIW	Antarctic Intermediate Water (originates along AAPF)
uCPDW	upper Circumpolar Deep Water (less saline than 1 & 2; oxygen minimum)
lCPDW1	lower Circumpolar Deep Water 1 (salinity maximum from NADW component)
lCPDW2	lower Circumpolar Deep Water 2 (less salinity than 1, but colder & oxygen maximum); consists of AABW (WSDW + RSDW) + AASW but NO NADW
PCW	Pacific Common Water (large component is CPDW)
PDW	Pacific Deep Water (large component is CPDW)
AABW	Antarctic Bottom Water (originates along AAD)
WSBW	Weddell Sea Bottom Water (forms AABW)
RSBW	Ross Sea Bottom Water (forms AABW)
RSSW	Ross Sea Shelf Water (forms AABW)
NADW	North Atlantic Deep Water
NPDW	North Pacific Deep Water (derives from DWBC upwelling in North Pacific returning southwards, east of NZ, but NOT in Tasman Sea; high silica & nutrients)
Ocean Fronts	
TF	Tasman Front
STF	Subtropical Front
SAF	Subantarctic Front
AAPF	Antarctic Polar Front
AAPFZ	Antarctic Polar Front Zone (northern margin is the SAF)
AAD	Antarctic Divergence
Ocean Currents	
EAC	East Australian Current
EAUC	East Auckland Current

TC	Tasman Current
SPC	South Pacific Current (flow along the STF)
ACC	Antarctic Circumpolar Current
DWBC	Deep Western Boundary Current
SEC	Southern Equatorial Current
NEC	Northern Equatorial Current
NGCUC	New Guinea Coastal Undercurrent
EUC	Equatorial Undercurrent
ECC	Equatorial Counter Current

Pre-modern Oceanography

NCW	Northern Component Water (equivalent to NADW)
SCW	Southern Component Water (equivalent to southern ocean watermasses)
SCMW	Southern Component Mode Water
SCIW	Southern Component Intermediate Water
SCBW	Southern Component Bottom Water
TISW	Tethys Indian Saline Water (western Tethys Sea - Mediterranean); may also be called Warm Saline Deep Water (pre-Neogene warm, low latitude, saline, deep water)

General oceanography

STD	salinity, temperature, and depth
SSTs	sea surface temperature(s)
SSPTs	sea surface palaeotemperatures
BWTs	bottom water temperature(s)
BWPTs	bottom water palaeotemperatures

General terms

mbsf	metres below sea floor
FAD (LAD)	First (Last) appearance datum
FCO (LCO)	First (Last) common occurrance
FAD (LAD)	First (Last) appearance datum

Neogene New Zealand Stages occurring in this project

Haweran	Hq	Holocene
Castlecliffian	Wc	Wanganui Series
Nukumaruan	Wn	
Mangapanian	Wn	
Opoitian	Wo	
Kapitean	Tk	Taranaki Series
Tongaporutuan	Tt	
Waiauan	Sw	Southland Series
Lillburnian	Sl	
Clifdenian	Sc	
Altonian	Pl	Pareora Series
Otaian	Po	

Appendix A

Oceanographic Data

Appendix A - Oceanographic data

This appendix contains the salinity, temperature, and depth (STD) data used in this study. It also details the various watermasses in and around the Tasman Sea, with their physico-chemical properties.

Watermass Characteristics and Defining Properties

Appendix A Table 1. General watermass characteristics in the Southwest Pacific (for Tasman Sea see specific data sheet). Max and min refer to identifying feature of the watermass. After Wyrtki (1961; 1962b), Gordon and Tchernia (1972), Gordon (1975), Lonsdale (1976), Godfrey et al. (1980), Thompson and Edwards (1981), Mantyla and Reid (1983), Heath (1985), Chiswell (1994), Johnson et al. (1994), Carter and McCave (1994), Szymanska and Tomczak (1994) and Neil (1997).

Watermass	Code	Depth (m)	Salinity (‰)	Density	Temp (°C)	O_2 (ml/l)	Nutrients
Thermocline Water	CSTW	0-400	34.42 - 35		10 - 17	4.4 - 5	low
Subantarctic Surface Water	SASW		34.2 - 34.6		8 - 10	high	
Circumpolar Surface Water	CSW		33.9		5.5		
Antarctic Surface Water	AASW	50-250	33.8		1.5		
AASW south of Polar Front (temp min)			33.9-34.4		-1.9 - 2.5		
Subantarctic Mode Water	SAMW	400-600	34.6 - 34.7	26.8-27.2	6 - 9	6.3 MAX	
		300-700					
Antarctic Intermediate Water (northern)	AAIW (n)	shoals to 700	34.4 - 34.48		5 - 6.5		rich
Antarctic Intermediate Water (southern)	AAIW (s)	600-1450	34.3 - 34.42	27.2-27.3	3.5 - 5	3.2-4.7	rich
AAIW combined			34.3 - 34.5		3.4 - 7	4.73	rich
Circumpolar Deep Water (upper)	*u*CPDW	1450-2500	34.5 - 34.7	27.35-37	2 - 3	2.8-3.3 MIN	
Circumpolar Deep Water (lower 1)	*l*CPDW$_1$	2500-3800	34.7 - 34.78 MAX	37-45.93	1 - 1.7	3.3-3.6	low Si
Circumpolar Deep Water (lower 2)	*l*CPDW$_2$	>3800	34.68 - 34.71	45.93-46	0.2 - 1	4.7-4.8 MAX	low Si
*u*CPDW south of Polar Front (temp min)		250-600	34.6 - 34.72		0.9 - 2.5		
Antarctic Bottom Water	AABW	~ >4500	34.66	>46	-1 - -0.5	~5 MAX	
Weddell Sea Bottom Water	WSBW		33.83		-1 - -0.5		
Ross Sea Shelf Water	RSSW	0-550	34.75 - 35		-1.8 - -2		
Ross Sea Bottom Water	RSBW		34.7 - 34.78	28.17	-1 - 0		
Pacific Deep Water	PDW	~3000	34.74 (PDW salinity max at ~3000m)				
North Indian Intermediate Water	NIIW		35.0		8.8		
Indian Deep Water	IDW		34.5		0.8 - 1		
North Atlantic Deep Water	NADW		34.84 - 35.0 MAX		2 - 3.5	3 - 5	poor
North Pacific Deep Water (east of NZ)	NPDW	1450-2550	34.5 - 34.67		1.8 - 3.2	2.8 - 3.2	MAX
*u*CPDW shallows to ~2500 m as NPDW arrives off the east coast of NZ and NPDW sits under AAIW displacing *u*CPDW							
NPDW (west of East Pacific Rise)		2500-3000					

Appendix A Table 2. Watermass data specific to the northern and southern Tasman Sea regions, these being separated by the Tasman Front (see Fig. 10). After Wyrtki (1961; 1962a; 1962b), Garner (1962; 1967), Garner and Ridgway (1965) and Villanoy and Tomczak (1991).

Northern Tasman Sea – flow into Tasman Sea via subtropical gyre							
Watermass	**Code**	**Depth (m)**	**Salinity (‰)**	**Density**	**Temp (°C)**	**O_2 (ml/l)**	**Si**
Subtropical Surface Water	SSW	0-125	34-35.6		>24		
Subtropical Lower Water	SLW(n)	125 - 250	35.6 - 35.95 ^{MAX}		21-24	3.0 - 4.0	
O min		150 - 500	34.9 - 35.9		12 -24	2.7 - 4.6	
Subantarctic Mode Water	SAMW(n)	200 - 500	34.6 - 35.2		8 - 14	4.4 - 6.1 ^{MAX}	
Antarctic Intermediate Water	AAIW(n)	700	34.37 - 34.53 ^{MIN}		4.2 - 6.0	>4.4 ml/l	

Southern Tasman Sea – flow between Australia and New Zealand							
Watermass	**Code**	**Depth (m)**	**Salinity (‰)**	**Density**	**Temp (°C)**	**O_2 (ml/l)**	**Si**
Subtropical Lower Water	SLW(s)	0-125	35.5 - 35.95 ^{MAX}		18 - 25	4.4 - 5.4	
(SLW(s) only present along Tasman Front, northwest of NZ)							
Thermocline Water	CSTW	0-400	34.6 - 35		10-17	4.4 - 5	
Bass Strait Water	BSW	200-400	>35.7		12-15		
Subantarctic Mode Water	SAMW	400-700	34.6 - 34.7	26.8-27.0	8-9	5.7-5.8 ^{MAX}	
Antarctic Intermediate Water west side (Di924)	AAIW w	600-1300	34.46 - 34.58		4-7.5	3.57-4.7	
Antarctic Intermediate Water east side (Di2819)	AAIW e	700-1370	34.39- 34.52 ^{MIN}		3.57-7.25	3.5-4.8	
Circumpolar Deep Water (upper)	*u*CPDW	1370-2100	34.56 - 34.60	27.35-27.5	2.5-3.5	3.3-3.5 ^{MIN}	
Circumpolar Deep Water (lower 1)	*l*CPDW$_1$	2100-3000	34.64-34.75 ^{MAX}	27.5-27.65	1.5-2.5	3.4-3.8	low
Circumpolar Deep Water (lower 2)	*l*CPDW$_2$	>3000	34.68 - 34.71		1	3.6-3.8 ^{MAX}	low
AABW of some sort (one site only)		>4000	34.74		1	3.8	

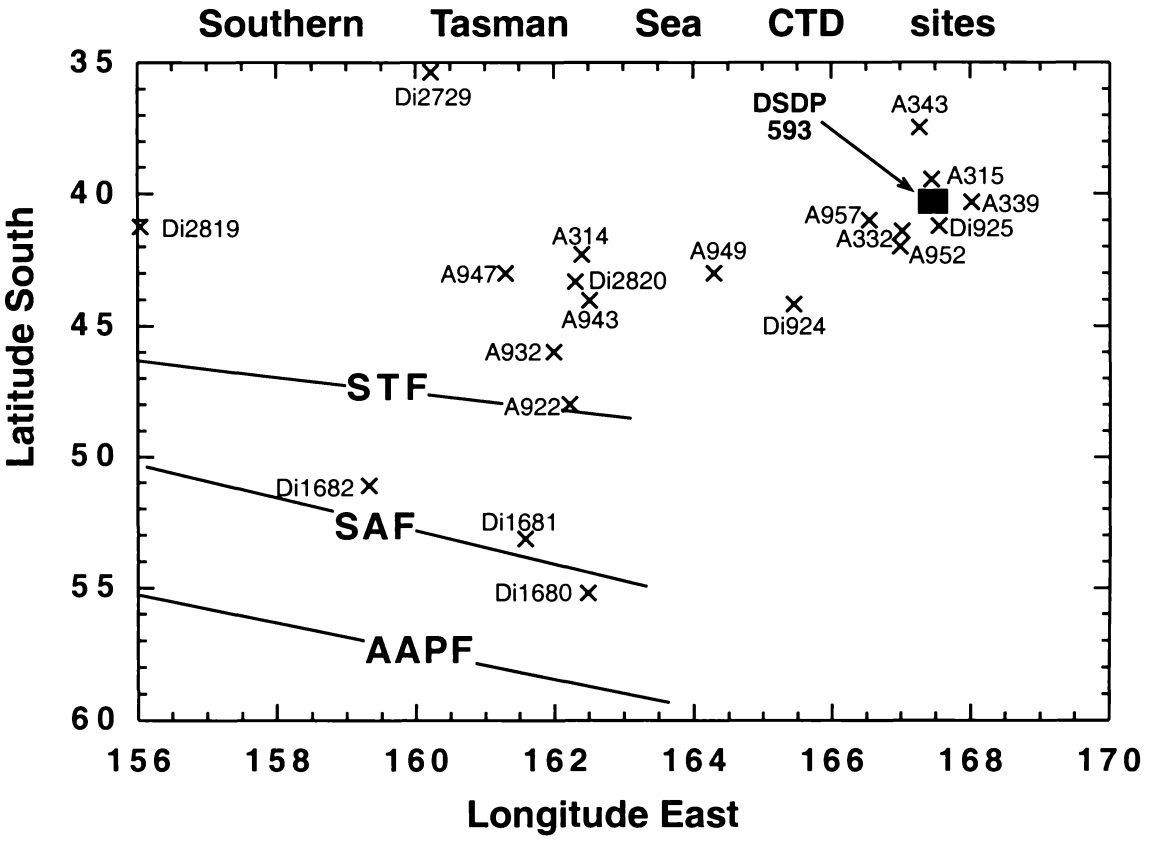
(n) = northern, (s) = southern, w = west, e = east

Appendix A Table 3. (a) Southwest Pacific surface watermasses and the fronts which separate them. The latitudes and longitudes at which the fronts occur in the region are noted in the lower (b), based on STD profiles (Webb et al., 1991). After Wyrtki (1961; 1962a; 1962b), Garner (1962; 1967), Garner and Ridgway (1965), Gordon and Goldberg (1970) and Gordon (1975).

Water Masses	Abb	Depth	Features
Warm Subtropical Surface Water	WSTW	Surface	>20°C
Tasman Front	*TF*		*Separates WSTW from CSTW at 20°C isotherm*
Cool Subtropical Surface Water	CSTW	Surface	>15/10°C
Subtropical Front	*STF*		*Separates CSTW from SASW at 15°C summer/10°C winter surface isotherm*
Subantarctic Surface Water	SASW	Surface	8-12°C
Subantarctic Front	*SAF*		*Separates SASW from CSW at 8°C summer surface isotherm*
Circumpolar Subantarctic Water	CSW	Surface	5-8°C
Antarctic Polar Front	*AAPF*		*Separates CSW from AASW at 5°C summer surface isotherm*
Antarctic Surface Water	AASW	Surface	<5°C with icebergs
Antarctic Divergence	*AAD*		

Longitude	AAD	AAPF	SAF	STF	TF
132°E	65°S	55°S	50°S	45°S	
145°E	66°S	55°S	50°S	45°S	
150°E	66°30'S	55°S	50°S	45°S	
155°E	66°30'S	55°30'S	50°S	46°S	30°S
160°E	70°S	58°S	53°S	47°S	33°S
165°E	70°S	60°S	55°30'S	48°S	33°S
170°E	70°S	62°S	56°S	49°S	

STD Station Locations and Data



Appendix A Fig. 1: STD sites in the southern Tasman Sea (Garner, 1962, 1967; Garner and Ridgway, 1965)

Appendix A Table 4a: STD data for southern Tasman Sea stations (Garner,1962). mbsl = metres below sea level.

Di2820 Winter				Di924 Winter				Di925 Winter			
depth (mbsl)	temp (°C)	salinity (‰)	oxygen (ml/l)	depth (mbsl)	temp (°C)	salinity (‰)	oxygen (ml/l)	depth (mbsl)	temp (°C)	salinity (‰)	oxygen (ml/l)
0	12.5	34.78	5.99	0	11.38	34.85	5.71	0	12.07	34.93	5.67
10	12.5	34.81		10	11.38	34.85		10	12.07	34.93	
20	12.5	34.76	5.93	20	11.38	34.85	5.72	20	12.08	34.93	5.67
30	12.5	34.79		30	11.38	34.85		30	12.08	34.93	
50	12.49	34.77	6.34	40	11.33	34.85	5.65	40	12.08	34.93	5.67
75	12.48	34.79		50	11.33	34.85		50	12.08	34.93	
100	11.56	34.97	5.5	60	11.32	34.85	5.67	60	12.08	34.93	5.65
150	10.8	34.84	5.48	80	11.32	34.85		80	12.08	34.93	
200	10.14	34.81	5.55	100	11.3	34.86	5.66	100	12.08	34.93	5.67
300	9.79	34.64	5.42	150	10.38	34.86	5.31	150	11.55	35.08	5.21
400	8.5	34.55	5.49	200	9.98	34.82	5.19	200	11.2	35.01	5.22
500	8.07	34.6	5.63	300	9.04	34.74	5.01	300	10.4	34.92	4.83
590	7.84	34.55	4.84	390	8.1	34.65	5.03	400	9.33	34.77	4.75
790	6.78	34.38	4.07	590	7.83	34.58	4.86	590	8.33	34.63	4.83
980	5.11	34.38	3.75	790	6.58	34.51	4.18	790	7.04	34.55	4.27
1180	3.93	34.5	3.49	980	5.2	34.46	4.11	990	5.34	34.43	4.02
1620	2.75	34.59	3.55	1470	3.03	34.56	3.53				
1960	2.37	34.6	3.33	1970	2.39	34.68	3.48				
2460	2.01	34.66		2460	1.95	34.74	3.94				
3430	1.32	34.7	3.81	2950	1.55	34.74	3.88				
4410	1.15	34.7	3.74	3440	1.28	34.74	3.95				
				3930	1.16	34.74	3.91				

Appendix A Table 4b: STD data for southern Tasman Sea stations (Garner and Ridgway,1965). mbsl = metres below sea level.

A332 Summer				A339 Summer				A343 Summer				A314 Winter				A315 Winter			
depth (mbsl)	temp (°C)	salinity (‰)	density (g/l)	depth (mbsl)	temp (°C)	salinity (‰)	density (g/l)	depth (mbsl)	temp (°C)	salinity (‰)	density (g/l)	depth (mbsl)	temp (°C)	salinity (‰)	density (g/l)	depth (mbsl)	temp (°C)	salinity (‰)	density (g/l)
0	17.43	35.26	25.63	0	18.55	35.41	25.47	0	19.9	35.57	25.24	0	12.92	35.09	26.5	0	14.31	35.24	26.32
10	17.43	35.26	25.63	10	18.55	35.41	25.47	10	19.87	35.57	25.25	10	12.92	35.09	26.5	10	14.29	35.24	26.32
20	17.17	35.26	25.69	20	18.54	35.41	25.47	20	19.8	35.57	25.27	20	12.78	35.09	26.53	20	14.27	35.24	26.33
30	16.9	35.25	25.75	30	18.43	35.41	25.5	30	19.6	35.37	25.32	30	12.75	35.09	26.54	30	14.25	35.24	26.33
50	16.3	35.2	25.85	50	17.25	35.39	25.77	50	18.35	35.55	25.62	50	12.65	35.08	26.55	50	14.22	35.24	26.34
75	14.25	35.15	26.27	75	16.15	35.43	26.06	75	16.15	35.5	26.11	75	12.54	35.05	26.55	75	14.2	35.23	26.34
100	13.45	35.33	26.58	100	15.03	35.42	26.31	100	15.43	35.52	26.29	100	12.47	35.00	26.52	100	14.2	35.23	26.34
150	12.6	35.39	26.79	150	13.48	35.39	26.62	150	14.5	35.48	26.47	120	12.4	34.96	26.5	120	14.2	35.23	26.34
200	12.07	35.35	26.87	200	12.75	35.32	26.71	200	13.73	35.35	26.53	150	12.28	34.9	26.48	150	14.2	35.23	26.34
300	11.15	35.22	26.94	300	11.35	35.14	26.84	300	12.2	35.11	26.66	200	10.81	34.79	26.67	200	14.15	35.23	26.34
400	10.4	34.89	26.82	400	10.12	34.96	26.92	400	10.85	34.94	26.78	300	9.62	34.65	26.76	250	14.05	35.22	26.36
500	9.68	34.8	26.87	500	9.2	34.83	26.97	500	9.75	34.81	26.87	400	8.65	34.52	26.82	300	13.21	35.19	26.52
600	8.94	34.75	26.95	600	8.3	34.74	27.05	600	8.75	34.74	26.97	500	8.09	34.46	26.86	400	11.18	34.97	26.74
800	7.3	34.67	27.14									600	7.51	34.42	26.91	500	9.69	34.71	26.8
1000	5.7	34.6	27.3									800	6.42	34.34	27	600	8.58	34.56	26.86
1200	4.36	34.56	27.42									1000	5.42	34.31	27.1	800	6.89	34.42	27.01
1500	3.03	34.59	27.58									1200	4.51	34.36	27.24				
2000	2.3	34.71	27.74									1500	3.43	34.43	27.42				
												2000	2.3	34.52	27.57				
												2500	1.79	34.58	27.68				
												3000	1.53	34.63	27.73				

Appendix A Table 4c: STD data for southern Tasman Sea stations (Garner,1967). mbsl = metres below sea level.

A922 Summer				A932 Summer				A943 Summer				A949 Summer			
depth (mbsl)	temp (°C)	sal (‰)	den (g/l)	depth (mbsl)	temp (°C)	sal (‰)	den (g/l)	depth (mbsl)	temp (°C)	sal (‰)	den (g/l)	depth (mbsl)	temp (°C)	sal (‰)	den (g/l)
0	10.51	34.24	26.29	0	12.24	34.31	26.03	0	14.5	34.87	26	0	15.8	34.88	25.72
23	9.96	34.32	26.45	21	10.99	34.39	26.32	19	14.45	34.87	26.01	24	15.6	34.89	25.77
47	9.83	34.32	26.47	42	10.3	34.51	26.54	38	14	34.94	26.16	48	13.88	34.95	26.19
71	8.99	34.37	26.65	63	9.89	34.61	26.69	57	12.79	34.91	26.38	72	13.14	34.98	26.37
94	8.35	34.39	26.76	85	9.8	34.73	26.79	76	12.24	35.01	26.57	95	11.85	35.01	26.64
142	8.52	34.51	26.83	128	9.18	34.74	26.91	119	11.35	35	26.73	142	11.02	34.98	26.78
189	8.9	34.63	26.86	171	8.9	34.66	26.89	157	10.67	34.96	26.82	190	10.65	34.93	26.8
236	8.83	34.64	26.88	215	8.76	34.63	26.89	194	10.38	34.91	26.84	237	10.26	34.87	26.82
309	8.47	34.59	26.9	301	8.25	34.55	26.9	272	9.75	34.78	26.84	332	9.57	34.76	26.86
448	7.73	34.48	26.93	431	7.97	34.52	26.92	394	8.79	34.64	26.89	475	8.57	34.61	26.9
582	7.4	34.45	26.95	562	7.78	34.51	26.94	508	8.23	34.56	26.91	616	7.81	34.53	26.95
717	6.49	34.38	27.02	693	7.02	34.45	27	626	7.87	34.55	26.96	759	6.88	34.47	27.04
807	5.76	34.37	27.11	781	6.24	34.4	27.07	703	7.21	34.5	27.02	854	6.11	34.46	27.13
896	4.94	34.33	27.17	869	5.41	34.36	27.14	782	6.58	34.47	27.08	949	5.42	34.42	27.19
985	4.3	34.32	27.24	955	4.88	34.37	27.21	861	5.97	34.44	27.14	1044	4.94	34.44	27.26
1075	3.8	34.32	27.29	1041	4.29	34.37	27.28	939	5.45	34.43	27.19	1139	4.38	34.44	27.32
1165	3.41	34.34	27.34	1129	3.83	34.38	27.33	1018	4.78	34.4	27.25	1489	2.99	34.55	27.55
1254	3.18	34.37	27.39	1215	3.57	34.44	27.41	1096	4.3	34.41	27.31				
1344	3.09	34.43	27.44	1303	3.41	34.48	27.45	1173	3.97	34.42	27.35				
1793	2.49	34.63	27.66	1727	2.52	34.61	27.64	1583	2.82	34.59	27.6				
2241	2.22	34.64	27.69	2162	2.14	34.65	27.7	1954	2.35	34.63	27.67				

Appendix A Table 4c (cont.): STD data for southern Tasman Sea stations (Garner,1967). mbsl = metres below sea level.

A952 Summer				A957 Summer			
depth (mbsl)	temp (°C)	sal (‰)	den (g/l)	depth (mbsl)	temp (°C)	sal (‰)	den (g/l)
0	16.98	35.14	25.64	0	18.13	35.22	25.43
24	16.58	35.14	25.74	17	18.12	35.24	25.44
48	14.26	35.14	26.26	34	16.7	35.18	25.74
72	13.45	35.17	26.45	51	14.88	35.17	26.15
96	12.48	35.19	26.66	70	14.32	35.15	26.25
145	11.94	35.17	26.75	100	13.13	35.19	26.53
194	11.65	35.1	26.75	130	12.49	35.2	26.67
243	11.3	35.05	26.78	150	12.09	35.16	26.71
340	10.07	34.84	26.83	202	11.77	35.12	26.74
485	8.58	34.62	26.91	290	11.2	35.04	26.79
631	7.66	34.56	27	375	10.39	34.89	26.82
776	6.58	34.49	27.1	445	9.48	34.74	26.86
874	5.81	34.45	27.16	507	8.82	34.63	26.88
970	5.11	34.45	27.25	569	8.39	34.59	26.91
1066	4.48	34.44	27.31	620	7.97	34.56	26.95
1163	3.98	34.46	27.38	668	7.72	34.54	26.97
1260	3.53	34.5	27.46	727	7.26	34.5	27.01
1356	3.15	34.53	27.52	778	6.78	34.48	27.06
1453	3.01	34.57	27.56	828	6.54	34.47	27.09
1937	2.36	34.67	27.7	1090	4.66	34.44	27.29
2420	1.9	34.75	27.8				

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Appendix B

Sedimentology Data

Appendix B - Sedimentology data

Preparation Procedures for Early to Late Miocene Samples

1.) Oven dry samples in labelled foil trays for 24hr at 35°C.

2.) Remove samples and room cool in dessicator for at least 1 hr. Transfer 10-15% of sample for archive, etc. into labelled vial, and cap.

3.) ASAP weigh the remaining 85-90% of sample to 4 decimal places (= Bulk sample wt) and transfer to a labelled 50 ml conical flask, add 40 ml buffer solution (pH c. 9.4; 4g $NaHCO_3$ + 1g Na_2CO_3 in 20 l distilled water), and leave overnight with a bung in top of flask.

4.) Wash sample using buffer solution through 63µm sieve placed over a labelled plastic pottle, and allow mud (<63 µm) to settle overnight, siphon off supernatant, and wash mud into labelled bottles using buffer solution. Store at 4°C.

5.) Rewash sand by returning to conical flask with distilled water, sonic bath 10 sec, repeat 4.

6.) Rinse sand with distilled water to remove traces of buffer solution, wash into filter paper in funnel, and leave to air dry.

7.) When satisfied sand clean and dry, dry sieve over 150µm sieve to obtain 63-150µm (Fine sand) and >150µm (Coarse sand) fractions, transfer into labelled vials for weighing to 4 decimal places.

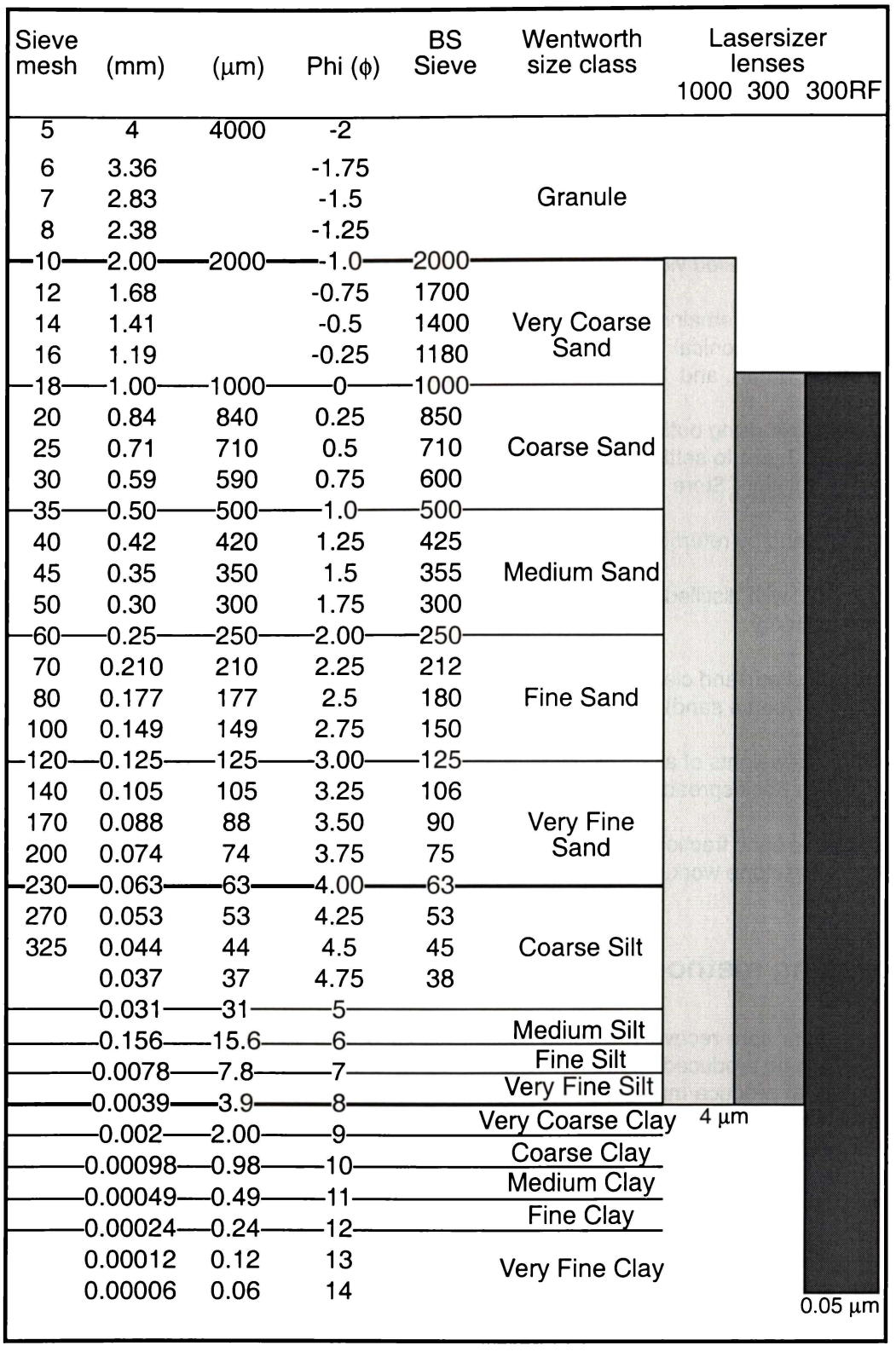
8.) Determine weights of all fractions: Mud wt = Bulk sample wt - (Fine sand wt + Coarse sand wt). Enter into data book/spreadsheet.

9.) Split coarse sand fraction with microsplitter into desired working subsamples for (a) foram census and (b) foram isotope work.

Processing methods for the mud fraction 0-120 mbsf

Due to the poor core recovery in some sections of Hole 593, samples from Hole 593A enabled a spliced core to be produced (Head and Nelson, 1994). Sample processing involved washing over a 63 µm sieve, to produce mud (<63 µm) and sand (>63 µm) fractions. Prior to processing samples between c. 420 and 120 mbsf were weighed, enabling the weight of the mud fraction to be calculated once the weight of the sand faction was determined. Samples from c. 120-0 mbsf had the amount of mud calculated using 50 ml aloquots from the <63 µm residue. As these samples had dried out, they were resuspended with the same bicarbonate buffer used in the initial washing process (see above). Lumps in the resuspended muds was an inevitable consequence of 20 years of storage and this processing history for the top 120 m (c. 5 Ma) of sediment is likely to be the cause of much of the apparent variability. In addition, the sand fraction samples from c. 120-0 mbsf were sieved at 125 µm, the fine sand/very fine sand boundary, where as the sand fraction from samples between c. 427 and 120 mbsf was sieved over a 150 µm sieve (fine sand), as this is the standard size used for foraminiferal studies.

The mud fraction (<63 µm) from all samples was analysed using a Malven lasersizer, enabling silt and clay fractions to be determined. Samples from 19-15 Ma have the silt fraction split at 3.6 µm rather than 4 µm because they were originally part of a separate study. Samples from 15-5 Ma use the standard textural boundary, so silt-sized grains are 4-63 µm, and clay-sized grains are <4 µm.



Appendix B Figure 1: Grainsize scale (after Folk, 1968).

Appendix B Table 1: Hole 593 stratigraphic tie-points and sedimentation rates.

Event	Depth (mbsf)	Age (Ma)	approx. Sed. Rate (m/Ma)
Radiocarbon date [a]	0.07	0.0069	
			39
Radiocarbon date [a]	0.31	0.013	
			19
FAD *Emiliania huxleyi* [a]	5.07	0.268	
			25
LAD *Pseudoemiliania lacunosa* [a]	9.91	0.458	
			20
Brunhes/Matuyama [b]	16.30	0.78	
			20
Top Jaramillo [b]	20.70	0.99	
			35
Base Jaramillo [b]	23.50	1.07	
			14
Top Olduvai [b]	33.33	1.77	
			10
Base Olduvai [b]	35.65	1.95	
			24
Isotope stage 100 [c]	49	2.53	
			21
Isotope stage 104 [c]	50.1	2.58	
			10
Base Gauss [b]	59.9	3.58	
			40
FAD *Globorotalia punticulata* [d]	123.04	5.197	
			66
FAD *Globorotalia sphericomiozea* [d]	143.72	5.511	
			35
FAD *Amorolithus primus* [e]	203.42	7.24	
			30
LO *Globoquidrina dehiscens* [d]	254.38	8.947	
			18
Top Tukemokihi Coiling Zone [d]	269.07	9.782	
			34
Base Tukemokihi Coiling Zone [d]	270.72	9.836	
			38
Top Kaiti Coiling Zone [d]	309.20	10.853	
			64
Base Kaiti Coiling Zone [d]	315.25	10.948	
			30
NN6/NN7 boundary [e]	341.16	11.8	
			26
LO *Fohsella peripheroronda* [f]	372.16	13.0	
			10
FCO *Orbulina suturalis* [f]	393.90	15.1	
			1
FO *Praeorbulina circularis* [f]	394.57	16.0	
			2
FO *Praeorbulina curva* [f]	395.08	16.3	
			9
FO *Globorotalia miozea* [f]	406.65	17.6	
			14
FO *Globorotalia praescitula* [f]	426.10	19	

[a] Determined using Nelson et al. (1986) and Dudley and Nelson (1989)
[b] Palaeomagnetic dates updated (Dudley and Nelson, 1989; Berggren et al., 1995a; Berggren et al., 1995b)
[c] After Naish (1996) following Shackleton et al. (1995)
[d] Dates determined Crundwell (in prep.)
[e] After Lohman (1986) and Raffi and Flores (1995)
[f] After Elkington (2000a and b) - notice condensed zone
LO = Last occurrence, FCO = First common occurrence, FO = First occurrence, FAD = First appearance datum, LAD = Last appearance datum

Appendix B Table 2: Hole 593 Sedimentation rates calculated using events in Table 1.

Depth (mbsf)	Age (ka)	Age (Ma)	depth diff (m)	depth diff (m)	age diff (ka)	age diff (Ma)	ka/cm	m/ka	m/Ma
0.07	6.9	0.0069							
			0.24	24	6.1	0.0061	0.254167	0.039	39.34
0.31	13	0.0130							
			4.76	476	255	0.2550	0.535714	0.019	18.67
5.07	268	0.2680							
			4.84	484	190	0.1900	0.392562	0.025	25.47
9.91	458	0.4580							
			6.54	654	322	0.3220	0.492355	0.020	20.31
16.45	780	0.7800							
			4.25	425	210	0.2100	0.494118	0.020	20.24
20.70	990	0.9900							
			2.80	280	80	0.0800	0.285714	0.035	35.00
23.50	1070	1.0700							
			9.83	983	700	0.7000	0.712106	0.014	14.04
33.33	1770	1.7700							
			1.82	182	180	0.1800	0.989011	0.010	10.11
35.15	1950	1.9500							
			13.85	1385	578	0.5780	0.417329	0.024	23.96
49.00	2528	2.5280							
			1.10	110	52	0.0520	0.472727	0.021	21.15
50.10	2580	2.5800							
			9.40	940	1000	1.0000	1.063830	0.009	9.40
59.50	3580	3.5800							
			63.54	6354	1617	1.6170	0.254485	0.039	39.29
123.04	5197	5.1970							
			20.68	2068	314	0.3140	0.151838	0.066	65.86
143.72	5511	5.5110							
			59.70	5970	1729	1.7290	0.289615	0.035	34.53
203.42	7240	7.2400							
			50.96	5096	1707	1.7070	0.334969	0.030	29.85
254.38	8947	8.9470							
			14.69	1469	835	0.8350	0.568414	0.018	17.59
269.07	9782	9.7820							
			1.75	175	54	0.0540	0.308571	0.032	32.41
270.82	9836	9.8360							
			38.38	3838	1017	1.0170	0.264982	0.038	37.74
309.20	10853	10.8530							
			6.05	605	95	0.0950	0.157025	0.064	63.68
315.25	10948	10.9480							
			25.91	2591	852	0.8520	0.328831	0.030	30.41
341.16	11800	11.8000							
			31.00	3100	1200	1.2000	0.387097	0.026	25.83
372.16	13000	13.0000							
			21.74	2174	2100	2.1000	0.965961	0.010	10.35
393.90	15100	15.1000							
			0.67	67	900	0.9000	13.432836	0.001	0.74
394.57	16000	16.0000							
			0.51	51	300	0.3000	5.882353	0.002	1.70
395.08	16300	16.3000							
			11.57	1157	1300	1.3000	1.123596	0.009	8.90
406.65	17600	17.6000							
			19.45	1945	1400	1.4000	0.719794	0.014	13.89
426.10	19000	19.0000							

Principles of the Malvern Lasersizer

A narrow beam of monochromatic light from a Helium-Neon Laser (650 nm wavelength, with a maximum diameter of 18 mm) is passed through a suspension containing particulate samples and the diffracted of scattered light energy (McCave et al., 1986; Singer et al., 1988). A lens placed between the illuminated sample with the detector at it's focal point, focuses the undiffracted light to a point at the centre and leaves only the surrounding diffraction pattern; this pattern is not affected by particle movement through the beam. Therefore a flow of particles can pass through the bean and generate a stable diffraction pattern (McCave et al., 1986).

This diffraction pattern is the essential data that is analysed to produce a size distribution. The fraction of light scattered is the sum of the individual particle contributions; the scattered light is typically measured and integrated over the time the particle takes to move through the beam. Particles is the suspension are not sized individually and counted, instead the laser beam is large at the point of measurement and many thousands of particles are simultaneously illuminated. Particle size is determined on the principle of the equivalent sphere; a sphere can be described in three dimensions with one number (i.e., stating that a particle is a 50 µm sphere which fully describes the particle). The lasersizer measures some property of an unknown particle and assumes this refers to a sphere of a volume equivalent to that of the measured particle.

The Malvern Laser Sizer set-up involves a laser source, beam expander, sample chamber, focusing lens and ring detector with associated electronics, and a systems computer which runs the measurement control and data storage. The size range detected by the laser sizer depends on the focal length of the focusing lens. Using the 300RF lens, the laser sizer can measure particle sizes between 0.05-900 µm. Since the diffraction pattern is not affected by the movement of particle through the beam, the flow rate can be high and this allows rapid analysis; approximately 3 minutes per sample. A pipette was used to remove about 1 ml of concentrated mud suspension, and approximately 5 drops were placed into the sample bath to reach an obscuration value of about 20%. The sample was then analysed by the machine.

MALVERN INSTRUMENTS MASTERSIZER

Result: Analysis Report

Sample Details

Sample ID: 32/2/73
Sample File: 32
Sample Path: Y:\PENTA\SIZERS\DSDP\
Sample Notes:

Run Number: 24
Record Number: 14

Measured: Tue 10 Dec 1996 11:47p.m.
Analysed: Tue 10 Dec 1996 11:47p.m.
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: None

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]

Sampler: MS17

Obscuration: 22.8 %
Residual: 0.369 %

Result Statistics

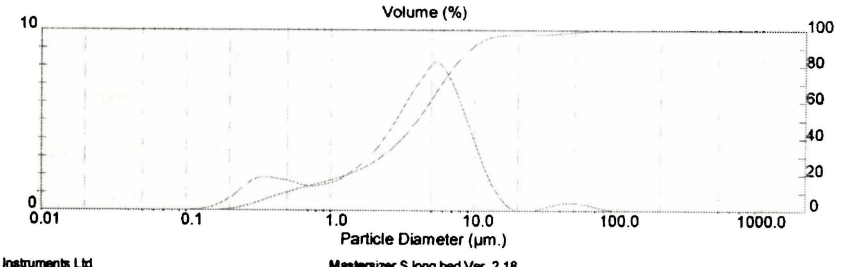
Distribution Type: Volume
Mean Diameters:
D [4, 3] = 5.43 um

Concentration = 0.0088 %Vol
D (v, 0.1) = 0.48 um
D [3, 2] = 1.47 um

Density = 2.650 g / cub. cm
D (v, 0.5) = 3.97 um
Span = 2.254E+00

Specific S.A. = 1.5378 sq. m / g
D (v, 0.9) = 9.43 um
Uniformity = 9.069E-01

Size Low (um)	In %	Size High (um)	Under%	Size Low (um)	In %	Size High (um)	Under%
0.05	0.00	0.06	0.00	6.63	6.88	7.72	83.05
0.06	0.00	0.07	0.00	7.72	5.55	9.00	88.60
0.07	0.00	0.08	0.00	9.00	4.06	10.48	92.66
0.08	0.01	0.09	0.01	10.48	2.65	12.21	95.31
0.09	0.02	0.11	0.03	12.21	1.49	14.22	96.80
0.11	0.05	0.13	0.09	14.22	0.65	16.57	97.45
0.13	0.13	0.15	0.22	16.57	0.16	19.31	97.62
0.15	0.26	0.17	0.48	19.31	0.00	22.49	97.62
0.17	0.50	0.20	0.98	22.49	0.00	26.20	97.62
0.20	0.86	0.23	1.85	26.20	0.11	30.53	97.73
0.23	1.31	0.27	3.16	30.53	0.27	35.56	98.00
0.27	1.70	0.31	4.86	35.56	0.40	41.43	98.40
0.31	1.86	0.36	6.72	41.43	0.46	48.27	98.86
0.36	1.82	0.42	8.54	48.27	0.44	56.23	99.30
0.42	1.74	0.49	10.27	56.23	0.35	65.51	99.65
0.49	1.63	0.58	11.90	65.51	0.23	76.32	99.89
0.58	1.47	0.67	13.37	76.32	0.11	88.91	100.00
0.67	1.38	0.78	14.75	88.91	0.00	103.58	100.00
0.78	1.43	0.91	16.18	103.58	0.00	120.67	100.00
0.91	1.54	1.06	17.72	120.67	0.00	140.58	100.00
1.06	1.74	1.24	19.46	140.58	0.00	163.77	100.00
1.24	2.06	1.44	21.52	163.77	0.00	190.80	100.00
1.44	2.45	1.68	23.97	190.80	0.00	222.28	100.00
1.68	2.90	1.95	26.87	222.28	0.00	258.95	100.00
1.95	3.51	2.28	30.38	258.95	0.00	301.68	100.00
2.28	4.24	2.65	34.62	301.68	0.00	351.46	100.00
2.65	5.09	3.09	39.71	351.46	0.00	409.45	100.00
3.09	5.98	3.60	45.69	409.45	0.00	477.01	100.00
3.60	6.84	4.19	52.54	477.01	0.00	555.71	100.00
4.19	7.59	4.88	60.12	555.71	0.00	647.41	100.00
4.88	8.22	5.69	68.34	647.41	0.00	754.23	100.00
5.69	7.83	6.63	76.17	754.23	0.00	878.67	100.00



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Appendix B Figure 2: Lasersizer report for sample 90-593-32-2-73 illustrating the trimodal nature of the grain size distribution in the <63 µm mud fraction, and the cumulative frequency curve used in the grain size statistics. The trimodal shape is very well defined in this sample, and discussion of this feature occurs in Chapter 2.

MALVERN INSTRUMENTS MASTERSIZER

Result: Analysis Report

Sample Details

Sample ID: 6/2/120
Sample File: PH593
Sample Path: Y:\PENTA\SIZERS\DSDP\
Sample Notes:

Run Number: 21
Record Number: 45

Measured: Thu 23 Jan 1997 11:59p.m.
Analysed: Thu 23 Jan 1997 11:59p.m.
Result Source: Analysed

System Details

Range Lens: 300RF mm
Presentation: 3OHD
Analysis Model: Polydisperse
Modifications: None

Beam Length: 2.40 mm
[Particle R.I. = (1.5295, 0.1000): Dispersant R.I. = 1.3300]

Sampler: MS17

Obscuration: 23.7 %
Residual: 0.450 %

Result Statistics

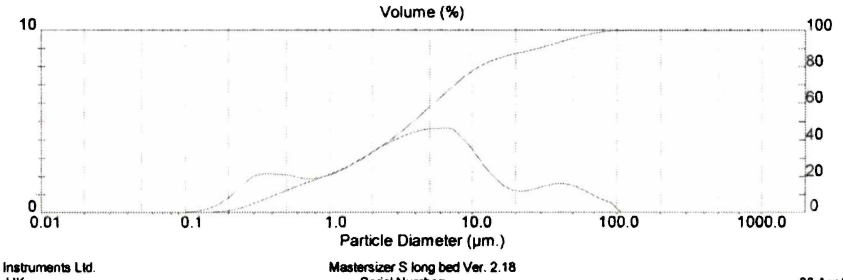
Distribution Type: Volume
Mean Diameters:
D [4, 3] = 9.58 um

Concentration = 0.0089 %Vol
D (v, 0.1) = 0.42 um
D [3, 2] = 1.32 um

Density = 2.650 g / cub. cm
D (v, 0.5) = 3.83 um
Span = 7.318E+00

Specific S.A. = 1.7168 sq. m / g
D (v, 0.9) = 28.44 um
Uniformity = 2.104E+00

Size Low (um)	In %	Size High (um)	Under%	Size Low (um)	In %	Size High (um)	Under%
0.05	0.00	0.06	0.00	6.63	4.58	7.72	70.99
0.06	0.00	0.07	0.00	7.72	4.16	9.00	75.15
0.07	0.01	0.08	0.01	9.00	3.57	10.48	78.72
0.08	0.02	0.09	0.02	10.48	2.88	12.21	81.61
0.09	0.04	0.11	0.06	12.21	2.22	14.22	83.83
0.11	0.08	0.13	0.14	14.22	1.69	16.57	85.52
0.13	0.18	0.15	0.32	16.57	1.34	19.31	86.86
0.15	0.35	0.17	0.67	19.31	1.20	22.49	88.06
0.17	0.63	0.20	1.30	22.49	1.23	26.20	89.29
0.20	1.03	0.23	2.33	26.20	1.36	30.53	90.65
0.23	1.51	0.27	3.84	30.53	1.50	35.56	92.15
0.27	1.94	0.31	5.78	35.56	1.60	41.43	93.75
0.31	2.14	0.36	7.91	41.43	1.59	48.27	95.34
0.36	2.14	0.42	10.06	48.27	1.45	56.23	96.79
0.42	2.12	0.49	12.17	56.23	1.19	65.51	97.98
0.49	2.07	0.58	14.24	65.51	0.93	76.32	98.91
0.58	1.94	0.67	16.18	76.32	0.67	88.91	99.58
0.67	1.87	0.78	18.05	88.91	0.42	103.58	100.00
0.78	1.94	0.91	19.99	103.58	0.00	120.67	100.00
0.91	2.06	1.06	22.05	120.67	0.00	140.58	100.00
1.06	2.25	1.24	24.29	140.58	0.00	163.77	100.00
1.24	2.53	1.44	26.82	163.77	0.00	190.80	100.00
1.44	2.83	1.68	29.65	190.80	0.00	222.28	100.00
1.68	3.13	1.95	32.79	222.28	0.00	258.95	100.00
1.95	3.46	2.28	36.25	258.95	0.00	301.68	100.00
2.28	3.75	2.65	40.00	301.68	0.00	351.46	100.00
2.65	4.00	3.09	44.00	351.46	0.00	409.45	100.00
3.09	4.22	3.60	48.22	409.45	0.00	477.01	100.00
3.60	4.41	4.19	52.63	477.01	0.00	555.71	100.00
4.19	4.54	4.88	57.18	555.71	0.00	647.41	100.00
4.88	4.62	5.69	61.79	647.41	0.00	754.23	100.00
5.69	4.62	6.63	66.41	754.23	0.00	878.67	100.00



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Appendix B Figure 3: Lasersizer report for sample 90-593-6-2-120 illustrating the trimodal nature of the grain size distribution in the <63 µm mud fraction, and the cumulative frequency curve used in the grain size statistics. The trimodal shape is less well defined in this sample because of the processing.

Grain Size Statistics

Graphic mean (Mz)

This is the best graphic measure for determining the overall grain size in phi, as it is based on 3 points (Folk, 1968).

$$Mz = \frac{(ø16 + ø50 + ø84)}{3}$$

where ø50 = median, ø16 = size corresponding to 16% on cumulative frequency plot, ø84 = size corresponding to 84% on cumulative frequency plot

Inclusive graphic standard deviation (σ_i)

Embraces 90% of the distribution and is the best overall measure of sorting as the spread in ø (Folk, 1968)

$$\sigma_I = \frac{ø84 - ø16}{4} + \frac{ø95 - ø5}{6.6}$$

where ø95 = size corresponding to 95% on cumulative frequency plot, ø5 = size corresponding to 5% on cumulative frequency plot

in phi	
<0.35	very well sorted (vws)
0.35 to 0.5	well sorted (ws)
0.5 to 0.71	moderately well sorted (mws)
0.71 to 1.0	moderately sorted
1.0 to 2.0	poorly sorted (ps)
2.0 to 4.0	very poorly sorted (vps)
>4.0	extremely poorly sorted (eps)

Inclusive graphic skewness (Sk_i)

Sk_i covers 90% of the curve and is the best measure of skewness as it determines the skewness of the 'tails' of the curve (Folk, 1968). It is geometrically independent of the sorting of the sample and is not written with any units (Folk, 1968).

$$Sk_i = \frac{ø16 + ø84 - 2ø50}{2(ø84 - ø16)} + \frac{ø5 + ø95 - 2ø50}{2(ø95 - ø5)}$$

+1.0 to +0.3	strongly finely skewed (sfs)
+0.3 to +0.1	finely skewed (fs)
+0.1 to -0.1	near symmetrical (ns)
-0.1 to -0.3	coarsely skewed (cs)
-0.3 to -1.0	strongly coarse skewed (scs)

e.g., samples with excess fines have positive skewness

Graphic kurtosis (K_G)

Kurtosis measures the ratio between the sorting in the tails of a curve and sorting in the central part (Folk, 1968), it is not written with any units.

$$K_G = \frac{ø95 - ø5}{2.44(ø75 - ø25)}$$

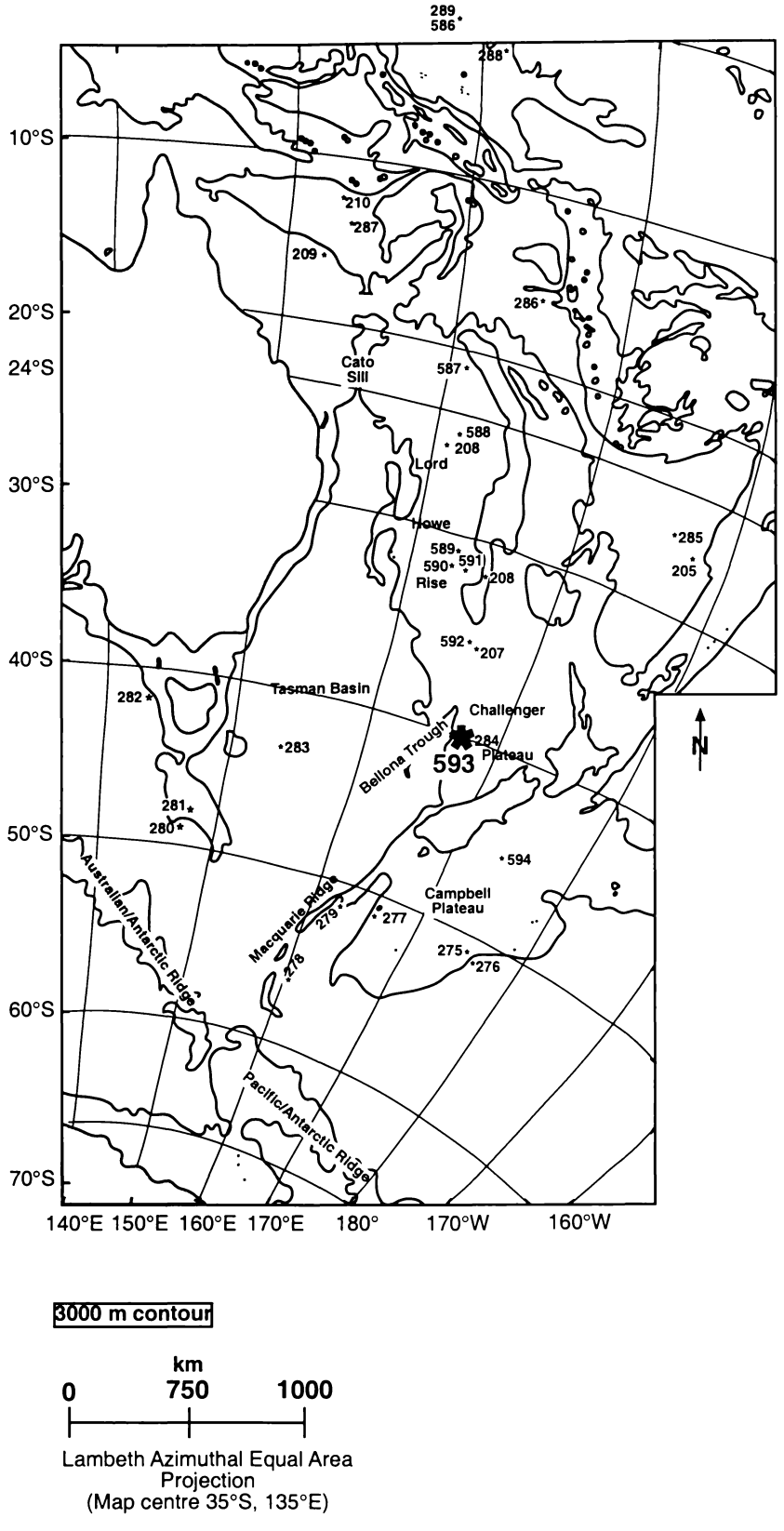
<0.67	very platykurtic (vpk)
0.67 to 0.9	platykurtic (pk)
0.9 to 1.11	mesokurtic (mk)
1.11 to 1.5	leptokurtic (lk)
1.5 to 3.0	very leptokurtic (vl)
>3.0	extremely leptokurtic (elk)

e.g., if the central part is better sorted than the 'tails', the curve will be leptokurtic, whereas if the 'tails' are better sorted than the central part the curve will be platykurtic (Folk, 1968).

Location of DSDP/ODP Sites

Appendix B Table 3: DSDP sites up to and including Leg 90, in the Southwest Pacific region and their location, and Legs 35, 113, 114, and 120 used in Chapter 5 - *Bolboforma*.

Leg	Site	Depth (mbsf)	Latitude	Longitude	Geographical location	Linked Sites
Leg 21	203	2720	22° 09.22'S	177° 32.77'W	Lau Basin (east of Lau Ridge)	
	204	5354	24° 57.27'S	174° 06.69'W	east of Tonga Trench	
	205	4320	25° 30.99'S	177° 53.95'E	South Fiji Basin	
	206	3196	32° 00.75'S	165° 26.06'E	New Caledonia Basin	591
	207	1389	36° 57.75'S	165° 26.06'E	Lord Howe Rise	592
	208	1545	26° 06.61'S	161° 13.27'E	north Lord Howe Rise	588
	209	1428	15° 56.19'S	152° 11.27'E	Queensland Plateau	
	210	4643	13° 45.99'S	152° 53.78'E	Coral Sea Basin	
Leg 29	275	2800	50° 26.34'S	176° 18.99'E	eastern Campbell Plateau	
	276	4671	50° 48.11'S	176° 48.40'E	eastern Campbell Plateau	
	277	1214	52° 13.43'S	166° 11.48'E	western Campbell Plateau	
	278	3675	56° 33.42'S	160° 04.29'E	Emerald Basin	
	279	3341	51° 20.14'S	162° 38.10'E	Solander Trough	
	280	4176	48° 57.44'S	147° 14.08'E	South Tasman Rise	
	281	1591	47° 59.84'S	147° 45.85'E	South Tasman Rise	
	282	4202	42° 14.76'S	143° 29.18'E	west of Tasmania	
	283	4729	43° 54.60'S	154° 16.96'E	Southern Tasman Basin	
	284	1066	40° 30.48'S	167° 40.81'E	Challenger Plateau	
Leg 30	285	4658	26° 49.16'S	175° 48.24'E	South Fiji Basin	
	286	4465	16° 31.92'S	166° 22.18'E	New Hebrides Trench	
	287	4632	15° 54.67'S	153° 15.93'E	Coral Sea Basin	
	288	3000	5° 58.35'S	161° 49.53'E	Ontong-Java Plateau	
	289	2206	00° 29.92'S	158° 30.69'E	Ontong-Java Plateau	586
Leg 89	586	2208	00° 29.84'S	158° 29.89'E	Ontong-Java Plateau	289
Leg 90	587	1101	21° 11.87'S	161° 19.99'E	Lansdowne Bank	
	588	1533	26° 06.07'S	161° 13.06'E	Lord Howe Rise	208
	589	1391	30° 42.72'S	163° 21.51'E	Lord Howe Rise	
	590	1299	31° 10.02'S	163° 21.51'E	Lord Howe Rise	
	591	2131	31° 35.06'S	164° 26.92'E	Lord Howe Rise	206
	592	1088	36° 28.40'S	165° 26.53'E	Lord Howe Rise	207
	593	1068	40° 30.47'S	167° 40.47'E	Challenger Plateau	284
	594	1204	45° 31.41'S	174° 56.88'E	Chatham Rise	
Leg 35	325	3745	65°S	73°W	Bellinghausen Basin	
Leg 113	689B	2080	64° 31S	3° 6'E	Maud Rise	
	690B	2914	65° S	1°E	Maud Rise	
Leg 114	699A 704B	1800-3700	46-51°S	30W-7°E	South Atlantic	
Leg 120	747-749, 737	1070-2030	54-58°S	76-81°E	Central Kerguelen Plateau	



Appendix B Figure 4: Map of the Southwest Pacific region illustrating the location of the DSDP sites drilled up to and including Leg 90.

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Sediment Texture Data Tables

Appendix B Table 4: Hole 593 texture data c. 0-130 mbsf (Hole 593A depths are integrated into Hole 593 depths). The presence of volcanic ash is marked by an A, not to be confused with the Hole 593A samples, in which the ash is denoted Å. (File on CD: App B Table 4).

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
1/1/30	0.30	12.75	0.013	63.54	13.00	23.46
1/1/56	0.56	26.39	0.026	43.58	13.84	42.59
1/1/80	0.80	39.25	0.039	42.45	20.22	37.32
1/1/128	1.28	64.96	0.065	58.25	14.45	27.30
2/1/30	1.80	92.82	0.093	53.84	17.39	28.77
2/1/56	2.06	106.75	0.107	48.75	16.72	34.53
2/1/80	2.30	119.61	0.120	63.95	12.76	23.29
1/2/128	2.78	145.32	0.145	65.65	14.97	19.38
3/1/28	3.28	172.11	0.172	73.96	11.03	15.01
3/1/56	3.56	187.11	0.187	43.89	20.04	36.08
3/1/80	3.80	199.96	0.200	42.18	17.77	40.06
1/3/128	4.28	225.68	0.226	42.72	22.05	35.23
4/1/30	4.80	253.54	0.254	59.78	13.74	26.48
4/1/56	5.07	268.00	0.268	61.42	14.82	23.76
1/2/30	5.40	280.95	0.281	84.43	14.81	0.76
1/2/80	5.90	300.58	0.301	58.23	13.58	28.19
2/1/128	6.39	319.82	0.320	76.40	9.64	13.96
2/1/143	6.50	324.14	0.324	76.28	9.93	13.79
2/2/30	6.91	340.23	0.340	54.24	8.10	37.66
2/2/80	7.41	359.86	0.360	73.45	11.80	14.75
2/1/126	7.87	377.92	0.378	72.17	11.65	16.18
2/2/143	8.07	385.77	0.386	71.60	12.09	16.31
3/2/30	8.41	399.12	0.399	73.48	9.05	17.47
3/2/80	8.91	418.74	0.419	72.50	8.38	19.12
2/3/128	9.39	437.59	0.438	77.22	9.47	13.31
2/3/143	9.54	443.48	0.443	78.13	9.70	12.17
4/2/30	9.91	458.00	0.458	69.48	11.89	18.63
4/2/80	10.40	482.13	0.482	77.13	10.03	12.83
2/4/128	10.89	506.25	0.506	79.50	8.99	11.51
2/4/143	11.04	513.64	0.514	71.90	12.63	15.47
5/2/30	11.41	531.85	0.532	77.86	8.88	13.26
5/2/80	11.91	556.47	0.556	70.56	14.46	14.98
2/5/128	12.39	580.10	0.580	72.22	12.86	14.93
2/5/143	12.54	587.49	0.587	55.30	18.43	26.26
6/2/30	12.90	605.21	0.605	66.33	13.95	19.72
6/2/80	13.41	630.32	0.630	39.66	23.79	36.55
2/6/128	13.88	653.46	0.653	48.82	18.74	32.45
1/3/30	15.00	708.61	0.709	38.26	25.41	36.33
1/3/56	15.26	721.41	0.721	36.73	26.60	36.67
1/3/80	15.50	733.23	0.733	43.71	20.36	35.93
3/1/128	15.98	756.86	0.757	67.89	10.92	21.19
2/3/30	16.50	782.47	0.782	71.93	12.08	15.98
2/3/56	16.76	795.32	0.795	75.11	10.66	14.24
2/3/80	17.00	807.18	0.807	71.30	12.36	16.34
3/2/128	17.48	830.89	0.831	48.68	21.99	29.34
3/3/30	18.00	856.59	0.857	44.50	19.06	36.43
3/3/56	18.16	864.49	0.864	50.94	19.34	29.72
3/3/80	18.50	881.29	0.881	50.96	19.06	29.98
3/3/128	18.98	905.01	0.905	52.09	16.36	31.54
4/3/30	19.50	930.71	0.931	66.61	14.30	19.09
4/3/56	19.76	943.55	0.944	67.18	13.07	19.75
4/3/80	20.01	955.91	0.956	62.38	13.80	23.82
3/4/128	20.48	979.13	0.979	76.29	4.44	19.27
5/3/30	21.00	998.57	0.999	61.87	16.39	21.74

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
5/3/56	21.26	1006.00	1.006	81.55	11.08	7.37
3/5/80A	21.54	1014.00	1.014	22.31	74.31	3.38
3/5/128	21.98	1026.57	1.027	70.90	11.51	17.59
6/3/30	22.50	1041.43	1.041	63.10	15.08	21.83
6/3/56	22.76	1048.86	1.049	68.11	19.15	12.74
6/3/80	23.00	1055.71	1.056	51.25	13.49	35.26
3/6/128	23.48	1069.43	1.069	67.05	13.07	19.89
1/4/30	24.60	1148.33	1.148	60.90	13.88	25.22
1/4/56	24.86	1166.85	1.167	42.96	30.39	26.66
4/1/80A	25.10	1183.94	1.184	66.72	14.58	18.69
4/1/128	25.58	1218.12	1.218	55.49	17.32	27.19
2/4/30	26.10	1255.15	1.255	53.17	12.05	34.78
2/4/56	26.37	1274.37	1.274	53.68	9.39	36.94
4/2/80A	26.60	1290.75	1.291	60.98	14.12	24.90
4/2/128	27.08	1324.93	1.325	57.63	15.75	26.61
3/4/30	27.60	1361.96	1.362	60.54	7.80	31.66
3/4/56	27.86	1380.48	1.380	65.70	12.59	21.72
3/4/80	28.10	1397.57	1.398	72.59	12.44	14.97
4/3/128	28.58	1431.75	1.432	57.91	17.12	24.96
4/4/30A	29.10	1468.78	1.469	54.75	16.16	29.09
4/4/56	29.36	1487.29	1.487	45.00	19.52	35.48
4/4/80	29.60	1504.38	1.504	57.33	22.46	20.21
4/4/128	30.09	1539.28	1.539	52.84	17.71	29.45
5/4/30	30.60	1575.60	1.576	47.17	18.60	34.23
5/4/56	30.86	1594.11	1.594	43.66	24.05	32.29
5/4/80	31.10	1611.20	1.611	39.79	19.63	40.59
4/5/128	31.58	1645.38	1.645	54.82	15.33	29.84
6/4/30	32.10	1682.41	1.682	33.74	27.26	38.99
6/4/56	32.36	1700.93	1.701	37.00	27.48	35.52
6/4/80	32.60	1718.02	1.718	44.67	22.70	32.63
1/5/30	34.20	1856.04	1.856	53.21	16.11	30.68
1/5/56	34.46	1881.76	1.882	57.31	17.55	25.14
1/5/80	34.70	1905.49	1.905	52.80	17.06	30.14
5/1/128	35.19	1951.67	1.952	72.30	11.54	16.17
5-1-10A	36.60	2010.51	2.011	57.97	18.05	23.98
5-1-20A	36.70	2014.69	2.015	66.83	14.65	18.52
5-1-30A	36.80	2018.86	2.019	62.83	15.56	21.61
5-1-40A	36.90	2023.03	2.023	54.74	20.37	24.88
5-1-50A	37.00	2027.21	2.027	61.74	16.58	21.68
5-1-60A	37.10	2031.38	2.031	73.01	1.86	25.12
5-1-70A	37.20	2035.55	2.036	68.96	13.04	18.00
5-1-80A	37.30	2039.73	2.040	79.27	9.18	11.54
5-1-90A	37.40	2043.90	2.044	64.29	15.17	20.54
5-1-100A	37.50	2048.07	2.048	70.67	12.21	17.12
5-1-110A	37.60	2052.25	2.052	72.08	11.24	16.68
5-1-120A	37.70	2056.42	2.056	80.10	7.90	11.99
5-1-130A	37.80	2060.59	2.061	79.35	8.86	11.79
5-1-140A	37.90	2064.77	2.065	80.36	7.82	11.82
5-1-148A	37.98	2068.10	2.068	62.56	14.61	22.83
5-2-10A	38.10	2073.11	2.073	60.59	14.39	25.02
5-2-20A	38.20	2077.29	2.077	58.68	16.38	24.94
5-2-30A	38.30	2081.46	2.081	61.33	15.11	23.56
5-2-40A	38.40	2085.63	2.086	65.97	11.05	22.98
5-2-50A	38.50	2089.81	2.090	84.53	6.72	8.75
5-2-60A	38.60	2093.98	2.094	75.03	10.31	14.66
5-2-70A	38.70	2098.15	2.098	74.73	12.27	12.99
5-2-80A	38.80	2102.33	2.102	70.67	12.24	17.09
5-2-90A	38.90	2106.50	2.106	73.20	12.62	14.18
5-2-100A	39.00	2110.67	2.111	71.09	12.80	16.11
5-2-110A	39.10	2114.84	2.115	72.64	10.98	16.38
5-2-120A	39.20	2119.02	2.119	68.79	13.66	17.55
5-2-130A	39.30	2123.19	2.123	73.10	11.04	15.85

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
5-2-140A	39.40	2127.36	2.127	78.71	9.39	11.90
5-2-148A	39.48	2130.70	2.131	74.87	10.72	14.41
5-3-10A	39.60	2135.71	2.136	78.33	9.16	12.52
5-3-20A	39.70	2139.88	2.140	52.50	14.15	33.35
5-3-30A	39.80	2144.06	2.144	57.35	14.76	27.89
5-3-40A	39.90	2148.23	2.148	58.88	14.95	26.18
5-3-50A	40.00	2152.40	2.152	61.08	14.32	24.59
5-3-60A	40.10	2156.58	2.157	42.52	26.48	31.00
5-3-70A	40.20	2160.75	2.161	73.77	11.13	15.10
5-3-80A	40.30	2164.92	2.165	60.80	14.67	24.53
5-3-90A	40.40	2169.10	2.169	61.56	14.64	23.80
5-3-100A	40.50	2173.27	2.173	67.54	13.26	19.21
5-3-110A	40.60	2177.44	2.177	59.08	17.14	23.77
5-3-120A	40.70	2181.62	2.182	66.98	14.40	18.62
5-3-130A	40.80	2185.79	2.186	63.65	15.20	21.15
5-3-140A	40.90	2189.96	2.190	68.29	12.25	19.47
5-3-148A	40.98	2193.30	2.193	71.26	12.24	16.50
5-4-10A	41.10	2198.31	2.198	71.93	11.24	16.83
5-4-20A	41.20	2202.48	2.202	56.97	17.93	25.09
5-4-30A	41.30	2206.66	2.207	57.07	17.01	25.92
5-4-40A	41.40	2210.83	2.211	28.71	30.57	40.72
5-4-50A	41.50	2215.00	2.215	62.89	15.27	21.84
5-4-60A	41.60	2219.18	2.219	53.01	18.51	28.48
5-4-70A	41.70	2223.35	2.223	51.61	17.97	30.42
5-4-80A	41.80	2227.52	2.228	62.22	13.73	24.05
5-4-90A	41.90	2231.70	2.232	48.19	15.37	36.44
5-4-100A	42.00	2235.87	2.236	62.16	14.38	23.46
5-4-110A	42.10	2240.04	2.240	49.75	17.14	33.11
5-4-120A	42.20	2244.22	2.244	62.92	12.34	24.73
5-4-130A	42.30	2248.39	2.248	69.40	10.64	19.96
5-4-140A	42.40	2252.56	2.253	63.21	12.47	24.33
5-4-148A	42.48	2255.90	2.256	67.40	12.51	20.09
5-5-10A	42.60	2260.91	2.261	67.31	12.42	20.27
5-5-20A	42.70	2265.08	2.265	70.23	9.41	20.36
5-5-30A	42.80	2269.26	2.269	65.00	13.18	21.82
5-5-40A	42.90	2273.43	2.273	74.11	8.98	16.91
5-5-50A	43.00	2277.60	2.278	68.84	8.78	22.38
5-5-60A	43.10	2281.78	2.282	75.60	7.52	16.88
5-5-70A	43.20	2285.95	2.286	77.80	7.39	14.81
5-5-80A	43.30	2290.12	2.290	78.15	7.30	14.55
5-5-90A	43.40	2294.30	2.294	76.02	7.25	16.73
5-5-100A	43.50	2298.47	2.298	70.71	8.58	20.71
5-5-110A	43.60	2302.64	2.303	66.94	9.52	23.54
5-5-120A	43.70	2306.82	2.307	70.63	7.86	21.51
5-5-130A	43.80	2310.99	2.311	74.77	8.23	16.99
5-5-140A	43.90	2315.16	2.315	65.79	10.55	23.66
5-5-148A	43.98	2318.50	2.319	69.65	10.24	20.10
5-6-10A	44.10	2323.51	2.324	69.20	10.05	20.75
5-6-20A	44.20	2327.68	2.328	50.30	15.06	34.64
5-6-30A	44.30	2331.86	2.332	69.49	9.65	20.86
5-6-40A	44.40	2336.03	2.336	77.62	7.58	14.80
6-1-10A	46.20	2411.15	2.411	62.40	11.03	26.57
6-1-20A	46.30	2415.32	2.415	56.95	13.10	29.95
6-1-100A	47.10	2448.71	2.449	74.02	7.78	18.19
6-1-110A	47.20	2452.88	2.453	58.83	11.31	29.86
6-1-120A	47.30	2457.05	2.457	67.70	9.30	23.00
6-1-130A	47.40	2461.23	2.461	58.87	12.58	28.55
6-1-140A	47.50	2465.40	2.465	58.07	12.99	28.95
6-1-148A	47.58	2468.74	2.469	62.47	10.58	26.95
6-2-10A	47.70	2473.75	2.474	54.77	12.51	32.71
6-2-20A	47.80	2477.92	2.478	54.35	11.47	34.18
6-2-30A	47.90	2482.09	2.482	56.24	12.86	30.90

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
6-2-40A	48.00	2486.27	2.486	61.49	11.63	26.88
6-2-50A	48.10	2490.44	2.490	73.80	8.58	17.62
6-2-60A	48.20	2494.61	2.495	73.51	7.26	19.23
6-2-70A	48.30	2498.79	2.499	63.74	10.46	25.81
6-2-80A	48.40	2502.96	2.503	67.84	10.24	21.92
6-2-90A	48.50	2507.13	2.507	70.47	10.49	19.04
6-2-100A	48.60	2511.31	2.511	72.41	9.18	18.40
6-2-110A	48.70	2515.48	2.515	77.76	8.53	13.71
6-2-120A	48.80	2519.65	2.520	64.97	11.82	23.22
6-2-130A	48.90	2523.83	2.524	67.21	13.06	19.74
6-2-140A	49.00	2528.00	2.528	82.09	7.39	10.52
6-2-148A	49.08	2531.78	2.532	78.75	8.69	12.55
6-3-10A	49.20	2537.45	2.537	77.61	8.52	13.87
6-3-20A	49.30	2542.18	2.542	78.38	8.28	13.34
6-3-30A	49.40	2546.91	2.547	76.23	8.91	14.86
6-3-40A	49.50	2551.64	2.552	72.12	11.14	16.74
6-3-50A	49.60	2556.36	2.556	79.96	7.21	12.83
6-3-60A	49.70	2561.09	2.561	75.68	8.51	15.82
6-3-70A	49.80	2565.82	2.566	74.64	8.81	16.55
6-3-80A	49.90	2570.55	2.571	63.51	12.12	24.37
6-3-90A	50.00	2575.27	2.575	70.13	11.10	18.76
6-3-100A	50.10	2580.00	2.580	79.09	6.84	14.07
6-3-110A	50.20	2590.64	2.591	75.78	8.46	15.77
6-3-120A	50.30	2601.28	2.601	84.22	5.69	10.10
6-3-130A	50.40	2611.91	2.612	79.23	6.96	13.81
6-3-140A	50.50	2622.55	2.623	80.61	7.25	12.14
6-3-148A	50.58	2631.06	2.631	78.64	7.37	13.99
6-4-10A	50.70	2643.83	2.644	81.91	6.02	12.07
6-4-20A	50.80	2654.47	2.654	74.00	7.78	18.22
6-4-30A	50.90	2665.11	2.665	74.68	9.67	15.66
6-4-40A	51.00	2675.74	2.676	64.48	13.75	21.77
6-4-50A	51.10	2686.38	2.686	75.39	8.30	16.31
6-4-60A	51.20	2697.02	2.697	72.20	11.33	16.47
6-4-70A	51.30	2707.66	2.708	80.89	7.35	11.76
6-4-80A	51.40	2718.30	2.718	77.01	8.95	14.04
6-4-90A	51.50	2728.94	2.729	71.40	11.04	17.56
6-4-100A	51.60	2739.57	2.740	71.27	11.04	17.69
6-4-110A	51.70	2750.21	2.750	77.47	8.34	14.19
6-4-120A	51.80	2760.85	2.761	53.09	18.00	28.91
6/4/130A	51.90	2771.49	2.771	66.60	13.56	19.84
6-4-140A	52.00	2782.13	2.782	71.09	10.62	18.28
6-4-148A	52.08	2790.64	2.791	60.07	14.40	25.54
6-5-10A	52.20	2803.40	2.803	63.50	13.17	23.33
6-5-20A	52.30	2814.04	2.814	63.68	12.03	24.29
6-5-30A	52.40	2824.68	2.825	77.34	8.71	13.95
6-5-40A	52.50	2835.32	2.835	79.23	7.78	12.99
6-5-50A	52.60	2845.96	2.846	64.62	12.54	22.85
6-5-60A	52.70	2856.60	2.857	79.07	7.23	13.70
6-5-70A	52.80	2867.23	2.867	60.82	12.47	26.71
6-5-80A	52.90	2877.87	2.878	60.67	13.44	25.89
6-5-90A	53.00	2888.51	2.889	82.19	6.30	11.51
6-5-100A	53.10	2899.15	2.899	75.88	7.48	16.64
6-5-110A	53.20	2909.79	2.910	70.26	11.03	18.71
6-5-120A	53.30	2920.43	2.920	77.99	7.55	14.46
6-5-130A	53.40	2931.06	2.931	71.64	10.04	18.33
6-5-140A	53.50	2941.70	2.942	79.50	7.19	13.31
6-5-148A	53.58	2950.21	2.950	69.14	12.69	18.16
6/6/10A	53.70	2962.98	2.963	83.46	6.85	9.69
6-6-20A	53.80	2973.62	2.974	70.84	10.71	18.45
6-6-30A	53.90	2984.26	2.984	79.25	8.31	12.44
6-6-40A	54.00	2994.89	2.995	79.92	7.26	12.82
6-6-50A	54.10	3005.53	3.006	78.80	7.60	13.61

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
6-6-60A	54.20	3016.17	3.016	79.46	7.92	12.62
6-6-70A	54.30	3026.81	3.027	64.03	14.23	21.74
6/6/80A	54.40	3037.45	3.037	62.57	14.05	23.38
6-6-90A	54.50	3048.09	3.048	79.65	7.76	12.58
6-6-100A	54.60	3058.72	3.059	75.98	9.48	14.54
6/6/110A	54.70	3069.36	3.069	73.24	8.87	17.89
6/6/120A	54.80	3080.00	3.080	74.29	9.18	16.53
6/6/130A	54.90	3090.64	3.091	71.69	10.57	17.74
6-6-140A	55.00	3101.28	3.101	70.86	11.47	17.67
6-6-148A	55.08	3109.79	3.110	65.26	12.52	22.21
6-7-10A	55.20	3122.55	3.123	73.06	10.08	16.86
6-7-20A	55.30	3133.19	3.133	69.46	11.36	19.18
6-7-30A	55.40	3143.83	3.144	67.90	10.97	21.13
7/1/10A	55.80	3186.38	3.186	65.56	11.29	23.15
7-1-20A	55.90	3197.02	3.197	42.85	15.53	41.62
7-1-30A	56.00	3207.66	3.208	76.80	8.37	14.83
7-1-40A	56.10	3218.30	3.218	72.52	10.06	17.42
7/1/50A	56.20	3228.94	3.229	72.34	10.00	17.66
7-1-60A	56.30	3239.57	3.240	64.54	13.30	22.16
7-1-70A	56.40	3250.21	3.250	66.66	11.90	21.44
7-1-80A	56.50	3260.85	3.261	71.44	9.82	18.74
7-1-90A	56.60	3271.49	3.271	57.25	13.51	29.24
7/1/100A	56.70	3282.13	3.282	69.90	8.96	21.14
7-1-110A	56.80	3292.77	3.293	64.19	10.37	25.44
7-1-120A	56.90	3303.40	3.303	70.62	6.28	23.10
7-1-130A	57.00	3314.04	3.314	66.34	9.85	23.80
7-1-140A	57.10	3324.68	3.325	59.83	12.31	27.86
7-1-148A	57.18	3333.19	3.333	64.32	11.80	23.89
7-2-10A	57.30	3345.96	3.346	70.81	9.51	19.69
7-2-20A	57.40	3356.60	3.357	68.41	10.50	21.09
7-2-30A	57.50	3367.23	3.367	65.60	11.56	22.84
7-2-40A	57.60	3377.87	3.378	68.13	10.53	21.34
7-2-50A	57.70	3388.51	3.389	67.39	11.26	21.35
7-2-60A	57.80	3399.15	3.399	64.88	11.25	23.87
7-2-70A	57.90	3409.79	3.410	65.25	10.79	23.96
7-2-80A	58.00	3420.43	3.420	56.40	13.38	30.22
7-2-90A	58.10	3431.06	3.431	67.02	10.59	22.40
7-2-100A	58.20	3441.70	3.442	64.84	12.54	22.62
7-2-110A	58.30	3452.34	3.452	66.36	11.18	22.46
7-2-120A	58.40	3462.98	3.463	58.03	13.47	28.50
7-2-130A	58.50	3473.62	3.474	48.35	15.86	35.79
7-2-140A	58.60	3484.26	3.484	64.72	11.43	23.85
7-2-148A	58.68	3492.77	3.493	64.14	10.25	25.61
7-3-10A	58.80	3505.53	3.506	68.94	9.25	21.81
7-3-18A	58.88	3514.04	3.514	71.93	7.76	20.31
7-3-30A	59.00	3526.81	3.527	64.43	10.07	25.51
7-3-40A	59.10	3537.45	3.537	75.23	7.16	17.61
7-3-50A	59.20	3548.09	3.548	73.89	7.93	18.18
7-3-60A	59.30	3558.72	3.559	67.90	9.89	22.21
7-3-68A	59.38	3567.23	3.567	73.09	8.00	18.91
7/3/90A	59.60	3582.54	3.583	67.95	10.04	22.00
7-3-99A	59.69	3584.84	3.585	77.64	7.49	14.87
7-3-108A	59.78	3587.13	3.587	69.36	9.29	21.35
7-3-120A	59.90	3590.18	3.590	69.62	8.02	22.35
7-3-128A	59.98	3592.22	3.592	63.82	9.67	26.52
7-3-140A	60.10	3595.27	3.595	61.80	10.24	27.96
7-3-148A	60.18	3597.30	3.597	68.27	8.51	23.22
7-4-10A	60.30	3600.36	3.600	62.16	9.54	28.30
7/4/17A	60.37	3602.14	3.602	58.37	11.50	30.13
7/4/29A	60.49	3605.19	3.605	69.12	9.73	21.15
7/4/40A	60.60	3607.99	3.608	66.32	9.91	23.77
7/4/50A	60.70	3610.54	3.611	80.50	5.89	13.61

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
7-4-60A	60.80	3613.08	3.613	67.27	10.36	22.36
7-4-70A	60.90	3615.63	3.616	72.32	8.48	19.20
7-4-90A	61.10	3620.72	3.621	69.20	10.67	20.13
7-4-100A	61.20	3623.26	3.623	78.68	7.85	13.47
7-4-108A	61.28	3625.30	3.625	78.92	7.00	14.08
7-4-120A	61.40	3628.35	3.628	76.73	7.35	15.92
7-4-128A	61.48	3630.39	3.630	74.08	8.38	17.54
7/4/130A	61.50	3630.90	3.631	69.90	10.71	19.39
7-4-140A	61.60	3633.44	3.633	70.26	11.38	18.36
7/4/148A	61.68	3635.48	3.635	70.86	10.78	18.36
7-5-9A	61.79	3638.28	3.638	77.51	8.01	14.48
7-5-17A	61.87	3640.31	3.640	74.70	8.69	16.61
7-5-29A	61.99	3643.37	3.643	76.59	8.90	14.51
7-5-39A	62.09	3645.91	3.646	67.04	10.27	22.69
7-5-47A	62.17	3647.95	3.648	61.30	12.14	26.56
7-5-60A	62.30	3651.26	3.651	76.88	8.48	14.64
7-5-69A	62.39	3653.55	3.654	72.62	9.21	18.18
7-5-88A	62.58	3658.38	3.658	79.75	5.58	14.67
7-5-99A	62.69	3661.18	3.661	78.73	6.82	14.44
7-5-106A	62.76	3662.96	3.663	67.72	11.47	20.81
7-5-119A	62.89	3666.27	3.666	65.82	10.98	23.20
7-5-127A	62.97	3668.31	3.668	61.41	13.70	24.90
7/5/130A	63.00	3669.07	3.669	69.94	11.42	18.65
7-5-139A	63.09	3671.36	3.671	67.77	11.43	20.80
7-5-148A	63.18	3673.65	3.674	73.18	11.42	15.40
7-6-10A	63.30	3676.70	3.677	63.56	12.63	23.82
7-6-20A	63.40	3679.25	3.679	46.20	16.85	36.96
7-6-29A	63.49	3681.54	3.682	60.11	13.83	26.06
7-6-40A	63.60	3684.34	3.684	59.14	13.94	26.92
7-6-50A	63.70	3686.88	3.687	39.01	18.65	42.34
7-6-60A	63.80	3689.43	3.689	69.15	9.92	20.93
7-6-70A	63.90	3691.97	3.692	66.01	12.13	21.85
7/6/82A	64.02	3695.03	3.695	61.02	14.19	24.78
8-1-40A	65.90	3742.87	3.743	42.10	18.65	39.25
8-1-80A	66.30	3753.05	3.753	63.24	10.66	26.10
8-1-120A	66.70	3763.23	3.763	62.38	12.76	24.85
8/1/130A	66.80	3765.77	3.766	61.82	17.77	20.41
8-1-148A	66.98	3770.35	3.770	34.47	22.11	43.42
8-2-40A	67.40	3781.04	3.781	51.19	16.59	32.22
8-2-80A	67.80	3791.22	3.791	69.73	11.45	18.82
8-2-120A	68.20	3801.40	3.801	53.65	14.95	31.40
8/2/130A	68.30	3803.95	3.804	62.14	12.98	24.88
8-2-148A	68.48	3808.53	3.809	48.21	17.08	34.72
8-3-40A	68.90	3819.22	3.819	43.85	19.48	36.67
8/3/84A	69.34	3830.41	3.830	69.90	11.75	18.35
8-3-120A	69.70	3839.57	3.840	62.29	14.41	23.30
8/3/130A	69.80	3842.12	3.842	64.53	16.13	19.34
8-3-148A	69.98	3846.70	3.847	72.35	11.56	16.08
8-4-40A	70.40	3857.39	3.857	55.47	15.79	28.75
8-4-77A	70.77	3866.80	3.867	81.81	7.81	10.38
8-4-120A	71.20	3877.75	3.878	62.03	14.37	23.60
8/4/130A	71.30	3880.29	3.880	72.83	11.15	16.02
8-4-148A	71.48	3884.87	3.885	64.12	12.17	23.71
8-5-40A	71.90	3895.56	3.896	58.32	13.15	28.54
8/5/70A	72.20	3903.20	3.903	63.51	14.09	22.40
8-5-148A	72.98	3923.05	3.923	47.83	20.17	32.00
8-6-40A	73.40	3933.73	3.934	57.20	18.61	24.19
9-1-40A	75.30	3982.09	3.982	64.29	14.69	21.02
9-1-80A	75.70	3992.27	3.992	35.17	27.95	36.88
9-1-120A	76.10	4002.45	4.002	66.51	14.52	18.97
9-1-148A	76.38	4009.57	4.010	71.22	11.99	16.79
9-2-40A	76.80	4020.26	4.020	71.92	10.44	17.64

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
9-2-80A	77.20	4030.44	4.030	80.56	7.33	12.11
9-2-120A	77.60	4040.62	4.041	67.28	12.61	20.11
9-2-130A	77.70	4043.16	4.043	77.71	9.61	12.68
9-2-148A	77.88	4047.74	4.048	73.25	9.30	17.45
9-3-40A	78.30	4058.43	4.058	75.14	10.03	14.83
9-3-80A	78.70	4068.61	4.069	69.30	12.52	18.18
9-3-120A	79.10	4078.79	4.079	68.40	10.40	21.20
9/3/130A	79.20	4081.34	4.081	61.88	15.44	22.69
9-3-144A	79.34	4084.90	4.085	78.02	8.70	13.29
9-4-40A	79.80	4096.60	4.097	63.06	13.31	23.63
9-4-80A	80.20	4106.78	4.107	47.98	16.81	35.21
9-4-120A	80.60	4116.96	4.117	56.69	17.19	26.12
9/4/130A	80.70	4119.51	4.120	75.66	9.90	14.44
9-4-148A	80.88	4124.09	4.124	67.60	11.50	20.90
9-5-40A	81.30	4134.78	4.135	62.71	13.56	23.73
9-5-81A	81.71	4145.21	4.145	85.35	4.82	9.83
9-5-130A	82.20	4157.68	4.158	83.58	6.89	9.53
9-5-148A	82.38	4162.26	4.162	71.89	10.56	17.55
9-6-39A	82.79	4172.70	4.173	69.93	10.73	19.34
9-6-81A	83.21	4183.38	4.183	32.76	29.41	37.83
9-6-120A	83.60	4193.31	4.193	70.70	12.18	17.11
9-6-130A	83.70	4195.85	4.196	60.97	15.92	23.11
9-6-148A	83.80	4198.40	4.198	43.01	25.90	31.09
9-7-29A	84.19	4208.32	4.208	60.21	14.42	25.37
10/1/40A	84.90	4226.39	4.226	50.51	15.46	34.03
10-1-81A	85.31	4236.83	4.237	77.80	8.28	13.92
10/1/121A	85.71	4247.01	4.247	72.13	11.56	16.31
10-1-130A	85.80	4249.30	4.249	68.44	13.16	18.40
10-1-148A	85.98	4253.88	4.254	57.18	17.02	25.81
10/2/40A	86.40	4264.56	4.265	48.11	19.93	31.96
10-2-81A	86.81	4275.00	4.275	66.83	13.11	20.06
10/2/128A	87.28	4286.96	4.287	74.96	10.74	14.30
10/2/130A	87.30	4287.47	4.287	80.74	7.83	11.43
10-2-148A	87.48	4292.05	4.292	82.07	7.83	10.10
10-3-40A	87.90	4302.74	4.303	72.46	13.48	14.05
10-3-80A	88.30	4312.92	4.313	71.14	12.53	16.32
10-3-121A	88.71	4323.35	4.323	57.22	18.89	23.89
10/3/130A	88.80	4325.64	4.326	77.42	10.55	12.04
10-3-141A	88.91	4328.44	4.328	74.92	10.79	14.29
10-4-40A	89.40	4340.91	4.341	76.88	9.35	13.77
10-4-80A	89.80	4351.09	4.351	83.97	6.61	9.41
10-4-120A	90.20	4361.27	4.361	70.34	12.18	17.47
10/4/130A	90.30	4363.81	4.364	79.41	7.32	13.27
10-4-148A	90.48	4368.39	4.368	79.23	8.76	12.01
10-5-40A	90.90	4379.08	4.379	74.08	10.11	15.81
10-5-81A	91.31	4389.52	4.390	73.44	13.71	12.85
10-5-121A	91.71	4399.70	4.400	77.67	9.61	12.72
10/5/130A	91.80	4401.99	4.402	84.40	6.49	9.10
10-5-148A	91.98	4406.57	4.407	68.33	12.12	19.54
10-6-38A	92.30	4414.71	4.415	79.10	8.49	12.41
10-6-78A	92.78	4426.93	4.427	69.25	13.50	17.25
10-6-115A	93.15	4436.34	4.436	79.27	9.56	11.16
11-1-40A	94.50	4470.70	4.471	73.75	11.49	14.76
11-1-77A	94.87	4480.11	4.480	78.87	8.65	12.48
11-1-121A	95.31	4491.31	4.491	71.71	12.30	15.99
11/1/130A	95.40	4493.60	4.494	70.86	12.44	16.70
11-1-148A	95.58	4498.18	4.498	45.81	21.21	32.98
11-2-39A	95.99	4508.62	4.509	73.97	9.41	16.62
11-2-78A	96.38	4518.54	4.519	68.29	13.29	18.43
11-2-120A	96.80	4529.23	4.529	71.66	13.49	14.85
11/2/130A	96.90	4531.77	4.532	55.96	18.24	25.80
11-2-148A	97.08	4536.35	4.536	73.71	10.12	16.17

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
11-3-40A	97.50	4547.04	4.547	68.64	13.86	17.50
11-3-79A	97.89	4556.97	4.557	73.49	10.69	15.82
11-3-118A	98.28	4566.89	4.567	73.00	11.67	15.33
11/3/130A	98.40	4569.95	4.570	59.65	16.71	23.63
11-3-141Å	98.51	4572.75	4.573	62.25	14.82	22.92
11-4-40A	99.00	4585.22	4.585	74.34	10.92	14.74
11-4-79A	99.39	4595.14	4.595	66.09	13.52	20.40
11/4/118A	99.78	4605.07	4.605	83.57	6.56	9.87
11/4/130A	99.90	4608.12	4.608	63.93	15.50	20.57
11-4-148A	100.08	4612.70	4.613	66.63	13.25	20.12
11-5-41A	100.51	4623.64	4.624	76.20	10.05	13.75
11-5-80A	100.90	4633.57	4.634	82.10	8.08	9.82
11-5-128A	101.38	4645.78	4.646	75.74	9.63	14.64
11-5-148A	101.58	4650.87	4.651	60.95	17.31	21.74
11-6-41A	102.10	4664.11	4.664	81.66	7.64	10.70
11-6-78A	102.38	4671.23	4.671	73.76	11.05	15.19
11-6-107A	102.67	4678.61	4.679	84.04	6.20	9.77
12-1-40Å	104.10	4715.00	4.715	80.21	8.55	11.24
12-1-80A	104.50	4725.18	4.725	83.75	7.46	8.80
12-1-120Å	104.90	4735.36	4.735	79.38	10.40	10.22
12-1-140A	105.10	4740.45	4.740	77.13	10.70	12.16
12-2-40A	105.60	4753.18	4.753	62.09	16.73	21.18
12/2/80A	106.00	4763.36	4.763	53.41	21.40	25.19
12-2-120A	106.40	4773.53	4.774	83.69	7.21	9.10
12-2-148A	106.68	4780.66	4.781	81.22	9.16	9.62
12-3-40A	107.10	4791.35	4.791	84.58	7.40	8.01
12-3-80A	107.50	4801.53	4.802	80.53	8.11	11.36
12-3-120A	107.90	4811.71	4.812	82.80	7.95	9.26
12-3-148A	108.18	4818.83	4.819	83.75	7.24	9.01
12-4-40A	108.60	4829.52	4.830	83.43	7.30	9.26
12-4-80A	109.00	4839.70	4.840	89.36	4.75	5.90
12-4-120A	109.40	4849.88	4.850	84.72	6.66	8.62
12-4-148A	109.68	4857.01	4.857	80.55	9.34	10.11
12-5-40A	110.10	4867.69	4.868	67.76	14.06	18.18
12-5-80A	110.50	4877.87	4.878	74.07	11.41	14.52
12-5-120A	110.90	4888.05	4.888	84.64	7.38	7.97
12-5-148A	111.18	4895.18	4.895	69.63	14.23	16.14
12-6-40A	111.40	4900.78	4.901	78.78	10.56	10.66
12-6-80Å	111.80	4910.96	4.911	48.64	23.34	28.03
12/6/118A	112.18	4920.63	4.921	25.89	37.84	36.27
13/1/40A	113.70	4959.31	4.959	77.55	11.58	10.87
13-1-80A	114.10	4969.49	4.969	75.42	12.55	12.03
13-1-120A	114.50	4979.67	4.980	85.17	6.49	8.34
13-1-148A	114.78	4986.79	4.987	84.10	7.42	8.48
13-2-40A	115.20	4997.48	4.997	86.41	6.36	7.23
13-2-80A	115.60	5007.66	5.008	85.51	6.96	7.53
13-2-120A	116.00	5017.84	5.018	85.79	6.37	7.84
13-2-148A	116.28	5024.97	5.025	85.47	6.59	7.94
13-3-40A	116.70	5035.65	5.036	85.05	7.21	7.74
13-3-80A	117.10	5045.83	5.046	85.05	7.45	7.49
13-3-120A	117.50	5056.01	5.056	87.76	6.37	5.86
13-3-148A	117.78	5063.14	5.063	88.38	6.42	5.19
13-4-40A	118.20	5073.83	5.074	79.47	9.97	10.56
13-4-80A	118.60	5084.01	5.084	87.79	6.59	5.62
13-4-120A	119.00	5094.19	5.094	83.17	7.93	8.90
13-4-148A	119.28	5101.31	5.101	83.92	7.76	8.32
13-5-40A	119.70	5112.00	5.112	70.23	13.33	16.43
13-5-80A	120.10	5122.18	5.122	75.89	12.74	11.37
13-5-120A	120.50	5132.36	5.132	86.63	6.29	7.08
13-5-148A	120.78	5139.48	5.139	64.69	18.91	16.40
13-6-40A	121.20	5150.17	5.150	63.59	18.68	17.73
13-6-80A	121.60	5160.35	5.160	70.53	16.72	12.75

DSDP Site 593 Sample No.	Depth	Age (ka)	Age (Ma)	% mud	% f. sand	%c.sand
13-6-118A	121.98	5170.02	5.170	64.76	18.28	16.96
14-1-40A	123.30	5200.95	5.201	88.23	4.93	6.84
14-1-80A	123.70	5207.02	5.207	67.84	15.67	16.50
14-1-120A	124.10	5213.09	5.213	89.70	5.23	5.07
14-1-148A	124.38	5217.35	5.217	70.20	14.74	15.07
14-2-40A	124.80	5223.72	5.224	83.18	8.31	8.51
14/2/80A	125.20	5229.80	5.230	87.30	4.85	7.85
14-2-120A	125.60	5235.87	5.236	85.89	7.45	6.66
14-2-148A	125.88	5240.12	5.240	82.99	8.05	8.96
14-3-40A	126.30	5246.50	5.246	84.33	7.73	7.94
14-3-80A	126.70	5252.57	5.253	82.42	8.33	9.25
14-3-120A	127.10	5258.65	5.259	85.31	7.49	7.20
14-3-148A	127.38	5262.90	5.263	85.49	6.79	7.73
14/4/40A	127.80	5269.27	5.269	71.27	16.23	12.51
14/4/80A	128.20	5275.35	5.275	82.95	8.24	8.81
14-4-120A	128.60	5281.42	5.281	62.63	18.76	18.61
14-4-148Å	128.88	5285.67	5.286	55.58	22.26	22.16
14-5-40A	129.30	5292.05	5.292	87.20	5.99	6.81
14-5-80Å	129.70	5298.12	5.298	88.20	5.73	6.08
14-5-120A	130.10	5304.20	5.304	68.55	15.64	15.81
14-5-148A	130.38	5308.45	5.308	89.06	5.31	5.62
14-6-40A	130.88	5316.04	5.316	51.68	25.25	23.07
14-6-80A	131.20	5320.90	5.321	68.83	13.64	17.53

Appendix B Table 5: Hole 593 texture data 120-329 mbsf. (File on CD: App B Table 5).

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
14/1/0-3	120.30	5127.27	5.1273	91.99	5.72	2.29	97.71			39.19	52.80
14/1/21-24	120.51	5132.61	5.1326	92.40	5.32	2.28	97.72	1.17		38.12	54.28
14/1/39-42	120.69	5137.19	5.1372	91.38	6.03	2.59	97.41			38.48	52.90
14/1/60-63	120.90	5142.54	5.1425	93.24	4.45	2.31	97.69	1.84		41.17	52.07
14/1/81-84	121.11	5147.88	5.1479	93.30	4.44	2.26	97.74			42.76	50.54
14/1/96-99	121.26	5151.70	5.1517	91.90	5.00	3.10	96.90			41.00	50.90
14/1/119-122	121.49	5157.55	5.1576	90.46	6.23	3.31	96.69			39.95	50.51
14/1/139-142	121.69	5162.64	5.1626	90.86	6.02	3.12	96.88			40.90	49.96
14/2/10-13	121.90	5167.99	5.1680	90.49	6.47	3.05	96.95	0.00		38.85	51.64
14/2/29-32	122.09	5172.82	5.1728	91.79	5.74	2.47	97.53			38.13	53.66
14/2/46-49	122.26	5177.15	5.1771	91.80	5.24	2.96	97.04	10.33		39.73	52.07
14/2/71-75	122.51	5183.51	5.1835	92.48	4.91	2.60	97.40	0.43		39.25	53.23
14/2/91-94	122.71	5188.60	5.1886	93.64	4.27	2.09	97.91	0.20		39.22	54.42
14/2/112-115	122.92	5193.94	5.1939	93.16	4.63	2.21	97.79			36.50	56.66
14/2/130-133	123.10	5197.91	5.1979	93.11	4.56	2.32	97.68	4.38		40.71	52.40
14/3/0-3	123.30	5200.95	5.2009	93.26	4.51	2.24	97.76			37.15	56.11
14/3/23-26	123.53	5204.44	5.2044	93.37	4.61	2.01	97.99	4.20		40.19	53.18
14/3/39-42	123.69	5206.87	5.2069	93.37	4.59	2.04	97.96	0.27		37.31	56.06
14/3/58-61	123.88	5209.75	5.2098	93.43	4.70	1.87	98.13			39.31	54.12
14/3/81-84	124.11	5213.25	5.2132	92.64	4.85	2.51	97.49			38.08	54.56
14/3/100-103	124.30	5216.13	5.2161	91.25	5.65	3.10	96.90	1.44		39.96	51.29
14/3/120-123	124.50	5219.17	5.2192	92.47	4.91	2.62	97.38	0.20		40.00	52.47
14/3/138-141	124.68	5221.90	5.2219	92.51	5.09	2.40	97.60	0.21		39.74	52.77
14/4/10-13	124.90	5225.24	5.2252	92.30	4.74	2.96	97.04	0.23		37.68	54.62
14/4/30-33	125.10	5228.28	5.2283	90.05	6.46	3.49	96.51	4.00		37.91	52.14
14/4/50-53	125.30	5231.32	5.2313	92.41	4.94	2.64	97.36			35.82	56.59
14/4/68-71	125.48	5234.05	5.2340	95.13	3.73	1.14	98.86			35.35	59.78
14/4/91-94	125.71	5237.54	5.2375	93.70	4.43	1.86	98.14			34.25	59.45
14/4/111-114	125.91	5240.58	5.2406	93.14	5.03	1.83	98.17			36.45	56.69
14/4/130-133	126.10	5243.46	5.2435	94.34	3.81	1.85	98.15			34.05	60.29
14/5/0-3	126.30	5246.50	5.2465	93.65	4.11	2.23	97.77			38.12	55.53
14/5/26-29	126.56	5250.45	5.2504	93.66	4.06	2.27	97.73			41.46	52.20

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
14/5/40-43	126.70	5252.57	5.2526	94.47	3.56	1.98	98.02			39.53	54.94
14/5/60-63	126.90	5255.61	5.2556	94.19	3.93	1.88	98.12			41.55	52.64
14/5/82-85	127.12	5258.95	5.2589	92.78	4.77	2.45	97.55			38.00	54.78
14/5/100-103	127.30	5261.68	5.2617	90.85	6.30	2.85	97.15			39.71	51.14
14/5/121-124	127.51	5264.87	5.2649	90.24	6.49	3.26	96.74			39.32	50.92
14/5/140-143	127.70	5267.76	5.2678	92.35	5.05	2.60	97.40			42.02	50.33
14/6/10-13	127.90	5270.79	5.2708	93.08	4.31	2.61	97.39			40.36	52.72
14/6/30-33	128.10	5273.83	5.2738	92.30	4.86	2.84	97.16	1.60		42.12	50.18
14/6/49-52	128.29	5276.71	5.2767	92.10	5.27	2.64	97.36	2.13		40.92	51.18
14/6/69-72	128.49	5279.75	5.2798	90.24	6.38	3.38	96.62	5.58		40.74	49.50
14/6/92-95	128.72	5283.24	5.2832	90.35	6.14	3.51	96.49			40.46	49.89
14/6/112-115	128.92	5286.28	5.2863	90.88	5.46	3.67	96.33	8.61		38.19	52.69
14/6/130-133	129.10	5289.01	5.2890	91.57	4.97	3.46	96.54			39.45	52.12
14/7/0-3	129.30	5292.05	5.2921	92.51	4.30	3.20	96.80	7.93		41.71	50.80
14/7/20-23	129.50	5295.09	5.2951	91.84	5.25	2.91	97.09			39.78	52.06
14 CC/10-13	129.69	5297.97	5.2980	91.13	5.40	3.48	96.52			38.69	52.44
15/1/0-3	129.90	5301.16	5.3012	92.01	4.45	3.54	96.46	0.02		37.46	54.55
15/1/22-25	130.12	5304.50	5.3045	91.25	5.23	3.51	96.49			38.97	52.28
15/1/39-42	130.29	5307.08	5.3071	91.42	5.07	3.52	96.48	2.76		39.59	51.83
15/1/60-63	130.50	5310.27	5.3103	93.10	4.05	2.85	97.15	2.56		39.29	53.81
15/1/79-82	130.69	5313.16	5.3132	93.67	4.26	2.07	97.93			40.54	53.13
15/1/99-102	130.89	5316.19	5.3162	93.11	3.77	3.12	96.88			41.64	51.47
15/1/120-123	131.10	5319.38	5.3194	93.77	3.77	2.47	97.53			39.55	54.22
15/1/140-143	131.30	5322.42	5.3224	93.31	4.08	2.61	97.39			38.93	54.38
15/2/11-14	131.51	5325.61	5.3256	94.07	3.88	2.05	97.95			38.06	56.01
15/2/30-33	131.70	5328.49	5.3285	94.72	3.06	2.22	97.78			38.53	56.19
15/2/51-53	131.91	5331.68	5.3317	93.99	3.48	2.53	97.47	3.44		41.02	52.97
15/2/71-74	132.11	5334.72	5.3347	93.10	3.90	3.00	97.00			39.85	53.25
15/2/93-96	132.33	5338.06	5.3381	92.94	4.10	2.96	97.04			40.54	52.40
15/2/113-116	132.53	5341.09	5.3411	93.59	3.58	2.83	97.17			41.29	52.30
15/2/134-136	132.74	5344.28	5.3443	93.70	3.47	2.82	97.18	0.95		40.06	53.64
15/3/0-3	132.90	5346.71	5.3467	93.30	3.82	2.88	97.12			37.08	56.22
15/3/17-20	133.07	5349.29	5.3493	93.63	3.71	2.65	97.35	1.68		38.99	54.64
15/3/39-42	133.29	5352.63	5.3526	93.29	4.04	2.67	97.33	2.63		40.00	53.29
15/3/56-59	133.46	5355.22	5.3552	93.24	3.97	2.79	97.21	0.36		39.89	53.35
15/3/78-81	133.68	5358.56	5.3586	94.65	3.50	1.84	98.16	2.34		39.23	55.42
15/3/99-102	133.89	5361.74	5.3617	93.03	4.24	2.73	97.27			37.97	55.06
15/3/120-123	134.10	5364.93	5.3649	93.27	4.36	2.37	97.63			39.77	53.50
15/3/140-143	134.30	5367.97	5.3680	93.27	4.18	2.55	97.45			39.22	54.05
15/4/10-13	134.50	5371.01	5.3710	94.46	3.47	2.07	97.93			36.22	58.24
15/4/30-33	134.70	5374.04	5.3740	95.29	3.31	1.40	98.60	0.05		38.04	57.25
15/4/50-53	134.90	5377.08	5.3771	93.97	3.60	2.43	97.57			37.86	56.11
15/4/70-73	135.10	5380.12	5.3801	91.46	4.36	4.18	95.82			36.96	54.50
15/4/90-93	135.30	5383.15	5.3832	90.80	5.44	3.76	96.24	0.00		36.57	54.23
15/4/110-113	135.50	5386.19	5.3862	92.06	4.33	3.61	96.39			40.12	51.94
15/4/130-133	135.70	5389.23	5.3892	92.63	4.42	2.94	97.06			37.14	55.49
15/5/0-3	135.90	5392.26	5.3923	93.33	4.18	2.49	97.51			38.24	55.09
15/5/16-19	136.06	5394.69	5.3947	92.72	4.68	2.60	97.40	0.40		39.63	53.09
15/5/42-45	136.32	5398.64	5.3986	91.92	4.81	3.27	96.73	0.15		37.74	54.18
15/5/61-63	136.51	5401.53	5.4015	92.99	4.41	2.61	97.39	0.00		36.93	56.06
15/5/102-105	136.92	5407.75	5.4078	92.01	4.63	3.35	96.65	0.33		37.30	54.71
15/5/123-126	137.13	5410.94	5.4109	90.94	5.52	3.55	96.45			36.96	53.98
15/5/142-145	137.32	5413.82	5.4138	90.39	5.65	3.96	96.04			34.15	56.24
15/6/12-15	137.52	5416.86	5.4169	94.08	3.48	2.45	97.55	0.23		34.24	59.84
15/6/31-34	137.71	5419.75	5.4197	94.52	2.74	2.74	97.26			34.03	60.49
15/6/51-54	137.91	5422.78	5.4228	94.81	3.10	2.08	97.92	17.65		34.65	60.16
15/6/65-68	138.05	5424.91	5.4249	94.18	3.31	2.50	97.50			35.84	58.34
15/6/87-90	138.27	5428.25	5.4282	94.48	3.11	2.41	97.59			35.95	58.53
15/6/107-110	138.47	5431.29	5.4313	93.92	3.49	2.59	97.41	0.00		37.17	56.75
15/6/126-129	138.66	5434.17	5.4342	93.88	3.34	2.78	97.22			37.79	56.09
15/7/0-3	138.90	5437.82	5.4378	94.55	3.19	2.26	97.74	0.33		37.91	56.64
15/7/17-20	139.07	5440.40	5.4404	94.95	3.23	1.82	98.18	3.52		38.03	56.92

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
15 CC/9-11	139.22	5442.67	5.4427	94.62	3.37	2.01	97.99	7.82		36.95	57.67
16/1/0-3	139.50	5446.93	5.4469	94.86	3.31	1.84	98.16	4.15		35.90	58.96
16/1/25-28	139.75	5450.72	5.4507	94.90	3.29	1.82	98.18			37.70	57.20
16/1/67-70	140.17	5457.10	5.4571	94.00	3.48	2.52	97.48	0.12		37.16	56.84
16/1/84-87	140.34	5459.68	5.4597	93.32	4.15	2.53	97.47			39.13	54.19
16/1/104-107	140.54	5462.72	5.4627	94.70	3.48	1.81	98.19	0.00		37.64	57.06
16/1/123-126	140.73	5465.60	5.4656	94.02	4.12	1.86	98.14	3.78		38.68	55.34
16/1/142-145	140.92	5468.49	5.4685	94.60	3.69	1.70	98.30	16.04		35.67	58.93
16/2/13-16	141.13	5471.67	5.4717	93.78	3.88	2.33	97.67	21.78		35.94	57.84
16/2/36-39	141.36	5475.17	5.4752	94.58	3.18	2.24	97.76	0.00		35.94	58.64
16/2/54-57	141.54	5477.90	5.4779	95.57	2.84	1.60	98.40	1.31		38.95	56.62
16/2/79-82	141.79	5481.70	5.4817	95.97	2.64	1.39	98.61			41.56	54.41
16/2/92-95	141.92	5483.67	5.4837	95.53	2.86	1.62	98.38			39.15	56.38
16/2/112-114	142.12	5486.71	5.4867	95.74	2.74	1.52	98.48			40.20	55.54
16/2/132-135	142.32	5489.74	5.4897	94.51	3.36	2.13	97.87			37.77	56.74
16/3/0-3	142.50	5492.48	5.4925	95.22	3.11	1.67	98.33	1.19		37.45	57.77
16/3/25-28	142.75	5496.27	5.4963	94.08	3.61	2.31	97.69			37.41	56.67
16/3/43-46	142.93	5499.01	5.4990	94.16	3.70	2.15	97.85	5.53		37.37	56.79
16/3/65-68	143.15	5502.35	5.5023	92.60	4.88	2.52	97.48			37.91	54.69
16/3/82-85	143.32	5504.93	5.5049	93.86	4.07	2.07	97.93	0.00		37.62	56.24
16/3/103-106	143.53	5508.12	5.5081	92.61	4.34	3.05	96.95	2.18		34.88	57.73
16/3/124-127	143.74	5511.58	5.5116	92.03	5.25	2.72	97.28	0.00		36.30	55.73
16/3/134-137	143.84	5514.48	5.5145	90.79	5.65	3.56	96.44	4.50		38.33	52.46
16/4/7-10	144.07	5521.14	5.5211	93.49	4.33	2.17	97.83	0.00		37.25	56.24
16/4/26-29	144.26	5526.64	5.5266	93.24	3.96	2.80	97.20	0.32		35.69	57.55
16/4/46-49	144.46	5532.43	5.5324	93.36	4.08	2.56	97.44	2.30		34.14	59.22
16/4/67-70	144.67	5538.51	5.5385	87.81	6.98	5.20	94.80			35.43	52.38
16/4/93-96	144.93	5546.04	5.5460	93.45	4.61	1.94	98.06	0.38		39.81	53.64
16/4/113-116	145.13	5551.84	5.5518	94.77	3.47	1.76	98.24	19.74		41.06	53.71
16/4/132-135	145.32	5557.34	5.5573	94.09	3.97	1.94	98.06			40.75	53.34
16/5/0-3	145.50	5562.55	5.5626	94.78	3.53	1.69	98.31			39.15	55.63
16/5/14-17	145.64	5566.61	5.5666	95.11	3.38	1.51	98.49			42.65	52.46
16/5/43-46	145.93	5575.00	5.5750	95.43	2.96	1.61	98.39			41.49	53.94
16/5/63-66	146.13	5580.80	5.5808	95.14	3.19	1.67	98.33			43.16	51.98
16/5/86-88	146.36	5587.46	5.5875	94.39	3.51	2.11	97.89	0.52		44.64	49.75
16/5/102-105	146.52	5592.09	5.5921	95.02	3.33	1.65	98.35	0.39		46.86	48.16
16/5/121-124	146.71	5597.59	5.5976	93.60	4.07	2.33	97.67			41.70	51.90
16/5/142-145	146.92	5603.68	5.6037	92.39	4.53	3.07	96.93			39.13	53.26
16/6/6-9	147.06	5607.73	5.6077	93.71	4.02	2.27	97.73			38.05	55.66
16/6/26-29	147.26	5613.52	5.6135	94.09	3.85	2.06	97.94			34.44	59.65
16/6/47-50	147.47	5619.61	5.6196	93.61	4.21	2.19	97.81			41.67	51.94
16/6/64-66	147.64	5624.53	5.6245	93.58	3.82	2.60	97.40	0.63		39.82	53.76
16/6/93-96	147.93	5632.93	5.6329	93.02	4.25	2.73	97.27			42.48	50.54
16/6/115-117	148.15	5639.30	5.6393	92.86	4.44	2.69	97.31			41.80	51.06
16/6/133-136	148.33	5644.51	5.6445	91.29	5.48	3.23	96.77			42.10	49.19
16/7/0-3	148.50	5649.44	5.6494	91.69	5.01	3.30	96.70			40.73	50.96
16/7/17-19	148.67	5654.36	5.6544	92.10	4.90	3.00	97.00			40.03	52.07
16 CC/8-11	148.77	5657.26	5.6573	89.71	6.23	4.06	95.94	0.62		39.61	50.10
17/1/0-3	149.10	5666.81	5.6668	92.48	5.05	2.47	97.53			40.77	51.71
17/1/26-28	149.36	5674.34	5.6743	93.45	4.21	2.35	97.65			40.66	52.79
17/1/42-45	149.52	5678.98	5.6790	91.99	5.85	2.16	97.84			40.34	51.65
17/1/82-85	149.92	5690.56	5.6906	93.33	3.55	3.12	96.88	2.52		36.83	56.50
17/1/101-104	150.11	5696.06	5.6961	93.52	3.86	2.62	97.38			38.18	55.34
17/1/121-124	150.31	5701.86	5.7019	91.29	4.86	3.85	96.15			37.44	53.85
17/1/141-144	150.51	5707.65	5.7076	90.52	5.50	3.97	96.03	4.92		35.57	54.95
17/2/7-10	150.67	5712.28	5.7123	90.98	5.24	3.78	96.22			40.99	49.99
17/2/27-30	150.87	5718.07	5.7181	92.13	4.75	3.13	96.87			44.35	47.78
17/2/47-50	151.07	5723.87	5.7239	92.60	4.96	2.44	97.56			41.13	51.47
17/2/73-76	151.33	5731.40	5.7314	92.67	4.76	2.57	97.43			39.86	52.81
17/2/92-95	151.52	5736.90	5.7369	92.52	5.42	2.06	97.94			38.67	53.85
17/2/115-118	151.75	5743.56	5.7436	92.62	4.90	2.48	97.52	1.71		39.03	53.59
17/2/136-138	151.96	5749.64	5.7496	91.09	5.35	3.56	96.44			42.41	48.68

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
17/3/0-3	152.10	5753.70	5.7537	92.93	4.33	2.74	97.26	0.46		35.81	57.12
17/3/15-18	152.25	5758.04	5.7580	94.30	3.65	2.05	97.95	0.33		38.49	55.81
17/3/37-40	152.47	5764.41	5.7644	94.93	3.41	1.66	98.34			41.12	53.81
17/3/65-67	152.75	5772.52	5.7725	94.45	3.70	1.86	98.14	6.64		41.02	53.43
17/3/81-84	152.91	5777.16	5.7772	94.38	3.72	1.91	98.09	5.47		40.88	53.50
17/3/102-105	153.12	5783.24	5.7832	93.48	3.96	2.56	97.44	2.74		37.70	55.78
17/3/116-119	153.26	5787.29	5.7873	93.41	3.99	2.60	97.40			42.28	51.13
17/3/135-138	153.45	5792.80	5.7928	93.28	4.37	2.35	97.65	8.13		40.31	52.97
17/4/6-9	153.66	5798.88	5.7989	94.22	3.51	2.27	97.73			39.75	54.47
17/4/37-39	153.97	5807.86	5.8079	96.18	2.45	1.37	98.63	0.82		37.72	58.46
17/4/53-56	154.13	5812.49	5.8125	95.67	2.70	1.64	98.36	0.43		38.40	57.27
17/4/72-75	154.32	5817.99	5.8180	95.78	2.69	1.54	98.46			38.78	57.00
17/4/94-97	154.54	5824.36	5.8244	95.12	3.17	1.71	98.29			40.92	54.20
17/4/117-119	154.77	5831.02	5.8310	94.55	3.16	2.29	97.71			36.15	58.40
17/4/135-138	154.95	5836.24	5.8362	94.01	3.62	2.37	97.63	0.34		37.92	56.09
17/5/0-3	155.10	5840.58	5.8406	93.10	3.76	3.15	96.85	2.40		35.38	57.72
17/5/14-17	155.24	5844.64	5.8446	93.71	3.46	2.84	97.16			39.13	54.58
17/5/38-40	155.48	5851.59	5.8516	93.31	3.71	2.98	97.02	0.54		39.70	53.61
17/5/57-60	155.67	5857.09	5.8571	94.99	2.95	2.06	97.94			38.95	56.04
17/5/84-87	155.94	5864.91	5.8649	95.89	2.35	1.76	98.24			40.06	55.83
17/5/103-106	156.13	5870.41	5.8704	95.07	2.91	2.02	97.98	0.77		39.30	55.77
17/5/117-120	156.27	5874.47	5.8745	94.34	3.52	2.14	97.86	0.25		39.02	55.32
17/5/137-140	156.47	5880.26	5.8803	94.35	3.67	1.98	98.02	0.37		36.24	58.11
17/6/11-14	156.71	5887.21	5.8872	94.25	3.67	2.08	97.92	7.48		41.26	52.99
17/6/35-38	156.95	5894.16	5.8942	94.77	2.88	2.35	97.65			42.12	52.65
17/6/52-55	157.12	5899.08	5.8991	94.14	3.54	2.32	97.68			42.49	51.65
17/6/77-79	157.37	5906.32	5.9063	94.15	3.55	2.31	97.69			42.12	52.03
17/6/92-95	157.52	5910.67	5.9107	93.47	3.96	2.57	97.43			42.64	50.83
17/6/116-119	157.76	5917.62	5.9176	93.92	3.27	2.81	97.19	0.12		37.15	56.77
17/6/133-136	157.93	5922.54	5.9225	95.51	2.47	2.02	97.98	7.69		39.90	55.61
17/7/0-3	158.10	5927.47	5.9275	93.60	4.06	2.35	97.65			39.02	54.58
17/7/17-20	158.27	5932.39	5.9324	93.37	4.18	2.45	97.55	0.31		39.81	53.56
17 CC/6-9	158.52	5939.63	5.9396	92.39	4.19	3.42	96.58	8.82		38.31	54.08
18/1/0-3	158.70	5944.84	5.9448	92.24	3.64	4.13	95.87	0.44		34.53	57.71
18/1/25-28	158.95	5952.08	5.9521	95.51	3.10	1.39	98.61	1.88		40.10	55.41
18/1/43-46	159.13	5957.30	5.9573	93.72	4.12	2.15	97.85	2.69		38.89	54.83
18/1/65-68	159.35	5963.67	5.9637	93.36	4.36	2.28	97.72	4.20		42.72	50.64
18/1/79-82	159.49	5967.72	5.9677	92.14	5.10	2.76	97.24	0.40		42.49	49.65
18/1/102-105	159.72	5974.38	5.9744	91.76	4.86	3.38	96.62	0.00		37.91	53.85
18/1/116-119	159.86	5978.44	5.9784	91.73	4.85	3.42	96.58	2.45		36.48	55.25
18/1/141-144	160.11	5985.68	5.9857	91.04	5.24	3.72	96.28	0.56		41.58	49.46
18/2/13-16	160.33	5992.05	5.9921	91.05	4.85	4.10	95.90	0.11		37.46	53.59
18/2/34-37	160.54	5998.13	5.9981	90.12	5.14	4.75	95.25	2.36		38.95	51.17
18/2/53-56	160.73	6003.64	6.0036	90.64	4.64	4.72	95.28			35.98	54.66
18/2/79-82	160.99	6011.17	6.0112	91.07	4.74	4.18	95.82	1.63		33.48	57.59
18/2/96-99	161.16	6016.09	6.0161	93.25	4.42	2.33	97.67	1.47		40.69	52.56
18/2/112-114	161.32	6020.72	6.0207	93.80	3.59	2.61	97.39	0.86		38.32	55.48
18/2/133-136	161.53	6026.80	6.0268	94.04	3.73	2.23	97.77			37.82	56.22
18/3/0-3	161.70	6031.73	6.0317	94.43	2.93	2.64	97.36	1.17		38.69	55.74
18/3/14-17	161.84	6035.78	6.0358	92.12	4.34	3.54	96.46	0.63		37.78	54.34
18/3/42-45	162.12	6043.89	6.0439	93.06	4.34	2.60	97.40	3.14		41.44	51.62
18/3/56-59	162.26	6047.95	6.0479	93.97	3.58	2.45	97.55	1.33		39.60	54.37
18/3/85-88	162.55	6056.35	6.0563	92.85	4.08	3.07	96.93	0.00		38.34	54.51
18/3/117-120	162.87	6065.61	6.0656	93.28	4.18	2.53	97.47	0.67		37.54	55.74
18/3/135-137	163.05	6070.83	6.0708	92.18	4.58	3.25	96.75	0.00		37.23	54.95
18/4/13-16	163.33	6078.94	6.0789	93.08	3.77	3.15	96.85	0.58		40.21	52.87
18/4/36-39	163.56	6085.60	6.0856	91.97	5.02	3.01	96.99	0.22		39.36	52.61
18/4/53-56	163.73	6090.52	6.0905	91.27	5.35	3.38	96.62			39.63	51.64
18/4/73-76	163.93	6096.31	6.0963	91.18	4.74	4.07	95.93			38.34	52.84
18/4/93-96	164.13	6102.10	6.1021	90.80	5.29	3.90	96.10	0.11		40.28	50.52
18/4/111-113	164.31	6107.32	6.1073	92.79	4.15	3.06	96.94	0.28		43.74	49.05
18/4/132-135	164.52	6113.40	6.1134	93.81	3.56	2.63	97.37			42.00	51.81

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
18/5/0-3	164.70	6118.61	6.1186	93.33	3.54	3.12	96.88	4.36		42.56	50.77
18/5/26-29	164.96	6126.14	6.1261	91.95	4.36	3.69	96.31	0.59		41.19	50.76
18/5/43-46	165.13	6131.07	6.1311	93.20	4.07	2.73	97.27	5.05		38.74	54.46
18/5/65-67	165.35	6137.44	6.1374	93.94	3.65	2.41	97.59	0.00		40.20	53.74
18/5/80-83	165.50	6141.78	6.1418	93.18	4.09	2.73	97.27	3.23		38.13	55.05
18/5/104-106	165.74	6148.73	6.1487	92.21	3.76	4.03	95.97	0.61		41.81	50.40
18/5/125-127	165.95	6154.81	6.1548	93.17	4.12	2.71	97.29			41.61	51.56
18/5/141-144	166.11	6159.45	6.1594	92.96	3.83	3.22	96.78	0.00		42.57	50.39
18/6/6-9	166.26	6163.79	6.1638	91.69	4.12	4.19	95.81			41.85	49.84
18/6/26-29	166.46	6169.58	6.1696	91.99	4.60	3.42	96.58	0.00		41.53	50.46
18/6/46-49	166.66	6175.38	6.1754	92.93	3.76	3.31	96.69	0.18		44.91	48.02
18/6/66-68	166.86	6181.17	6.1812	92.53	4.36	3.11	96.89	2.81		44.54	47.99
18/6/86-89	167.06	6186.96	6.1870	91.09	4.56	4.35	95.65			42.18	48.91
18/6/104-106	167.24	6192.17	6.1922	90.94	4.20	4.85	95.15	1.27		42.36	48.58
18/6/124-127	167.44	6197.97	6.1980	90.08	6.00	3.91	96.09	5.82		43.28	46.80
18 CC/7-10	167.57	6201.73	6.2017	89.77	5.57	4.66	95.34	1.86		41.79	47.98
19/1/0-3	168.30	6222.87	6.2229	93.33	4.16	2.51	97.49	1.66		44.96	48.37
19/1/22-24	168.52	6229.25	6.2292	91.94	4.64	3.42	96.58	0.56		45.76	46.18
19/1/41-44	168.71	6234.75	6.2347	90.70	6.09	3.21	96.79	2.45		40.84	49.86
19/1/62-65	168.92	6240.83	6.2408	92.70	4.16	3.15	96.85	0.27		45.60	47.10
19/1/83-85	169.13	6246.91	6.2469	92.28	4.63	3.09	96.91			43.31	48.97
19/1/104-107	169.34	6252.99	6.2530	91.90	4.66	3.43	96.57	0.32		41.07	50.83
19/1/121-124	169.51	6257.92	6.2579	91.73	5.10	3.16	96.84	0.18		41.09	50.64
19/1/142-145	169.72	6264.00	6.2640	93.01	3.32	3.68	96.32			39.44	53.57
19/2/5-8	169.85	6267.76	6.2678	93.15	3.81	3.04	96.96			41.98	51.17
19/2/26-28	170.06	6273.85	6.2738	91.45	4.72	3.83	96.17			41.83	49.62
19/2/52-55	170.32	6281.38	6.2814	90.99	5.29	3.72	96.28			42.50	48.49
19/2/72-74	170.52	6287.17	6.2872	93.19	3.20	3.61	96.39	1.08		46.04	47.15
19/2/93-96	170.73	6293.25	6.2933	93.26	3.36	3.39	96.61	0.08		44.90	48.36
19/2/114-117	170.94	6299.33	6.2993	92.45	4.83	2.72	97.28			45.09	47.36
19/2/135-138	171.15	6305.41	6.3054	92.02	5.07	2.91	97.09	0.90		43.07	48.95
19/3/0-3	171.30	6309.76	6.3098	91.59	3.67	4.74	95.26	0.66		40.78	50.81
19/3/27-29	171.57	6317.58	6.3176	92.17	5.47	2.36	97.64	1.68		44.43	47.74
19/3/42-45	171.72	6321.92	6.3219	91.78	5.08	3.13	96.87			45.95	45.83
19/3/62-64	171.92	6327.71	6.3277	93.51	4.11	2.37	97.63			43.54	49.97
19/3/83-86	172.13	6333.80	6.3338	92.28	4.42	3.30	96.70	0.35		43.84	48.44
19/3/102-105	172.32	6339.30	6.3393	92.46	4.55	2.98	97.02	6.31		43.94	48.52
19/3/117-120	172.47	6343.64	6.3436	88.99	7.32	3.70	96.30			42.65	46.34
19/3/136-138	172.66	6349.15	6.3491	92.67	4.19	3.15	96.85			44.34	48.33
19/4/6-9	172.86	6354.94	6.3549	91.82	4.81	3.37	96.63	0.68		46.26	45.56
19/4/27-29	173.07	6361.02	6.3610	92.06	4.65	3.29	96.71	0.91		44.85	47.21
19/4/47-50	173.27	6366.81	6.3668	92.04	4.81	3.15	96.85	0.35		44.98	47.06
19/4/72-74	173.52	6374.05	6.3741	92.22	4.67	3.12	96.88	1.03		47.58	44.64
19/4/92-95	173.72	6379.85	6.3798	94.38	3.66	1.96	98.04	0.61		45.36	49.02
19/4/113-115	173.93	6385.93	6.3859	93.46	4.28	2.26	97.74	0.34		43.00	50.46
19/4/134-137	174.14	6392.01	6.3920	93.60	4.08	2.32	97.68	0.38		42.48	51.12
19/5/0-3	174.30	6396.64	6.3966	93.79	3.82	2.39	97.61			41.07	52.72
19/5/24-27	174.54	6403.59	6.4036	95.36	3.01	1.63	98.37	0.32		43.63	51.73
19/5/42-45	174.72	6408.81	6.4088	95.26	2.97	1.77	98.23	9.80		47.61	47.65
19/5/56-59	174.86	6412.86	6.4129	95.10	3.17	1.73	98.27			45.42	49.68
19/5/96-99	175.26	6424.45	6.4244	96.38	2.62	1.00	99.00	3.54		47.23	49.15
19/5/117-120	175.47	6430.53	6.4305	95.88	2.77	1.34	98.66	1.10		44.38	51.50
19/5/141-144	175.71	6437.48	6.4375	95.86	2.72	1.43	98.57	0.55		43.45	52.41
19/6/6-9	175.86	6441.82	6.4418	94.96	3.19	1.86	98.14	1.23		45.81	49.15
19/6/26-29	176.06	6447.61	6.4476	94.61	3.36	2.04	97.96			46.78	47.83
19/6/52-55	176.32	6455.14	6.4551	95.95	2.50	1.55	98.45	2.02		44.43	51.52
19/6/67-69	176.47	6459.49	6.4595	94.87	2.98	2.15	97.85	0.32		44.57	50.30
19/6/84-87	176.64	6464.41	6.4644	94.32	3.30	2.39	97.61	2.19		44.96	49.36
19/6/112-114	176.92	6472.52	6.4725	96.35	2.36	1.29	98.71	2.44		44.84	51.51
19/6/134-137	177.14	6478.89	6.4789	97.48	1.69	0.83	99.17	3.09		43.05	54.43
19/7/0-3	177.30	6483.53	6.4835	96.07	3.02	0.91	99.09	2.21		45.31	50.76
19/7/22-25	177.52	6489.90	6.4899	96.88	2.34	0.78	99.22	1.06		42.71	54.17

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
19 CC/0-3	177.82	6498.59	6.4986	94.95	3.21	1.84	98.16			43.35	51.60
20/1/0-3	177.90	6500.90	6.5009	95.81	2.53	1.66	98.34	4.05		42.72	53.09
20/1/15-18	178.05	6505.25	6.5052	96.16	2.38	1.46	98.54			45.22	50.94
20/1/37-40	178.27	6511.62	6.5116	96.42	2.25	1.33	98.67	1.09		41.79	54.63
20/1/58-60	178.48	6517.70	6.5177	95.81	2.57	1.62	98.38	2.61		41.82	53.99
20/1/78-80	178.68	6523.49	6.5235	96.30	2.40	1.30	98.70			40.22	56.08
20/1/97-99	178.87	6529.00	6.5290	96.60	2.10	1.30	98.70	0.76		43.79	52.81
20/1/118-120	179.08	6535.08	6.5351	96.56	2.44	1.01	98.99	11.32		42.01	54.55
20/1/137-139	179.27	6540.58	6.5406	97.48	1.66	0.86	99.14	0.48		41.95	55.53
20/2/5-7	179.45	6545.79	6.5458	97.66	1.64	0.70	99.30			44.46	53.20
20/2/27-29	179.67	6552.17	6.5522	95.86	2.72	1.42	98.58			42.83	53.03
20/2/46-48	179.86	6557.67	6.5577	96.34	2.32	1.34	98.66			43.29	53.05
20/2/77-79	180.17	6566.65	6.5666	96.96	1.95	1.10	98.90			43.51	53.45
20/2/93-95	180.33	6571.28	6.5713	95.78	2.59	1.63	98.37			44.59	51.19
20/2/106-108	180.46	6575.05	6.5750	95.39	2.71	1.90	98.10	4.32		45.77	49.62
20/2/133-135	180.73	6582.87	6.5829	94.76	2.66	2.58	97.42	0.94		41.44	53.32
20/3/1-3	180.91	6588.08	6.5881	94.91	2.93	2.17	97.83	3.25		40.80	54.11
20/3/24-26	181.14	6594.74	6.5947	97.34	1.55	1.11	98.89	2.47		40.63	56.71
20/3/42-44	181.32	6599.95	6.6000	96.74	1.87	1.39	98.61	31.50		41.32	55.42
20/3/67-69	181.57	6607.19	6.6072	97.21	1.87	0.92	99.08	0.00		45.66	51.55
20/3/82-84	181.72	6611.54	6.6115	96.93	2.03	1.04	98.96	1.11		43.62	53.31
20/3/96-98	181.86	6615.59	6.6156	96.95	2.08	0.97	99.03			42.45	54.50
20/3/116-118	182.06	6621.38	6.6214	97.11	1.88	1.01	98.99			40.71	56.40
20/3/133-135	182.23	6626.31	6.6263	97.51	1.49	1.00	99.00	5.20		42.37	55.14
20/4/7-9	182.47	6633.26	6.6333	96.11	2.52	1.36	98.64	2.06		40.78	55.33
20/4/28-30	182.68	6639.34	6.6393	95.44	2.79	1.77	98.23	0.53		41.94	53.50
20/4/48-50	182.88	6645.13	6.6451	95.39	2.88	1.72	98.28	1.27		41.69	53.70
20/4/68-70	183.08	6650.92	6.6509	93.90	3.11	2.99	97.01	0.00		39.47	54.43
20/4/86-88	183.26	6656.14	6.6561	96.43	2.27	1.30	98.70			41.09	55.34
20/4/105-107	183.45	6661.64	6.6616	95.76	2.81	1.43	98.57			44.15	51.61
20/4/132-135	183.72	6669.46	6.6695	94.26	3.69	2.05	97.95	0.49		41.33	52.93
20/5/1-3	183.91	6674.96	6.6750	94.24	3.64	2.13	97.87	1.13		44.08	50.16
20/5/25-27	184.15	6681.91	6.6819	94.59	3.54	1.88	98.12	6.87		40.57	54.02
20/5/42-44	184.32	6686.84	6.6868	94.64	3.56	1.80	98.20			45.47	49.17
20/5/61-63	184.51	6692.34	6.6923	92.45	4.49	3.06	96.94			43.07	49.38
20/5/82-84	184.72	6698.42	6.6984	94.11	3.84	2.05	97.95			44.53	49.58
20/5/101-103	184.91	6703.92	6.7039	92.66	4.12	3.21	96.79	1.06		44.18	48.48
20/5/117-119	185.07	6708.56	6.7086	91.87	5.35	2.78	97.22	0.73		45.13	46.74
20/5/137-139	185.27	6714.35	6.7144	93.33	3.44	3.23	96.77	0.00		42.99	50.34
20/6/7-9	185.47	6720.14	6.7201	94.94	3.22	1.84	98.16			45.75	49.19
20/6/34-36	185.74	6727.96	6.7280	95.91	2.88	1.22	98.78			45.55	50.36
20/6/52-54	185.92	6733.18	6.7332	95.12	3.02	1.86	98.14			44.94	50.18
20/6/68-70	186.08	6737.81	6.7378	93.97	3.60	2.42	97.58			45.43	48.54
20/6/92-94	186.32	6744.76	6.7448	94.77	3.31	1.92	98.08			45.04	49.73
20/6/111-113	186.51	6750.26	6.7503	95.79	2.49	1.71	98.29			43.03	52.76
20/6/132-134	186.72	6756.34	6.7563	96.01	2.51	1.48	98.52	12.76		41.88	54.13
20/7/0-2	186.90	6761.56	6.7616	94.52	3.31	2.16	97.84			39.86	54.66
20/7/17-19	187.07	6766.48	6.7665	93.86	3.58	2.57	97.43	1.68		41.57	52.29
20 CC/7-9	187.22	6770.83	6.7708	93.18	3.16	3.66	96.34	15.42		39.41	53.77
21/1/1-3	187.51	6779.22	6.7792	94.80	3.13	2.07	97.93			39.31	55.49
21/1/26-28	187.76	6786.46	6.7865	96.49	2.16	1.34	98.66			38.58	57.91
21/1/43-45	187.93	6791.39	6.7914	96.30	2.46	1.24	98.76			42.69	53.61
21/1/58-60	188.08	6795.73	6.7957	95.89	2.64	1.47	98.53	0.04		39.47	56.42
21/182-84	188.32	6802.68	6.8027	95.67	2.57	1.76	98.24			42.05	53.62
21/1/102-104	188.52	6808.48	6.8085	96.00	2.24	1.76	98.24			44.18	51.82
21/1/117-119	188.67	6812.82	6.8128	96.20	2.32	1.49	98.51			40.69	55.51
21/1142-144	188.92	6820.06	6.8201	95.98	2.41	1.61	98.39	1.70		39.65	56.33
21/2/8-10	189.08	6824.69	6.8247	91.42	5.73	2.85	97.15	0.00		41.50	49.92
21/2/33-35	189.33	6831.93	6.8319	95.88	2.78	1.34	98.66			42.81	53.07
21/2/46-48	189.46	6835.70	6.8357	96.52	2.54	0.94	99.06			43.08	53.44
21/2/75-77	189.75	6844.10	6.8441	95.98	2.79	1.23	98.77	9.92		43.48	52.50
21/2/93-96	189.93	6849.31	6.8493	95.64	2.80	1.56	98.44			42.66	52.98

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
21/2/117-119	190.17	6856.26	6.8563	95.41	2.81	1.78	98.22	0.00		42.83	52.58
21/2/142-144	190.42	6863.50	6.8635	96.67	2.43	0.90	99.10			42.31	54.36
21/3/1-3	190.51	6866.11	6.8661	96.41	2.46	1.13	98.87	18.08		42.40	54.01
21/3/16-18	190.66	6870.45	6.8705	96.03	2.81	1.17	98.83			41.33	54.70
21/3/37-39	190.87	6876.53	6.8765	96.37	2.56	1.07	98.93			42.03	54.34
21/3/62-64	191.12	6883.78	6.8838	95.03	3.18	1.79	98.21	9.13		40.76	54.27
21/3/82-84	191.32	6889.57	6.8896	95.10	3.16	1.74	98.26			40.50	54.60
21/3/102-104	191.52	6895.36	6.8954	94.55	3.51	1.94	98.06	0.29		43.45	51.10
21/3/121-123	191.71	6900.86	6.9009	95.50	2.86	1.64	98.36			40.57	54.93
21/3/136-139	191.86	6905.21	6.9052	95.14	3.27	1.59	98.41			43.24	51.90
21/4/7-9	192.07	6911.29	6.9113	95.64	2.85	1.52	98.48			43.66	51.98
21/4/36-38	192.36	6919.69	6.9197	95.28	3.33	1.40	98.60			40.71	54.57
21/4/52-54	192.52	6924.32	6.9243	95.37	3.11	1.52	98.48			47.05	48.32
21/4/73-75	192.73	6930.40	6.9304	95.02	3.10	1.88	98.12			45.23	49.79
21/4/96-98	192.96	6937.06	6.9371	94.07	3.58	2.35	97.65	0.00		43.95	50.12
21/4/112-114	193.12	6941.70	6.9417	93.40	3.92	2.67	97.33	0.00		40.23	53.17
21/4/133-135	193.33	6947.78	6.9478	95.39	3.02	1.59	98.41			41.13	54.26
21/5/0-2	193.50	6952.70	6.9527	93.91	3.90	2.19	97.81			40.84	53.07
21/5/22-24	193.72	6959.08	6.9591	93.92	3.57	2.51	97.49	0.31		42.06	51.86
21/5/42-44	193.92	6964.87	6.9649	94.98	2.93	2.08	97.92			39.20	55.78
21/5/62-64	194.12	6970.66	6.9707	94.73	2.81	2.46	97.54	0.00		43.97	50.76
21/5/84-86	194.34	6977.03	6.9770	88.84	5.77	5.39	94.61			38.45	50.39
21/5/102-104	194.52	6982.24	6.9822	91.46	4.90	3.63	96.37			40.10	51.36
21/5/122-124	194.72	6988.04	6.9880	94.49	3.43	2.08	97.92			45.70	48.79
21/5/140-142	194.90	6993.25	6.9932	93.70	4.23	2.07	97.93			43.52	50.18
21/6/7-9	195.07	6998.17	6.9982	93.18	3.84	2.98	97.02	0.00		44.06	49.12
21/6/33-35	195.33	7005.70	7.0057	95.25	2.71	2.04	97.96			44.72	50.53
21/6/49-51	195.49	7010.34	7.0103	93.76	3.75	2.49	97.51	1.59		41.35	52.41
21/6/66-68	195.66	7015.26	7.0153	94.36	3.49	2.15	97.85			42.60	51.76
21/6/87-89	195.87	7021.34	7.0213	93.40	4.17	2.42	97.58			42.63	50.77
21/6/107-109	196.07	7027.13	7.0271	93.11	4.16	2.73	97.27	0.00		44.83	48.28
21/6/134-136	196.34	7034.95	7.0350	92.80	4.37	2.83	97.17			42.62	50.18
21/7/0-2	196.50	7039.59	7.0396	93.27	3.78	2.95	97.05			44.31	48.96
21/7/22-24	196.72	7045.96	7.0460	94.89	3.21	1.90	98.10			44.03	50.86
21 CC/6-8	197.00	7054.07	7.0541	93.67	3.78	2.54	97.46	0.00		42.77	50.90
22/1/1-3	197.11	7057.25	7.0573	94.73	3.29	1.97	98.03	0.22		43.52	51.21
22/1/16-18	197.26	7061.60	7.0616	94.88	3.32	1.80	98.20			41.57	53.31
22/1/38-40	197.48	7067.97	7.0680	94.25	3.98	1.77	98.23			43.47	50.78
22/1/58-60	197.68	7073.76	7.0738	94.60	3.70	1.70	98.30			43.91	50.69
22/1/84-86	197.94	7081.29	7.0813	95.17	3.38	1.45	98.55			44.28	50.89
22/1/104-106	198.14	7087.08	7.0871	94.68	3.89	1.44	98.56	0.00		42.92	51.76
22/1/122-124	198.32	7092.30	7.0923	96.82	2.08	1.10	98.90			43.49	53.33
22/1/142-144	198.52	7098.09	7.0981	94.26	3.55	2.19	97.81			40.61	53.65
22/2/13-15	198.73	7104.17	7.1042	94.02	3.80	2.18	97.82			41.65	52.37
22/2/32-34	198.92	7109.67	7.1097	92.71	4.34	2.96	97.04			45.14	47.57
22/2/54-56	199.14	7116.05	7.1160	94.12	3.85	2.03	97.97	0.00		49.17	44.95
22/2/74-77	199.34	7121.84	7.1218	92.75	4.39	2.87	97.13			45.45	47.30
22/2/93-95	199.53	7127.34	7.1273	93.83	4.19	1.98	98.02	0.00		44.56	49.27
22/2/112-114	199.72	7132.84	7.1328	94.27	3.67	2.07	97.93			46.59	47.68
22/2/133-135	199.93	7138.93	7.1389	92.77	4.82	2.41	97.59			45.43	47.34
22/3/1-3	200.11	7144.14	7.1441	94.52	3.77	1.71	98.29	0.00		46.79	47.73
22/3/15-17	200.25	7148.19	7.1482	92.85	4.65	2.50	97.50			45.63	47.22
22/3/42-44	200.52	7156.01	7.1560	93.46	4.20	2.34	97.66			41.72	51.74
22/3/56-58	200.66	7160.07	7.1601	93.16	4.24	2.61	97.39			46.94	46.22
22/3/82-84	200.92	7167.60	7.1676	92.98	4.28	2.75	97.25			46.76	46.22
22/3/95-97	201.05	7171.36	7.1714	93.68	4.23	2.09	97.91	2.06		44.54	49.14
22/3/117-119	201.27	7177.73	7.1777	93.85	3.68	2.47	97.53			46.08	47.77
22/3/132-134	201.42	7182.08	7.1821	93.60	3.93	2.47	97.53			43.85	49.75
22/4/7-9	201.67	7189.32	7.1893	93.67	3.83	2.51	97.49			41.88	51.79
22/4/33-35	201.93	7196.85	7.1968	94.00	3.94	2.06	97.94			44.00	50.00
22/4/73-75	202.33	7208.43	7.2084	94.65	3.80	1.54	98.46	0.00		48.93	45.72
22/4/92-95	202.52	7213.94	7.2139	94.36	3.95	1.69	98.31			48.73	45.63

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
22/4/113-115	202.73	7220.02	7.2200	94.49	3.60	1.91	98.09	0.68		53.00	41.49
22/4/133-135	202.93	7225.81	7.2258	95.10	3.21	1.69	98.31			55.74	39.36
22 CC/7-10	203.17	7232.76	7.2328	93.23	4.79	1.98	98.02			35.57	57.66
23/1/1-3	206.71	7350.20	7.3502	95.55	3.07	1.38	98.62	11.78		44.40	51.15
23/1/15-17	206.85	7354.89	7.3549	94.94	3.36	1.70	98.30			47.56	47.38
23/1/43-45	207.13	7364.27	7.3643	93.86	4.18	1.96	98.04	0.00		46.47	47.39
23/1/58-60	207.28	7369.30	7.3693	94.29	3.76	1.95	98.05			44.86	49.43
23/1/78-80	207.48	7376.00	7.3760	94.46	3.63	1.91	98.09	0.77		44.53	49.93
23/1/103-105	207.73	7384.37	7.3844	93.62	3.95	2.43	97.57			45.23	48.39
23/1/118-120	207.88	7389.40	7.3894	93.98	3.53	2.49	97.51			46.12	47.86
23/1/142-144	208.12	7397.44	7.3974	95.72	2.65	1.62	98.38			49.50	46.22
23/2/6-8	208.26	7402.12	7.4021	96.41	2.33	1.26	98.74	1.96		47.19	49.22
23/2/32-34	208.52	7410.83	7.4108	95.93	2.83	1.24	98.76			48.28	47.65
23/2/53-55	208.73	7417.87	7.4179	95.80	2.81	1.39	98.61			48.71	47.09
23/2/86-88	209.06	7428.92	7.4289	94.54	3.08	2.38	97.62			48.03	46.51
23/2/107-109	209.27	7435.96	7.4360	95.02	3.20	1.78	98.22	9.51		47.81	47.21
23/2/134-136	209.54	7445.00	7.4450	95.83	2.62	1.55	98.45			47.66	48.17
23/3/0-2	209.70	7450.36	7.4504	96.30	2.51	1.19	98.81			48.38	47.92
23/3/15-17	209.85	7455.39	7.4554	96.26	2.61	1.13	98.87			50.03	46.23
23/3/42-44	210.12	7464.43	7.4644	95.05	3.25	1.70	98.30	0.00		47.45	47.60
23/3/63-65	210.33	7471.46	7.4715	94.85	3.46	1.69	98.31			47.53	47.32
23/3/83-85	210.53	7478.16	7.4782	95.77	2.79	1.45	98.55			44.81	50.96
23/3/102-104	210.72	7484.53	7.4845	95.81	2.49	1.70	98.30			47.59	48.22
23/3/117-119	210.87	7489.55	7.4896	96.09	2.69	1.23	98.77			44.58	51.51
23/3/136-138	211.06	7495.92	7.4959	95.07	3.33	1.60	98.40	5.14		46.53	48.54
23/4/7-9	211.27	7502.95	7.5030	94.02	3.86	2.12	97.88			45.71	48.31
23/4/32-34	211.52	7511.32	7.5113	94.29	3.78	1.93	98.07			47.64	46.65
23/4/52-54	211.72	7518.02	7.5180	94.10	3.58	2.32	97.68			47.14	46.96
23/4/73-75	211.93	7525.06	7.5251	93.43	4.08	2.48	97.52			46.65	46.78
23/4/93-95	212.13	7531.76	7.5318	92.84	4.45	2.71	97.29	0.00		44.65	48.19
23/4/112-114	212.32	7538.12	7.5381	92.91	4.77	2.31	97.69			46.74	46.17
23/4/133-135	212.53	7545.16	7.5452	92.05	4.76	3.19	96.81	0.61		48.64	43.41
23/5/1-3	212.71	7551.19	7.5512	94.71	3.47	1.82	98.18			47.67	47.04
23/5/24-26	212.94	7558.89	7.5589	93.77	4.10	2.13	97.87			48.87	44.90
23/5/42-44	213.12	7564.92	7.5649	95.08	3.37	1.55	98.45	0.00		49.29	45.79
23/5/83-85	213.53	7578.65	7.5787	94.26	3.88	1.86	98.14			48.26	46.00
23/5/102-104	213.72	7585.02	7.5850	93.01	4.50	2.49	97.51			48.45	44.56
23/5/122-124	213.92	7591.72	7.5917	91.34	5.12	3.54	96.46			47.55	43.79
23/5/142-144	214.12	7598.42	7.5984	93.06	4.28	2.66	97.34	0.00		45.49	47.57
23/6/7-9	214.27	7603.44	7.6034	93.25	4.39	2.36	97.64			46.81	46.44
23/6/31-33	214.51	7611.48	7.6115	92.26	4.80	2.93	97.07			47.85	44.41
23/6/52-54	214.72	7618.51	7.6185	93.08	4.20	2.72	97.28			48.22	44.86
23/6/85-87	215.05	7629.57	7.6296	94.61	3.84	1.55	98.45	0.62		48.65	45.96
23/6/111-113	215.31	7638.28	7.6383	92.99	4.36	2.65	97.35			49.71	43.28
23/6/133-135	215.53	7645.65	7.6456	93.85	3.81	2.35	97.65			51.46	42.39
23/7/1-3	215.71	7651.68	7.6517	93.40	4.08	2.52	97.48			48.76	44.64
23/7/23-25	215.93	7659.05	7.6590	93.81	4.07	2.13	97.87			49.67	44.14
23 CC/7-10	216.22	7668.76	7.6688	92.06	4.96	2.98	97.02	6.78		48.84	43.22
24/1/1-3	216.31	7671.78	7.6718	95.09	3.35	1.56	98.44			45.95	49.14
24/1/27-29	216.57	7680.48	7.6805	94.67	3.76	1.57	98.43	0.55		47.67	47.00
24/1/43-45	216.73	7685.84	7.6858	94.87	3.41	1.72	98.28			47.94	46.93
24/1/64-66	216.94	7692.88	7.6929	87.88	8.41	3.71	96.29			48.24	39.64
24/1/82-84	217.12	7698.91	7.6989	91.92	5.32	2.76	97.24	0.61		50.74	41.18
24/1/104-106	217.34	7706.28	7.7063	91.09	5.65	3.25	96.75			52.27	38.82
24/1/123-125	217.53	7712.64	7.7126	91.38	5.37	3.25	96.75			55.32	36.06
24/1/142-144	217.72	7719.01	7.7190	94.11	3.92	1.97	98.03	4.19		54.73	39.38
24/2/12-14	217.92	7725.71	7.7257	93.60	3.92	2.48	97.52			53.30	40.30
24/2/28-30	218.08	7731.06	7.7311	94.35	3.97	1.68	98.32	0.04		53.69	40.66
24/2/46-48	218.26	7737.09	7.7371	94.57	3.86	1.57	98.43			53.04	41.53
24/2/72-74	218.52	7745.80	7.7458	95.58	3.07	1.34	98.66	26.35		53.52	42.06
24/2/87-89	218.67	7750.83	7.7508	95.25	3.15	1.60	98.40			51.40	43.85
24/2/107-109	218.87	7757.53	7.7575	94.83	3.47	1.70	98.30			50.47	44.36

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
24/2/135-137	219.15	7766.91	7.7669	93.67	3.70	2.63	97.37	0.00		49.60	44.07
24/3/1-3	219.31	7772.27	7.7723	93.39	4.39	2.22	97.78			52.80	40.59
24/3/23-25	219.53	7779.64	7.7796	93.46	4.30	2.24	97.76			55.11	38.35
24/3/42-44	219.72	7786.00	7.7860	94.46	3.69	1.85	98.15			55.45	39.01
24/3/56-58	219.86	7790.69	7.7907	93.84	4.22	1.94	98.06			54.56	39.28
24/3/82-84	220.12	7799.40	7.7994	94.44	3.74	1.82	98.18	0.14		54.54	39.90
24/3/102-104	220.32	7806.10	7.8061	93.53	4.18	2.30	97.70			55.70	37.83
24/3/116-118	220.46	7810.79	7.8108	93.25	4.48	2.27	97.73	0.91		52.13	41.12
24/3/133-135	220.63	7816.48	7.8165	92.72	4.54	2.74	97.26			49.95	42.77
24/4/7-9	220.87	7824.52	7.8245	93.19	4.36	2.45	97.55			51.76	41.43
24/4/32-34	221.12	7832.90	7.8329	94.26	3.70	2.04	97.96	0.00		53.09	41.17
24/4/47-49	221.27	7837.92	7.8379	93.32	4.65	2.03	97.97	1.51		54.28	39.04
24/4/72-74	221.52	7846.29	7.8463	92.86	4.61	2.53	97.47			52.45	40.41
24/4/86-88	221.66	7850.98	7.8510	93.59	4.27	2.13	97.87			52.22	41.37
24/4/112-114	221.92	7859.69	7.8597	92.67	4.67	2.66	97.34			51.65	41.02
24/4/133-135	222.13	7866.73	7.8667	92.42	4.82	2.76	97.24	0.23		50.32	42.10
24/5/1-3	222.31	7872.76	7.8728	91.92	4.83	3.25	96.75			48.70	43.22
24/5/15-17	222.45	7877.45	7.8774	92.54	4.74	2.71	97.29			48.40	44.14
24/5/43-45	222.73	7886.83	7.8868	92.72	4.49	2.79	97.21			48.81	43.91
24/5/63-65	222.93	7893.52	7.8935	92.94	4.14	2.92	97.08			52.18	40.76
24/5/84-86	223.14	7900.56	7.9006	95.61	2.55	1.83	98.17	0.00		54.35	41.26
24/5/103-105	223.33	7906.92	7.9069	95.17	2.78	2.06	97.94			52.55	42.62
24/5/118-120	223.48	7911.95	7.9119	93.71	3.84	2.45	97.55			50.83	42.88
24/5/142-144	223.72	7919.99	7.9200	93.32	4.11	2.57	97.43			52.15	41.17
24/6/7-9	223.87	7925.01	7.9250	93.30	4.22	2.48	97.52			49.94	43.36
24/6/27-29	224.07	7931.71	7.9317	90.85	5.65	3.50	96.50	21.49		50.94	39.91
24/6/47-49	224.27	7938.41	7.9384	91.51	5.76	2.73	97.27			51.58	39.93
24/6/67-69	224.47	7945.11	7.9451	94.30	3.88	1.81	98.19			51.15	43.15
24/6/86-88	224.66	7951.47	7.9515	93.37	3.88	2.76	97.24			52.51	40.86
24/6/107-109	224.87	7958.51	7.9585	96.09	2.53	1.38	98.62	5.58		54.35	41.74
24/6/132-134	225.12	7966.88	7.9669	91.69	5.63	2.68	97.32	0.36		50.88	40.81
24 CC/9-11	225.36	7974.92	7.9749	87.96	7.57	4.47	95.53			47.22	40.74
25/1/1-3	225.91	7993.35	7.9933	88.40	7.60	4.00	96.00	0.53		45.41	42.99
25/1/23-25	226.13	8000.71	8.0007	89.26	6.75	3.99	96.01	0.57		49.61	39.65
25/1/42-44	226.32	8007.08	8.0071	87.96	7.47	4.57	95.43			48.79	39.17
25/1/63-65	226.53	8014.11	8.0141	89.34	7.41	3.24	96.76			46.21	43.13
25/1/85-87	226.75	8021.48	8.0215	88.75	7.75	3.51	96.49			46.66	42.09
25/1/103-105	226.93	8027.51	8.0275	90.01	6.35	3.65	96.35			46.31	43.70
25/1/125-123	227.13	8034.21	8.0342	90.86	5.62	3.52	96.48	0.00		45.64	45.22
25/1/144-146	227.34	8041.25	8.0412	91.15	5.38	3.47	96.53	0.71		47.30	43.85
25/2/5-7	227.45	8044.93	8.0449	91.10	5.75	3.15	96.85			46.20	44.90
25/2/-32-34	227.72	8053.97	8.0540	90.87	5.92	3.22	96.78	14.19		47.45	43.42
25/2/53-55	227.93	8061.01	8.0610	91.81	5.65	2.54	97.46			48.29	43.52
25/2/72-74	228.12	8067.37	8.0674	88.50	7.17	4.33	95.67	0.00		46.36	42.14
25/2/95-97	228.35	8075.08	8.0751	85.87	8.37	5.76	94.24			45.64	40.23
25/2/112-114	228.52	8080.77	8.0808	83.24	8.43	8.34	91.66			45.57	37.67
25/2/134-136	228.74	8088.14	8.0881	87.69	7.68	4.64	95.36			45.83	41.86
25/3/0-2	228.90	8093.50	8.0935	85.96	8.68	5.36	94.64			43.78	42.18
25/3/23-25	229.13	8101.21	8.1012	86.76	8.16	5.08	94.92	0.00		43.92	42.84
25/3/43-45	229.33	8107.90	8.1079	88.18	7.43	4.39	95.61			45.63	42.55
25/3/63-65	229.53	8114.60	8.1146	87.92	7.64	4.43	95.57			46.51	41.41
25/3/95-97	229.85	8125.32	8.1253	88.52	7.02	4.47	95.53			46.91	41.61
25/3/118-120	230.08	8133.03	8.1330	92.53	4.54	2.94	97.06	0.00		49.51	43.02
25/3/137-139	230.27	8139.39	8.1394	89.97	6.16	3.88	96.12			47.81	42.16
25/4/7-9	230.47	8146.09	8.1461	91.52	6.05	2.43	97.57			48.19	43.33
25/4/32-34	230.72	8154.47	8.1545	93.35	4.72	1.93	98.07			48.23	45.12
25/4/53-55	230.93	8161.50	8.1615	93.60	4.13	2.26	97.74			47.94	45.66
25/4/74-76	231.14	8168.53	8.1685	92.53	4.27	3.20	96.80	0.00		48.83	43.70
25/4/93-95	231.33	8174.90	8.1749	93.07	4.64	2.29	97.71			53.39	39.68
25/4/112-114	231.52	8181.26	8.1813	94.34	3.87	1.79	98.21			48.44	45.90
25/4/133-135	231.73	8188.30	8.1883	95.40	3.19	1.41	98.59			49.13	46.27
25/5/1-3	231.91	8194.33	8.1943	94.31	3.78	1.92	98.08			47.38	46.93

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
25/5/16-18	232.06	8199.35	8.1994	92.50	4.88	2.63	97.37	0.00		47.91	44.59
25/5/38-40	232.28	8206.72	8.2067	91.08	6.12	2.81	97.19			47.87	43.21
25/5/62-64	232.52	8214.76	8.2148	92.36	5.29	2.34	97.66			49.09	43.27
25/5/82-84	232.72	8221.46	8.2215	90.34	6.02	3.64	96.36	44.40		47.01	43.33
25/5/102-104	232.92	8228.16	8.2282	91.93	5.03	3.04	96.96			50.15	41.78
25/5/117-119	233.07	8233.18	8.2332	89.04	6.08	4.88	95.12	0.00		49.01	40.03
25/5137-139	233.27	8239.88	8.2399	92.14	4.68	3.18	96.82			49.88	42.26
25/6/7-9	233.47	8246.58	8.2466	90.79	5.48	3.74	96.26	0.13		47.65	43.14
25/6/27-29	233.67	8253.28	8.2533	91.82	5.48	2.70	97.30			50.46	41.36
25/6/48-50	233.88	8260.32	8.2603	93.41	4.27	2.32	97.68			48.63	44.78
25/6/75-77	234.15	8269.36	8.2694	89.88	6.35	3.77	96.23	0.08		48.75	41.13
25/6/93-95	234.33	8275.39	8.2754	90.54	6.07	3.39	96.61			48.30	42.24
25/6/112-114	234.52	8281.75	8.2818	92.11	5.14	2.74	97.26			48.58	43.53
25/6/133-135	234.73	8288.79	8.2888	92.50	5.07	2.43	97.57			47.82	44.68
25/7/1-3	234.91	8294.82	8.2948	91.73	5.49	2.78	97.22			48.76	42.97
25/7/17-19	235.07	8300.18	8.3002	90.97	5.72	3.31	96.69	0.00		46.40	44.57
25 CC/10-22	235.26	8306.54	8.3065	90.41	6.34	3.25	96.75	0.51		46.30	44.11
26/1/1-3	235.51	8314.92	8.3149	94.76	3.76	1.48	98.52			51.69	43.07
26/1/23-25	235.73	8322.28	8.3223	95.09	3.48	1.43	98.57			50.61	44.48
26/1/41-43	235.91	8328.31	8.3283	95.44	2.94	1.62	98.38			48.11	47.33
26/1/58-60	236.08	8334.01	8.3340	95.54	2.89	1.57	98.43	0.00		51.83	43.71
26/1/82-84	236.32	8342.05	8.3420	94.33	3.56	2.12	97.88	2.56		48.83	45.50
26/1/102-104	236.52	8348.75	8.3487	94.19	3.71	2.10	97.90	0.46		49.31	44.88
26/1/117-119	236.67	8353.77	8.3538	93.67	4.05	2.29	97.71	2.31		49.86	43.81
26/1/142-144	236.92	8362.15	8.3621	93.23	4.62	2.14	97.86	0.00		49.08	44.15
26/2/13-15	237.13	8369.18	8.3692	93.22	4.61	2.17	97.83	0.19		48.36	44.86
26/2/32-34	237.32	8375.54	8.3755	94.84	3.65	1.51	98.49	0.00		50.17	44.67
26/2/56-58	237.56	8383.58	8.3836	94.01	4.19	1.79	98.21	0.78		49.50	44.51
26/2/93-95	237.93	8395.98	8.3960	93.20	4.83	1.97	98.03			48.84	44.36
26/2/112-114	238.12	8402.34	8.4023	90.57	6.51	2.92	97.08	0.25		46.96	43.61
26/2/133-135	238.33	8409.38	8.4094	90.75	6.34	2.91	97.09			49.30	41.45
26/3/1-3	238.51	8415.41	8.4154	92.75	5.42	1.83	98.17	1.11		48.20	44.55
26/3/22-24	238.72	8422.44	8.4224	91.27	6.07	2.66	97.34			49.86	41.41
26/3/43-45	238.93	8429.47	8.4295	91.15	5.89	2.96	97.04			48.90	42.25
26/3/56-58	239.06	8433.83	8.4338	89.79	6.37	3.84	96.16	0.27		48.60	41.19
26/3/82-84	239.32	8442.54	8.4425	91.72	5.76	2.52	97.48			51.03	40.69
26/3/102-104	239.52	8449.24	8.4492	89.82	6.25	3.93	96.07	0.00		49.57	40.25
26/3/117-119	239.67	8454.26	8.4543	90.21	6.09	3.70	96.30			50.11	40.10
26/3/133-135	239.83	8459.62	8.4596	87.52	8.58	3.90	96.10	0.00		47.95	39.57
26/4/7-9	240.07	8467.66	8.4677	85.08	10.08	4.83	95.17	0.00		48.12	36.96
26/4/32-34	240.32	8476.04	8.4760	88.18	7.56	4.26	95.74			53.43	34.75
26/4/52-54	240.52	8482.73	8.4827	95.27	3.01	1.72	98.28			56.37	38.90
26/4/72-74	240.72	8489.43	8.4894	93.63	4.15	2.21	97.79			53.33	40.30
26/4/92-94	240.92	8496.13	8.4961	88.43	6.76	4.81	95.19			51.91	36.52
26/4/112-114	241.12	8502.83	8.5028	90.23	6.36	3.41	96.59	0.00		52.38	37.85
26/4/132-134	241.32	8509.53	8.5095	92.46	5.01	2.53	97.47			52.07	40.39
26/5/0-2	241.50	8515.56	8.5156	87.87	7.56	4.56	95.44			51.05	36.82
26/5/15-17	241.65	8520.59	8.5206	91.58	6.12	2.30	97.70			52.02	39.56
26/5/42-44	241.92	8529.63	8.5296	90.22	6.75	3.03	96.97			50.73	39.49
26/5/63-65	242.13	8536.66	8.5367	92.98	5.21	1.80	98.20	0.20		51.98	41.00
26/5/82-84	242.32	8543.03	8.5430	93.53	4.74	1.73	98.27			54.02	39.51
26/5/102-104	242.52	8549.73	8.5497	95.94	3.04	1.02	98.98			52.88	43.06
26/5/117-119	242.67	8554.75	8.5548	94.22	4.79	0.99	99.01			50.02	44.20
26/5/142-144	242.92	8563.13	8.5631	91.69	5.76	2.55	97.45			49.87	41.82
26/6/7-9	243.07	8568.15	8.5682	92.53	4.99	2.47	97.53	0.00		47.28	45.25
26/6/26-28	243.26	8574.52	8.5745	85.63	8.29	6.08	93.92			50.40	35.23
26/6/47-49	243.47	8581.55	8.5816	91.43	5.13	3.44	96.56			44.07	47.36
26/6/63-65	243.63	8586.91	8.5869	92.50	4.19	3.31	96.69			40.83	51.67
26 CC/13-15	243.86	8594.61	8.5946	89.95	6.22	3.83	96.17			43.94	46.01
27/1/1-3	245.11	8636.49	8.6365	91.40	5.07	3.53	96.47	2.70		44.09	47.31
27/1/25-27	245.35	8644.53	8.6445	92.89	4.85	2.26	97.74			44.80	48.09
27/1/43-45	245.53	8650.55	8.6506	92.63	4.96	2.41	97.59			44.92	47.71

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
27/1/65-67	245.75	8657.92	8.6579	94.86	3.54	1.60	98.40			40.42	54.44
27/1/81-83	245.91	8663.28	8.6633	94.84	3.58	1.59	98.41			41.31	53.53
27/1/96-98	246.06	8668.31	8.6683	95.05	3.30	1.65	98.35	0.15		39.31	55.74
27/1/117-119	246.27	8675.34	8.6753	94.68	3.69	1.63	98.37			41.01	53.67
27/1/142-144	246.52	8683.72	8.6837	94.99	3.68	1.33	98.67			40.33	54.66
27/2/5-7	246.65	8688.07	8.6881	94.10	4.11	1.79	98.21			40.96	53.14
27/2/27-29	246.87	8695.44	8.6954	94.52	3.87	1.61	98.39			39.47	55.05
27/2/53-55	247.13	8704.15	8.7041	89.61	6.85	3.54	96.46	0.08		42.78	46.83
27/2/73-76	247.33	8710.85	8.7108	86.92	8.42	4.66	95.34			46.24	40.68
27/2/93-95	247.53	8717.55	8.7175	85.02	8.88	6.10	93.90			45.42	39.60
27/2/107-109	247.67	8722.24	8.7222	88.33	7.62	4.05	95.95			46.73	41.60
27/2/132-134	247.92	8730.61	8.7306	90.44	6.51	3.05	96.95			45.75	44.69
27/3/1-3	248.11	8736.98	8.7370	85.50	9.17	5.33	94.67	0.13		45.23	40.27
27/3/16-18	248.26	8742.00	8.7420	85.64	9.04	5.32	94.68			45.73	39.91
27/3/37-39	248.47	8749.04	8.7490	87.00	8.61	4.39	95.61			47.14	39.86
27/3/56-58	248.66	8755.40	8.7554	89.54	7.36	3.10	96.90			48.72	40.82
27/3/83-85	248.93	8764.44	8.7644	89.85	6.70	3.46	96.54			46.08	43.77
27/3/104-106	249.14	8771.48	8.7715	89.28	6.71	4.01	95.99	0.04		44.10	45.18
27/3/117-119	249.27	8775.83	8.7758	90.51	6.40	3.09	96.91			43.50	47.01
27/7/142-144	249.52	8784.21	8.7842	90.35	6.02	3.62	96.38			44.08	46.27
27/4/7-9	249.67	8789.23	8.7892	90.51	6.42	3.07	96.93			42.78	47.73
27/4/32-34	249.92	8797.61	8.7976	94.27	4.23	1.50	98.50			40.85	53.42
27/4/52-54	250.12	8804.31	8.8043	94.44	3.86	1.70	98.30	0.00		42.91	51.53
27/4/67-69	250.27	8809.33	8.8093	93.81	4.11	2.08	97.92			45.90	47.91
27/4/86-88	250.46	8815.69	8.8157	95.51	3.23	1.27	98.73			41.40	54.11
27/4/112-114	250.72	8824.40	8.8244	95.03	3.28	1.68	98.32			44.45	50.58
27/4/132-134	250.92	8831.10	8.8311	94.58	3.40	2.02	97.98			44.95	49.63
27/5/0-2	251.10	8837.13	8.8371	94.03	3.91	2.05	97.95	0.00		44.05	49.98
27/5/23-26	251.33	8844.84	8.8448	91.21	5.25	3.54	96.46			43.24	47.97
27/5/38-40	251.48	8849.86	8.8499	91.99	4.64	3.38	96.62			44.39	47.60
27/5/57-59	251.67	8856.23	8.8562	93.48	4.29	2.23	97.77			42.64	50.84
27/5/83-85	251.93	8864.93	8.8649	93.41	4.51	2.08	97.92			43.48	49.93
27/5/103-105	252.13	8871.63	8.8716	92.90	4.38	2.72	97.28			43.43	49.47
27/5/118-120	252.28	8876.66	8.8767	93.41	4.36	2.23	97.77			42.31	51.10
27/5/143-145	252.53	8885.03	8.8850	93.27	4.39	2.35	97.65			43.38	49.89
27/6/7-9	252.67	8889.72	8.8897	91.95	4.93	3.11	96.89			43.69	48.26
27/6/32-34	252.92	8898.10	8.8981	92.31	4.88	2.81	97.19			45.12	47.19
27/6/53-55	253.13	8905.13	8.9051	93.36	4.44	2.20	97.80	0.00		46.21	47.15
27/6/73-75	253.33	8911.83	8.9118	93.20	4.50	2.30	97.70			46.85	46.35
27/6/87-89	253.47	8916.52	8.9165	92.37	4.59	3.04	96.96			45.68	46.69
27/6/107-109	253.67	8923.22	8.9232	90.75	5.32	3.93	96.07			45.54	45.21
27/6/132-134	253.92	8931.59	8.9316	94.44	3.62	1.94	98.06			47.57	46.87
27/7/0-2	254.10	8937.62	8.9376	91.84	4.97	3.19	96.81			48.92	42.92
27/7/17-19	254.27	8943.32	8.9433	92.16	4.95	2.89	97.11			49.59	42.57
27 CC/10-12	254.49	8953.25	8.9533	91.68	5.57	2.75	97.25			49.12	42.56
28/1/4-6	254.74	8967.46	8.9675	94.08	3.96	1.97	98.03			48.81	45.27
28/1/23-25	254.93	8978.26	8.9783	95.09	3.25	1.66	98.34			52.83	42.26
28/1/42-44	255.12	8989.06	8.9891	94.66	3.48	1.86	98.14	0.00		49.05	45.61
28/1/58-60	255.28	8998.16	8.9982	94.75	3.42	1.83	98.17			49.36	45.39
28/1/83-85	255.53	9012.37	9.0124	95.00	3.39	1.61	98.39			49.90	45.10
28/1/103-105	255.73	9023.74	9.0237	94.39	3.57	2.04	97.96			49.29	45.10
28/1/121-123	255.91	9033.97	9.0340	95.20	3.22	1.58	98.42			51.31	43.89
28/1/141-143	256.11	9045.34	9.0453	95.39	3.12	1.48	98.52			50.24	45.15
28/2/7-9	256.27	9054.43	9.0544	96.32	2.41	1.27	98.73			51.37	44.95
28/2/33-35	256.53	9069.21	9.0692	94.82	3.49	1.70	98.30			51.85	42.97
28/2/54-56	256.74	9081.15	9.0811	95.38	3.04	1.58	98.42			53.06	42.32
28/2/83-85	257.03	9097.63	9.0976	95.24	2.80	1.96	98.04	0.00		53.21	42.03
28/2/98-100	257.18	9106.16	9.1062	95.86	2.73	1.41	98.59			52.69	43.17
28/2/113-115	257.33	9114.68	9.1147	94.06	3.72	2.22	97.78			52.56	41.50
28/2/133-135	257.53	9126.05	9.1261	94.00	3.66	2.33	97.67			51.41	42.59
28/3/1-3	257.71	9136.28	9.1363	93.48	3.94	2.57	97.43			50.38	43.10
28/3/25-27	257.95	9149.92	9.1499	93.30	4.34	2.36	97.64			51.74	41.56

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
28/3/42-44	258.12	9159.59	9.1596	94.26	3.68	2.06	97.94	0.36		53.29	40.97
28/3/55-57	258.25	9166.98	9.1670	96.07	2.86	1.07	98.93			54.35	41.72
28/3/84-86	258.54	9183.46	9.1835	95.69	2.87	1.44	98.56			52.41	43.28
28/3/118-120	258.88	9202.79	9.2028	95.92	2.86	1.23	98.77			54.08	41.84
28/3/137-139	259.07	9213.59	9.2136	95.99	2.85	1.16	98.84	0.00		53.79	42.20
28/4/6-8	259.26	9224.39	9.2244	94.64	3.55	1.81	98.19	1.41		53.46	41.18
28/4/33-35	259.53	9239.73	9.2397	94.44	3.76	1.80	98.20			52.65	41.79
28/4/47-49	259.67	9247.69	9.2477	93.04	4.30	2.65	97.35			51.83	41.21
28/4/66-68	259.86	9258.49	9.2585	94.51	3.63	1.86	98.14			50.73	43.78
28/4/93-95	260.13	9273.84	9.2738	92.82	4.46	2.72	97.28			51.12	41.70
28/4/108-110	260.28	9282.36	9.2824	93.95	4.03	2.02	97.98	0.00		51.15	42.80
28/4/134-136	260.54	9297.14	9.2971	95.26	2.83	1.91	98.09			51.21	44.05
28/5/1-3	260.71	9306.81	9.3068	96.03	2.46	1.51	98.49			55.97	40.06
28/5/16-18	260.86	9315.33	9.3153	95.91	2.67	1.42	98.58			52.30	43.61
28/5/42-44	261.12	9330.11	9.3301	95.96	2.56	1.48	98.52	0.17		52.45	43.51
28/5/61-63	261.31	9340.91	9.3409	95.31	2.98	1.72	98.28			54.48	40.83
28/5/85-87	261.55	9354.55	9.3546	90.37	6.02	3.61	96.39			49.17	41.20
28/5/102-104	261.72	9364.22	9.3642	92.02	5.07	2.91	97.09			53.09	38.93
28/5/121-123	261.91	9375.02	9.3750	91.07	5.83	3.10	96.90			53.04	38.03
28/5/141-143	262.11	9386.38	9.3864	91.67	5.26	3.06	96.94	0.00		52.45	39.22
28/6/8-10	262.28	9396.05	9.3960	94.06	3.77	2.17	97.83			52.75	41.31
28 CC/8-10	262.45	9405.71	9.4057	92.56	4.68	2.76	97.24			50.46	42.10
29/1/0-2	264.30	9510.87	9.5109	91.34	5.44	3.22	96.78	0.00		48.80	42.54
29/1/34-36	264.64	9530.19	9.5302	92.20	4.83	2.97	97.03			51.21	40.99
29/1/58-60	264.88	9543.83	9.5438	92.00	5.06	2.94	97.06			51.38	40.62
29/1/80-82	265.10	9556.34	9.5563	88.12	7.39	4.49	95.51	0.00		48.21	39.91
29/1/96-98	265.26	9565.43	9.5654	89.25	6.88	3.87	96.13			49.32	39.93
29/1/117-119	265.47	9577.37	9.5774	89.64	6.30	4.07	95.93			49.76	39.88
29/1/142-144	265.72	9591.58	9.5916	91.56	5.09	3.35	96.65			49.50	42.06
29/2/12-14	265.92	9602.95	9.6029	90.73	5.71	3.56	96.44			48.95	41.78
29/2/32-34	266.12	9614.32	9.6143	92.37	5.03	2.60	97.40	0.00		49.46	42.91
29/2/46-48	266.26	9622.28	9.6223	95.17	3.42	1.41	98.59			49.40	45.77
29/2/64-66	266.44	9632.51	9.6325	93.96	4.21	1.83	98.17			51.68	42.28
29/2/85-87	266.65	9644.44	9.6444	94.30	3.76	1.93	98.07			52.06	42.24
29/2/107-109	266.87	9656.95	9.6569	94.94	3.22	1.84	98.16			51.36	43.58
29/2/133-135	267.13	9671.73	9.6717	96.29	2.54	1.17	98.83	0.42		54.18	42.11
29/3/1- 3	267.31	9681.96	9.6820	96.22	2.62	1.15	98.85			52.41	43.81
29/3/23-25	267.53	9694.46	9.6945	96.52	2.41	1.07	98.93			53.01	43.51
29/3/42-44	267.72	9705.26	9.7053	96.46	2.42	1.12	98.88	0.00		61.18	35.28
29/3/57-59	267.87	9713.79	9.7138	96.03	2.92	1.05	98.95			51.46	44.57
29/3/84-86	268.14	9729.14	9.7291	94.28	4.04	1.68	98.32	0.00		52.32	41.96
29/3/104-106	268.34	9740.51	9.7405	93.93	3.96	2.12	97.88	0.00		51.04	42.89
29/3/117-119	268.47	9747.90	9.7479	95.34	3.15	1.50	98.50			52.47	42.87
29/3/138-140	268.68	9759.83	9.7598	95.83	2.85	1.31	98.69			49.67	46.16
29/4/6- 8	268.86	9770.06	9.7701	93.83	3.85	2.32	97.68			50.59	43.24
29/4/48-50	269.28	9788.48	9.7885	93.93	3.96	2.11	97.89	0.00		50.50	43.43
29/4/72-74	269.52	9795.89	9.7959	95.27	3.29	1.44	98.56			48.20	47.07
29/4/95-97	269.75	9802.98	9.8030	94.86	3.50	1.64	98.36	0.00		49.83	45.03
29/4/107-109	269.87	9806.69	9.8067	94.82	3.24	1.94	98.06			48.86	45.96
29/4/135-137	270.15	9815.33	9.8153	95.25	3.19	1.57	98.43	0.00		49.52	45.73
29/5/1- 3	270.31	9820.26	9.8203	94.66	3.48	1.86	98.14			48.81	45.85
29/5/15-17	270.45	9824.58	9.8246	92.65	4.47	2.88	97.12			50.46	42.19
29/5/42-44	270.72	9832.91	9.8329	95.32	3.27	1.40	98.60	2.62		51.40	43.92
29/5/61-63	270.91	9838.38	9.8384	91.43	5.70	2.86	97.14	0.00		54.47	36.96
29/5/85-87	271.15	9844.74	9.8447	97.06	2.19	0.75	99.25	1.48		55.16	41.90
29/5/104-106	271.34	9849.78	9.8498	96.70	2.54	0.76	99.24	0.00		57.12	39.58
29/5/118-120	271.48	9853.49	9.8535	93.24	5.48	1.28	98.72	2.18		57.23	36.01
29/5/142-144	271.72	9859.85	9.8598	94.45	3.42	2.13	97.87		21.25	46.05	48.40
29/6/14-16	271.94	9865.68	9.8657	92.21	5.56	2.23	97.77		1.69	50.28	41.93
29 CC/17-19	272.19	9872.30	9.8723	94.91	3.39	1.70	98.30	0.00		49.83	45.08
30/1/1- 3	273.91	9917.88	9.9179	94.29	4.02	1.69	98.31	0.00	0.46	45.51	48.78
30/1/14-16	274.04	9921.32	9.9213	95.00	3.59	1.40	98.60	0.00		49.13	45.87

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
30/1/42-44	274.32	9928.74	9.9287	96.58	2.54	0.89	99.11			49.03	47.55
30/1/58-60	274.48	9932.98	9.9330	95.53	3.22	1.25	98.75	0.00		51.04	44.49
30/1/82-84	274.72	9939.34	9.9393	96.56	2.48	0.95	99.05			48.44	48.12
30/1/103-105	274.93	9944.91	9.9449	96.52	2.53	0.95	99.05			50.51	46.01
30/1/122-124	275.12	9949.94	9.9499	95.90	2.61	1.49	98.51	0.00		48.12	47.78
30/1/141-143	275.31	9954.98	9.9550	93.39	3.80	2.81	97.19			48.39	45.00
30/2/5- 7	275.45	9958.69	9.9587	93.79	3.64	2.58	97.42			48.61	45.18
30/2/32-34	275.72	9965.84	9.9658	94.64	3.47	1.89	98.11			50.10	44.54
30/2/53-55	275.93	9971.41	9.9714	93.78	3.82	2.41	97.59			51.77	42.01
30/2/92-94	276.32	9981.74	9.9817	93.65	4.22	2.13	97.87	0.00		50.63	43.02
30/2/112-114	276.52	9987.04	9.9870	95.78	3.11	1.10	98.90			51.28	44.50
30/2/133-135	276.73	9992.60	9.9926	94.46	3.93	1.61	98.39			49.57	44.89
30/3/1- 3	276.91	9997.37	9.9974	94.47	3.86	1.67	98.33			51.51	42.96
30/3/15-17	277.05	10001.08	10.0011	95.93	3.24	0.83	99.17	0.00		52.12	43.81
30/3/43-45	277.33	10008.50	10.0085	94.06	4.06	1.89	98.11			51.71	42.35
30/3/65-67	277.55	10014.33	10.0143	94.90	3.52	1.58	98.42			51.97	42.93
30/3/84-86	277.74	10019.37	10.0194	95.02	3.30	1.68	98.32			51.74	43.28
30/3/103-105	277.93	10024.40	10.0244	93.85	4.10	2.06	97.94			50.54	43.31
30/3/117-119	278.07	10028.11	10.0281	93.99	4.01	2.00	98.00	0.22		50.14	43.85
30/3/138-140	278.28	10033.68	10.0337	94.62	3.63	1.75	98.25			50.80	43.82
30/4/9- 11	278.49	10039.24	10.0392	94.47	3.71	1.82	98.18			53.82	40.65
30/4/32-34	278.72	10045.34	10.0453	95.77	2.76	1.47	98.53			51.01	44.76
30/4/48-50	278.88	10049.58	10.0496	95.19	3.33	1.48	98.52			49.82	45.37
30/4/73-75	279.13	10056.20	10.0562	95.20	3.26	1.54	98.46	0.00		49.65	45.55
30/4/93-95	279.33	10061.50	10.0615	95.41	3.12	1.47	98.53			48.84	46.57
30/4/113-115	279.53	10066.80	10.0668	92.26	4.55	3.19	96.81			49.12	43.14
30/4/135-137	279.75	10072.63	10.0726	95.74	3.02	1.24	98.76			47.22	48.52
30/5/6- 8	279.96	10078.19	10.0782	95.57	3.07	1.36	98.64			47.96	47.61
30/5/15-17	280.05	10080.58	10.0806	95.58	3.31	1.11	98.89	0.00		46.59	48.99
30/5/35-37	280.25	10085.88	10.0859	95.77	3.01	1.22	98.78			48.69	47.08
30/5/84-86	280.74	10098.86	10.0989	95.27	3.21	1.51	98.49			47.61	47.66
30/5/102-104	280.92	10103.63	10.1036	96.33	2.49	1.18	98.82			51.13	45.20
31/1/1- 3	283.51	10172.26	10.1723	94.64	3.40	1.96	98.04	2.40		43.94	50.70
31/1/17-19	283.67	10176.50	10.1765	93.48	4.25	2.27	97.73			49.01	44.47
31/1/44-46	283.94	10183.66	10.1837	93.54	4.30	2.16	97.84			48.15	45.39
31/1/58-60	284.08	10187.37	10.1874	94.80	3.57	1.63	98.37			49.49	45.31
31/1/83-85	284.33	10193.99	10.1940	94.78	3.59	1.63	98.37			51.01	43.77
31/1/105-107	284.55	10199.82	10.1998	94.46	3.66	1.88	98.12			48.48	45.98
31/1/118-120	284.68	10203.27	10.2033	93.65	4.20	2.14	97.86			47.49	46.16
31/1/138-140	284.88	10208.56	10.2086	94.91	3.49	1.60	98.40			48.48	46.43
31/2/9- 11	285.09	10214.13	10.2141	94.41	3.62	1.97	98.03	0.95		50.01	44.40
31/2/29-31	285.29	10219.43	10.2194	94.45	3.70	1.85	98.15			48.87	45.58
31/2/48-50	285.48	10224.46	10.2245	93.49	4.29	2.22	97.78			49.31	44.18
31/2/73-75	285.73	10231.09	10.2311	93.11	4.48	2.41	97.59			51.57	41.54
31/2/88-90	285.88	10235.06	10.2351	93.25	4.20	2.55	97.45			52.20	41.05
31/2/110-112	286.10	10240.89	10.2409	94.96	3.43	1.60	98.40	0.00		51.17	43.79
31/2/134-136	286.34	10247.25	10.2473	94.81	3.50	1.69	98.31			48.99	45.82
31/3/1- 3	286.51	10251.76	10.2518	95.03	3.22	1.75	98.25			50.95	44.08
31/3/23-25	286.73	10257.59	10.2576	95.06	3.14	1.80	98.20			49.21	45.85
31/3/38-40	286.88	10261.56	10.2616	93.65	3.92	2.43	97.57			49.38	44.27
31/3/57-59	287.04	10265.80	10.2658	95.69	3.11	1.20	98.80	0.00		50.30	45.39
31/3/82-84	287.32	10273.22	10.2732	95.40	3.11	1.49	98.51			49.61	45.79
31/3/102-104	287.52	10278.52	10.2785	95.25	3.00	1.75	98.25			48.46	46.79
31/3/117-119	287.67	10282.49	10.2825	96.32	2.42	1.26	98.74			50.77	45.55
31/3/141-143	287.91	10288.85	10.2889	94.29	3.52	2.20	97.80			52.18	42.11
31/4/8- 10	288.08	10293.36	10.2934	95.83	2.82	1.34	98.66			53.04	42.79
31/4/30-32	288.30	10299.19	10.2992	96.74	2.09	1.18	98.82			53.70	43.04
31/4/55-57	288.55	10305.81	10.3058	95.86	2.87	1.27	98.73			51.78	44.08
31/4/70-72	288.70	10309.79	10.3098	95.83	2.96	1.22	98.78			56.00	39.83
31/4/89-91	288.89	10314.82	10.3148	96.80	2.21	0.98	99.02			55.81	40.99
31/4/110-112	289.10	10320.39	10.3204	95.72	2.88	1.41	98.59	0.00		55.31	40.41
31/4/134-136	289.34	10326.75	10.3267	96.82	2.22	0.96	99.04			55.24	41.58

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
31/5/0-2	289.50	10330.99	10.3310	95.37	3.15	1.48	98.52			52.71	42.66
31/5/23-25	289.73	10337.08	10.3371	96.21	2.71	1.08	98.92			51.74	44.47
31/5/43-45	289.93	10342.38	10.3424	96.30	2.75	0.95	99.05			50.50	45.80
31/5/62-64	290.12	10347.42	10.3474	94.88	3.36	1.76	98.24	0.33		50.65	44.23
31/5/83-85	290.33	10352.98	10.3530	96.45	2.54	1.01	98.99			50.68	45.77
31/5/101-103	290.51	10357.75	10.3577	95.14	3.05	1.80	98.20			50.90	44.24
31/5/120-122	290.70	10362.78	10.3628	96.84	2.33	0.83	99.17			49.76	47.08
31 CC/0-2	290.74	10363.84	10.3638	95.51	2.94	1.54	98.46			51.76	43.75
32/1/1- 3	293.11	10426.64	10.4266	95.89	2.83	1.28	98.72	1.13		45.33	50.56
32/1/23-25	293.33	10432.47	10.4325	96.20	2.58	1.22	98.78			53.11	43.09
32/1/41-43	293.51	10437.24	10.4372	97.00	1.96	1.04	98.96			51.96	45.04
32/1/61-63	293.71	10442.54	10.4425	96.85	2.24	0.91	99.09			52.39	44.46
32/1/83-85	293.93	10448.37	10.4484	97.15	1.92	0.94	99.06			52.68	44.47
32/1/102-104	294.12	10453.41	10.4534	96.29	2.54	1.17	98.83	0.00		51.87	44.42
32/1/121-123	294.31	10458.44	10.4584	96.23	2.58	1.19	98.81			50.25	45.98
32/1/141-143	294.51	10463.74	10.4637	96.34	2.57	1.08	98.92			48.27	48.07
32/2/11- 13	294.71	10469.04	10.4690	97.21	1.91	0.87	99.13			51.36	45.85
32/2/30-32	294.90	10474.08	10.4741	98.19	1.18	0.63	99.37			51.37	46.82
32/2/52-54	295.12	10479.91	10.4799	97.59	1.60	0.81	99.19	0.00		48.43	49.16
32/2/73-75	295.33	10485.47	10.4855	96.89	2.19	0.92	99.08			48.93	47.96
32/2/93-95	295.53	10490.77	10.4908	96.14	2.36	1.50	98.50			49.59	46.55
32/2/113-115	295.73	10496.07	10.4961	97.32	1.92	0.75	99.25			50.94	46.38
32/2/133-135	295.93	10501.37	10.5014	93.74	2.85	3.41	96.59			49.48	44.26
32/3/1- 3	296.11	10506.14	10.5061	97.00	2.17	0.83	99.17	0.00		53.25	43.75
32/3/40-42	296.50	10516.47	10.5165	94.37	3.46	2.17	97.83			50.05	44.32
32/3/62-64	296.72	10522.30	10.5223	96.48	2.63	0.89	99.11			47.64	48.84
32/3/83-85	296.93	10527.87	10.5279	95.43	3.17	1.39	98.61			47.52	47.91
32/3/102-104	297.12	10532.90	10.5329	93.66	3.85	2.48	97.52			51.78	41.88
32/3/123-125	297.33	10538.47	10.5385	94.69	3.75	1.56	98.44			53.43	41.26
32/3/140-142	297.50	10542.97	10.5430	95.53	3.07	1.40	98.60			51.68	43.85
32/4/10- 12	297.70	10548.27	10.5483	96.15	2.56	1.29	98.71	2.12		54.13	42.02
32/4/30-32	297.90	10553.57	10.5536	96.28	2.54	1.18	98.82			53.35	42.93
32/4/48-50	298.08	10558.34	10.5583	96.98	2.12	0.91	99.09	0.00		51.55	45.43
32/4/68-70	298.28	10563.64	10.5636	96.25	2.64	1.11	98.89			53.58	42.67
32/4/92-94	298.52	10570.00	10.5700	95.11	3.07	1.83	98.17			53.16	41.95
32/4/110-112	298.70	10574.77	10.5748	96.43	2.48	1.09	98.91			52.90	43.53
32/4/133-135	298.93	10580.86	10.5809	96.23	2.38	1.39	98.61	0.00		51.48	44.75
32/5/1- 3	299.11	10585.63	10.5856	95.86	2.87	1.27	98.73			51.96	43.90
32/5/28-30	299.38	10592.79	10.5928	95.12	3.24	1.64	98.36			52.87	42.25
32/5/40-42	299.50	10595.97	10.5960	95.55	3.18	1.27	98.73			48.77	46.78
32 CC/2- 4	299.67	10600.47	10.6005	96.37	2.66	0.97	99.03			47.74	48.63
33/1/1- 3	302.71	10681.03	10.6810	96.19	2.55	1.26	98.74	0.00		46.17	50.02
33/1/27-29	302.97	10687.92	10.6879	97.05	2.28	0.67	99.33			52.60	44.45
33/1/40-42	303.10	10691.36	10.6914	97.30	2.11	0.59	99.41	1.36		51.92	45.38
33/1/59-61	303.29	10696.40	10.6964	97.47	2.05	0.48	99.52			52.77	44.70
33/1/83-85	303.53	10702.76	10.7028	97.53	1.91	0.56	99.44			52.03	45.50
33/1/107-109	303.77	10709.12	10.7091	97.27	2.02	0.71	99.29			50.94	46.33
33/1/121-123	303.91	10712.83	10.7128	97.79	1.76	0.45	99.55			51.01	46.78
33/1/143-145	304.13	10718.66	10.7187	97.34	2.06	0.60	99.40	0.00		53.48	43.86
33/2/9- 11	304.29	10722.89	10.7229	97.26	2.13	0.61	99.39			50.71	46.55
33/2/27-29	304.47	10727.66	10.7277	96.76	2.51	0.73	99.27			52.00	44.76
33/2/46-48	304.66	10732.70	10.7327	96.49	2.68	0.83	99.17			51.57	44.92
33/2/82-84	305.02	10742.24	10.7422	96.89	2.34	0.77	99.23	0.00		49.83	47.06
33/2/95-97	305.15	10745.68	10.7457	96.90	2.37	0.74	99.26			48.81	48.09
33/2/114-116	305.34	10750.72	10.7507	95.42	3.14	1.44	98.56			49.55	45.87
33/2/135-137	305.55	10756.28	10.7563	97.49	1.92	0.60	99.40			49.56	47.93
33/3/1- 3	305.71	10760.52	10.7605	96.73	2.16	1.11	98.89			52.67	44.06
33/3/23-25	305.93	10766.35	10.7664	97.08	2.10	0.82	99.18		0.00	50.04	47.04
33/3/41-43	306.11	10771.12	10.7711	96.68	2.51	0.81	99.19	0.00		50.10	46.58
33/3/57-59	306.27	10775.36	10.7754	96.79	2.25	0.96	99.04	0.00		50.37	46.42
33/3/84-86	306.54	10782.52	10.7825	97.47	1.81	0.72	99.28			50.57	46.90
33/3/105-107	306.75	10788.08	10.7881	97.76	1.65	0.59	99.41			50.44	47.32

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
33/3/116-118	306.86	10791.00	10.7910	97.49	1.84	0.66	99.34			52.66	44.83
33/3/138-140	307.08	10796.82	10.7968	97.68	1.65	0.67	99.33			51.14	46.54
33/4/10- 12	307.30	10802.65	10.8027	97.16	1.92	0.92	99.08			51.09	46.07
33/4/29-31	307.49	10807.69	10.8077	97.32	1.98	0.70	99.30			52.61	44.71
33/4/50-52	307.70	10813.25	10.8133	96.95	2.22	0.83	99.17			52.46	44.49
33/4/73-75	307.93	10819.35	10.8193	96.36	2.45	1.19	98.81			51.28	45.08
33/4/94-96	308.14	10824.91	10.8249	97.19	2.08	0.73	99.27	0.77		51.38	45.81
33/4/110-112	308.30	10829.15	10.8292	96.58	2.59	0.83	99.17			51.43	45.15
33/4/133/135	308.53	10835.25	10.8352	96.54	2.52	0.93	99.07			49.89	46.65
33/5/1- 3	308.71	10840.02	10.8400	95.73	2.97	1.30	98.70			50.62	45.11
33/5/29-31	308.99	10847.44	10.8474	96.43	2.61	0.95	99.05			52.52	43.91
33/5/41-43	309.11	10851.59	10.8516	96.10	2.63	1.27	98.73	0.00		49.91	46.19
33/5/58-60	309.28	10854.26	10.8543	96.49	2.28	1.23	98.77			50.01	46.48
33/5/84-86	309.54	10858.34	10.8583	96.24	2.69	1.07	98.93			48.90	47.34
33/5/104-106	309.74	10861.48	10.8615	95.63	3.06	1.31	98.69			51.88	43.75
34/1/1- 3	312.31	10901.83	10.9018	96.68	2.29	1.03	98.97	0.31		48.91	47.77
34/1/24-26	312.54	10905.45	10.9054	96.90	2.13	0.97	99.03			55.13	41.77
34/1/37-39	312.67	10907.49	10.9075	96.63	2.33	1.04	98.96			55.34	41.29
34/1/57-59	312.87	10910.63	10.9106	96.61	2.50	0.89	99.11			55.10	41.51
34/1/77-79	313.07	10913.77	10.9138	96.71	2.48	0.81	99.19	0.00		55.07	41.64
34/1/101-103	313.31	10917.54	10.9175	95.30	2.82	1.88	98.12	18.08		54.27	41.03
34/1/123-125	313.53	10920.99	10.9210	96.07	2.69	1.24	98.76	7.17		58.14	37.93
34/1/141-143	313.71	10923.82	10.9238	96.11	2.63	1.26	98.74			54.10	42.01
34/2/10- 12	313.90	10926.80	10.9268	96.57	2.38	1.05	98.95			53.75	42.82
34/2/29-31	314.09	10929.79	10.9298	96.85	2.17	0.98	99.02	0.84		53.85	43.00
34/2/49-51	314.29	10932.93	10.9329	95.48	3.28	1.25	98.75			53.75	41.73
34/2/65-67	314.45	10935.44	10.9354	95.64	2.93	1.43	98.57			53.37	42.27
34/2/89-91	314.69	10939.21	10.9392	96.96	1.90	1.13	98.87			54.30	42.66
34/2/110-112	314.90	10942.50	10.9425	96.01	2.67	1.32	98.68			54.32	41.69
34/2/133-135	315.13	10946.12	10.9461	96.31	2.69	1.00	99.00			51.67	44.64
34/3/0- 2	315.30	10949.64	10.9496	95.67	2.86	1.48	98.52			51.64	44.03
34/3/22-24	315.52	10956.88	10.9569	96.57	2.38	1.05	98.95			51.96	44.61
34/3/41-43	315.71	10963.13	10.9631	95.63	3.01	1.36	98.64			51.22	44.41
34/3/76-78	316.06	10974.64	10.9746	96.99	2.15	0.87	99.13			54.03	42.96
34/3/97-99	316.27	10981.54	10.9815	97.71	1.69	0.60	99.40			52.24	45.47
34/3/118-120	316.48	10988.45	10.9884	97.24	2.02	0.74	99.26			51.07	46.17
34/3/137-139	316.67	10994.69	10.9947	97.17	2.02	0.81	99.19			49.70	47.47
34/4/8- 10	316.88	11001.60	11.0016	98.07	1.45	0.47	99.53			55.53	42.54
34/4/30-32	317.10	11008.83	11.0088	97.02	2.18	0.80	99.20			54.60	42.42
34/4/50-52	317.30	11015.41	11.0154	97.19	2.19	0.62	99.38			51.96	45.23
34/4/70-72	317.50	11021.99	11.0220	95.91	2.91	1.18	98.82			53.47	42.44
34/4/88-90	317.68	11027.91	11.0279	97.93	1.53	0.54	99.46			53.30	44.63
34/4/110-112	317.90	11035.14	11.0351	97.07	2.00	0.93	99.07			52.44	44.63
34/4/133-135	318.13	11042.70	11.0427	98.29	1.29	0.41	99.59	14.94		50.07	48.22
34/5/5- 7	318.35	11049.94	11.0499	97.57	1.90	0.53	99.47			53.73	43.84
34/5/30-32	318.60	11058.16	11.0582	97.87	1.66	0.47	99.53			53.13	44.74
35/1/1- 3	321.91	11167.00	11.1670	96.75	2.09	1.15	98.85	35.69		48.08	48.67
35/1/23-25	322.13	11174.24	11.1742	96.17	2.49	1.34	98.66	0.00		56.11	40.06
35/1/43-45	322.33	11180.81	11.1808	96.39	2.48	1.13	98.87			55.32	41.07
35/1/64-66	322.54	11187.72	11.1877	97.27	2.02	0.71	99.29			55.51	41.76
35/1/82-84	322.72	11193.64	11.1936	97.07	2.17	0.77	99.23			54.49	42.58
35/1/100-102	322.90	11199.56	11.1996	96.57	2.48	0.94	99.06			53.78	42.79
35/1/119-121	323.09	11205.80	11.2058	96.30	2.62	1.08	98.92			52.69	43.61
35/1/141-143	323.31	11213.04	11.2130	97.26	2.06	0.69	99.31			55.28	41.98
35/2/8- 10	323.48	11218.63	11.2186	97.75	1.76	0.49	99.51			51.93	45.82
35/2/32-34	323.72	11226.52	11.2265	95.99	2.84	1.16	98.84			51.84	44.15
35/2/51-53	323.91	11232.77	11.2328	97.15	2.11	0.74	99.26			52.68	44.47
35/2/90-92	324.30	11245.59	11.2456	96.47	2.49	1.04	98.96	0.00		53.44	43.03
35/2/110-112	324.50	11252.17	11.2522	98.37	1.32	0.31	99.69			55.83	42.54
35/2/130-132	324.70	11258.75	11.2587	97.86	1.65	0.50	99.50			52.90	44.96
35/3/1- 3	324.91	11265.65	11.2657	98.24	1.30	0.46	99.54	4.77		53.64	44.60
35/3/22-24	325.12	11272.56	11.2726	97.85	1.46	0.69	99.31	14.88		54.51	43.34

DSDP Site 593 Sample No.	depth (mbsf)	Age (ka)	Age (Ma)	% mud	% f.ine sand	% coarse sand	% mud + f. sand	pyrite in csand wt %	Celestite wt %	%silt of total mud exclu <4 phi	% clay of total mud excl < 4 phi
35/3/43-45	325.33	11279.46	11.2795	98.31	1.24	0.46	99.54			52.34	45.97
35/3/67-69	325.57	11287.35	11.2874	98.38	1.29	0.33	99.67			52.00	46.38
35/3/81-83	325.71	11291.96	11.2920	97.36	2.02	0.62	99.38			51.09	46.27
35/3/104-106	325.94	11299.52	11.2995	98.63	1.09	0.27	99.73			53.87	44.76
35/3/117-119	326.07	11303.80	11.3038	98.43	1.31	0.26	99.74	2.13		51.56	46.87
35/3/138-140	326.28	11310.70	11.3107	97.19	2.18	0.63	99.37			55.82	41.37
35/4/10- 12	326.50	11317.93	11.3179	98.15	1.37	0.48	99.52			53.75	44.40
35/4/30-32	326.70	11324.51	11.3245	98.03	1.39	0.59	99.41			53.01	45.02
35/4/48-50	326.88	11330.43	11.3304	98.01	1.40	0.59	99.41			53.55	44.46
35/4/69-71	327.09	11337.34	11.3373	98.12	1.28	0.60	99.40	7.73		54.51	43.61
35/4/88-90	327.28	11343.58	11.3436	97.33	1.89	0.78	99.22			53.90	43.43
35/4/110-112	327.50	11350.82	11.3508	97.73	1.74	0.53	99.47			51.87	45.86
35/4/134-136	327.74	11358.71	11.3587	97.13	2.09	0.78	99.22	9.45		51.37	45.76
35/5/1- 3	327.91	11364.30	11.3643	95.12	3.23	1.65	98.35			48.26	46.86
35/5/16-18	328.06	11369.23	11.3692	97.46	1.83	0.71	99.29	0.47		48.37	49.09
35/5/37-39	328.27	11376.14	11.3761	96.73	2.47	0.80	99.20			47.40	49.33
35/5/57-59	328.47	11382.71	11.3827	96.00	2.65	1.35	98.65			46.79	49.21
35/5/82-84	328.72	11390.94	11.3909	96.72	2.09	1.19	98.81			49.21	47.51
36/1/19-21	331.69	11488.60	11.4886	90.53	2.78	6.69	93.31	65.48	18.08		
36/1/61-63	332.11	11502.41	11.5024	93.26	4.53	2.21	97.79				
36/1/118-120	332.68	11521.15	11.5212	97.71	1.59	0.70	99.30				
36/1/148-150	332.98	11531.02	11.5310	96.20	2.69	1.11	98.89				
36/2/40-42	333.40	11544.83	11.5448	95.28	3.30	1.42	98.58				
36/2/100-102	334.00	11564.56	11.5646	96.79	2.41	0.79	99.21				
36/2/136-138	334.36	11576.40	11.5764	95.75	2.96	1.29	98.71				
36/3/37-39	334.87	11593.17	11.5932	93.30	3.75	2.95	97.05				
36/3/97-99	335.47	11612.90	11.6129	95.74	3.02	1.24	98.76				
36/3/138-140	335.88	11626.38	11.6264	94.97	3.36	1.68	98.32				
36/4/20-22	336.20	11636.90	11.6369	94.90	3.35	1.76	98.24				
36/4/60-62	336.60	11650.05	11.6501	97.22	1.94	0.84	99.16				

Appendix B Table 6: Hole 593 sediment texture data (330-398 mbsf) (after Elkington, 2000a). (File on CD: App B Table 6).

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
36/1/19p	331.69	11.489	89.26	0.00	2.62	8.12	2.62	89.26	46.63	42.63
36/1/40	331.90	11.496	93.65	0.57	4.43	1.92	5.00	93.12	54.18	38.93
36/1/61p	332.11	11.502	93.26	0.84	4.15	2.59	4.99	92.48	52.26	40.22
36/1/80	332.30	11.509	93.34	0.50	4.23	2.43	4.73	92.87	52.02	40.86
36/1/101	332.51	11.516	95.65	0.46	2.92	1.43	3.38	95.22	52.61	42.60
36/1/118p	332.68	11.521	97.71	0.37	1.54	0.75	1.91	97.35	55.29	42.05
36/1/130	332.80	11.525	97.69	0.29	1.69	0.63	1.98	97.41	54.17	43.24
36/1/137	332.87	11.527	97.09	0.34	2.06	0.85	2.40	96.76	53.22	43.54
36/1/148p	332.98	11.531	96.20	0.37	2.56	1.24	2.93	95.84	50.97	44.87
36/2/18	333.18	11.538	94.02	0.53	4.06	1.93	4.59	93.52	51.32	42.20
36/2/40p	333.40	11.545	95.28	0.51	3.07	1.65	3.57	94.80	49.16	45.64
36/2/61	333.61	11.552	93.17	0.70	4.04	2.79	4.74	92.52	49.73	42.79
36/2/80	333.80	11.558	96.85	0.32	2.23	0.92	2.55	96.54	51.77	44.77
36/2/100p	334.00	11.565	96.79	0.34	2.26	0.95	2.60	96.47	50.16	46.31
36/2/118	334.18	11.570	94.75	0.47	3.48	1.77	3.95	94.31	54.50	39.81
36/2/130	334.30	11.574	93.68	1.04	4.16	2.16	5.20	92.71	51.72	40.99
36/2/136p	334.36	11.576	95.75	0.48	2.70	1.55	3.17	95.30	52.84	42.46
36/2/143	334.43	11.579	95.84	0.51	2.70	1.46	3.21	95.35	52.94	42.41
36/3/20	334.70	11.588	94.45	0.47	3.37	2.18	3.83	94.01	54.74	39.27
36/3/37p	334.87	11.593	93.30	0.54	3.42	3.27	3.96	92.80	53.79	39.01
36/3/61	335.11	11.601	96.48	0.56	2.25	1.27	2.81	95.94	53.76	42.18
36/3/80	335.30	11.607	95.39	0.46	3.14	1.47	3.60	94.95	54.18	40.77
36/3/97p	335.47	11.613	95.74	0.50	2.82	1.44	3.33	95.26	53.73	41.53
36/3/118	335.68	11.620	95.17	0.58	3.17	1.66	3.75	94.62	55.07	39.55

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
36/3/130	335.80	11.624	95.41	0.52	3.13	1.47	3.64	94.91	53.98	40.93
36/3/138p	335.88	11.626	94.97	0.54	3.22	1.82	3.76	94.45	54.74	39.71
36/3/148	335.98	11.630	94.74	0.54	3.08	2.18	3.62	94.23	55.77	38.46
36/4/20p	336.20	11.637	94.90	0.52	3.06	2.05	3.58	94.40	54.14	40.26
36/4/37	336.37	11.642	96.43	0.51	2.30	1.27	2.81	95.94	55.11	40.83
36/4/60p	336.60	11.650	97.22	0.42	1.85	0.93	2.27	96.82	53.86	42.95
36/4/80	336.80	11.657	94.92	0.53	3.44	1.65	3.97	94.41	53.51	40.91
37/1/19p	341.29	11.805	97.72	0.51	1.46	0.82	1.97	97.23	55.37	41.86
37/1/40	341.50	11.813	96.60	0.43	2.21	1.19	2.64	96.19	56.72	39.47
37/1/60p	341.70	11.821	96.44	0.69	2.32	1.24	3.00	95.78	56.46	39.32
37/1/80	341.90	11.829	95.50	1.39	3.03	1.47	4.42	94.17	57.84	36.33
37/1/96	342.06	11.835	96.64	0.11	2.33	1.03	2.44	96.53	55.30	41.23
37/1/118p	342.28	11.843	95.88	0.38	2.60	1.52	2.98	95.52	55.56	39.96
37/1/130	342.44	11.850	96.96	0.43	2.08	0.95	2.51	96.55	56.75	39.80
37/1/138	342.48	11.851	96.70	0.46	2.15	1.15	2.61	96.26	56.03	40.23
37/1/147p	342.57	11.855	96.91	0.43	1.92	1.17	2.35	96.50	55.57	40.93
37/2/20	342.80	11.863	97.03	0.53	2.02	0.94	2.56	96.52	56.00	40.52
37/2/40p	343.00	11.871	97.92	0.44	1.36	0.73	1.79	97.49	55.81	41.68
37/2/58	343.18	11.878	97.61	0.36	1.32	1.07	1.68	97.26	56.24	41.02
37/2/80	343.40	11.887	89.06	0.38	1.69	9.25	2.06	88.73	51.48	37.25
37/2/100p	343.60	11.894	97.09	0.42	1.72	1.19	2.15	96.68	54.98	41.70
37/2/118	343.78	11.901	96.79	0.43	2.05	1.16	2.47	96.38	55.81	40.57
37/2/130	343.90	11.906	97.06	0.57	1.75	1.19	2.32	96.51	56.39	40.12
37/2/138p	343.98	11.909	97.13	0.48	1.71	1.15	2.19	96.67	55.52	41.15
37/2/148	344.08	11.913	96.09	0.44	2.25	1.66	2.69	95.67	54.21	41.46
37/3/20p	344.30	11.922	96.47	0.44	2.10	1.43	2.53	96.05	56.30	39.76
37/3/40	344.50	11.929	97.40	0.45	1.58	1.02	2.03	96.96	57.09	39.87
37/3/61p	344.71	11.937	96.57	0.48	2.01	1.41	2.49	96.11	55.85	40.26
37/3/80	344.90	11.945	96.55	0.49	2.38	1.08	2.87	96.07	56.11	39.96
37/3/98	345.08	11.952	97.65	0.49	1.65	0.70	2.14	97.17	57.28	39.89
37/3/118p	345.28	11.959	95.93	0.69	2.34	1.73	3.02	95.28	54.77	40.51
37/3/130	345.40	11.964	95.56	0.49	2.75	1.70	3.23	95.09	56.19	38.90
37/3/139	345.49	11.968	95.73	0.57	2.93	1.34	3.50	95.18	56.65	38.53
37/3/143	345.53	11.969	96.19	0.47	2.63	1.18	3.11	95.73	54.91	40.82
37/4/20p	345.80	11.980	96.98	0.56	2.11	0.90	2.67	96.45	58.58	37.87
37/4/40	346.00	11.987	97.26	0.48	1.84	0.90	2.31	96.80	60.17	36.63
37/4/58p	346.18	11.994	96.48	0.53	2.41	1.12	2.94	95.96	56.18	39.78
37/4/80	346.48	12.006	96.92	0.61	2.25	0.83	2.86	96.33	57.61	38.72
37/4/100	346.60	12.011	94.05	0.64	3.99	1.95	4.64	93.45	55.78	37.66
37/4/119p	346.79	12.018	93.99	0.83	3.88	2.13	4.71	93.21	55.94	37.27
37/4/130	346.90	12.022	92.86	0.90	4.31	2.83	5.20	92.03	56.74	35.30
37/4/139	346.99	12.026	94.81	0.91	4.84	0.35	5.75	93.95	56.46	37.49
37/4/148p	347.08	12.029	93.15	0.67	3.94	2.92	4.61	92.52	54.79	37.73
37/5/21	347.31	12.038	93.07	0.68	4.37	2.56	5.05	92.44	56.84	35.60
37/5/40p	347.50	12.045	94.40	0.69	3.50	2.11	4.19	93.75	55.18	38.57
38/1/20	350.90	12.177	95.18	0.53	2.86	1.96	3.39	94.68	56.68	38.00
38/1/40	351.10	12.185	93.74	0.54	2.71	3.55	3.25	93.23	54.95	38.28
38/1/58	351.28	12.192	95.70	0.52	2.58	1.71	3.11	95.20	55.72	39.48
38/1/80	351.50	12.200	95.21	0.72	2.76	2.03	3.47	94.53	56.40	38.13
38/1/100	351.70	12.208	95.71	0.50	2.21	2.08	2.71	95.24	57.62	37.61
38/1/119	351.89	12.215	95.28	0.63	2.67	2.05	3.30	94.68	57.10	37.58
38/1/130	352.00	12.220	94.67	0.70	2.94	2.39	3.64	94.01	57.31	36.70
38/1/138	352.08	12.223	94.21	0.78	3.42	2.37	4.20	93.47	58.07	35.40
38/1/148	352.18	12.227	94.20	0.89	3.54	2.25	4.44	93.36	54.21	39.16
38/2/20	352.40	12.235	89.50	0.87	3.00	7.49	3.87	88.73	53.25	35.48
38/2/40	352.60	12.243	94.53	0.54	2.70	2.77	3.24	94.02	56.31	37.71
38/2/60	352.80	12.251	96.88	0.41	1.97	1.16	2.38	96.48	59.51	36.97
38/2/80	353.00	12.258	98.41	0.40	1.04	0.55	1.44	98.01	59.74	38.27
38/2/100	353.20	12.266	96.06	0.51	2.57	1.37	3.08	95.57	58.99	36.58
38/2/120	353.40	12.274	94.32	0.59	3.52	2.15	4.11	93.77	56.65	37.12
38/2/130	353.50	12.278	91.99	0.88	3.44	4.57	4.32	91.18	57.72	33.46
38/2/138	353.58	12.281	96.00	0.73	3.00	1.00	3.73	95.30	55.48	39.82

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
38/2/148	353.68	12.285	94.86	0.62	3.25	1.88	3.87	94.28	54.90	39.38
38/3/21	353.91	12.294	92.23	0.59	5.34	2.42	5.93	91.69	54.34	37.35
38/3/40	354.11	12.301	94.19	0.71	3.64	2.16	4.36	93.52	54.94	38.59
38/3/61	354.31	12.309	93.49	0.55	4.69	1.82	5.24	92.98	54.64	38.34
38/3/80	354.50	12.316	94.72	0.65	3.30	1.99	3.95	94.10	55.64	38.46
38/3/101	354.71	12.325	95.13	0.52	3.25	1.62	3.76	94.64	54.51	40.13
38/3/120	354.80	12.328	94.97	0.59	3.20	1.84	3.79	94.40	55.82	38.58
38/3/130	354.90	12.332	93.55	0.80	3.79	2.66	4.59	92.80	56.33	36.47
38/3/135	354.95	12.334	93.09	0.61	4.49	2.41	5.10	92.52	54.67	37.85
38/3/143	355.03	12.337	95.04	0.52	3.01	1.95	3.53	94.55	55.12	39.43
38/4/21	355.41	12.352	92.43	0.75	4.54	3.03	5.29	91.74	53.12	38.61
38/4/40	355.60	12.359	94.06	0.57	3.83	2.11	4.40	93.52	55.78	37.74
38/4/60	355.80	12.367	95.10	0.70	3.36	1.53	4.06	94.44	57.70	36.73
38/4/80	356.00	12.374	94.60	0.58	3.53	1.88	4.11	94.05	58.35	35.70
38/4/100	356.20	12.382	93.33	0.56	3.76	2.91	4.32	92.81	54.69	38.12
38/4/120	356.40	12.390	94.25	0.54	3.53	2.22	4.07	93.75	57.70	36.05
38/4/130	356.50	12.394	94.74	0.54	2.94	2.32	3.47	94.24	59.57	34.67
38/4/138	356.58	12.400	95.40	0.58	2.76	1.83	3.35	94.85	58.56	36.29
38/4/148	356.68	12.397	95.15	0.82	2.86	2.00	3.68	94.36	57.70	36.67
38/5/21	356.91	12.401	94.68	0.67	3.04	2.28	3.71	94.04	57.16	36.89
38/5/37	357.07	12.410	94.58	0.84	3.68	1.74	4.51	93.79	57.37	36.42
38/5/60	357.30	12.425	91.78	0.90	4.91	3.32	5.81	90.95	55.76	35.20
38/5/80	357.50	12.433	93.67	1.09	4.14	2.19	5.23	92.65	57.05	35.60
38/5/100	357.70	12.440	91.88	0.59	4.76	3.36	5.35	91.34	54.76	36.59
38/5/120	357.90	12.448	94.14	0.71	3.78	2.08	4.49	93.47	54.89	38.59
38/5/130	358.00	12.452	93.46	1.06	4.10	2.45	5.15	92.47	57.53	34.94
38/5/138	358.08	12.455	92.86	0.67	4.25	2.89	4.92	92.23	54.55	37.69
38/5/148	358.18	12.459	92.51	0.61	4.53	2.96	5.13	91.95	56.29	35.66
38/6/16	358.36	12.466	92.25	0.79	4.84	2.91	5.63	91.52	56.21	35.31
38/6/37	358.57	12.474	91.55	0.89	4.97	3.48	5.87	90.73	53.77	36.96
38/6/60	358.80	12.483	95.02	0.49	3.13	1.85	3.62	94.56	57.83	36.73
38/6/80	359.00	12.491	94.32	0.58	3.50	2.18	4.08	93.77	57.08	36.69
38/6/100	359.20	12.498	93.63	0.54	3.85	2.52	4.39	93.13	55.07	38.06
38/6/118	359.38	12.505	92.72	0.99	4.30	2.98	5.28	91.81	55.86	35.95
38/6/130	359.50	12.510	94.01	0.76	3.50	2.49	4.26	93.29	56.91	36.38
38/6/138	359.58	12.513	94.16	0.75	3.48	2.36	4.24	93.45	55.29	38.16
38/6/148	359.68	12.517	95.20	0.50	2.93	1.87	3.42	94.73	55.76	38.96
38/7/20	359.90	12.525	94.49	0.55	3.23	2.27	3.78	93.97	55.78	38.19
39/1/20	360.50	12.549	92.62	0.63	4.27	3.12	4.89	92.04	52.99	39.04
39/1/40	360.70	12.556	92.66	0.67	4.15	3.18	4.83	92.04	54.90	37.14
39/1/61	360.91	12.565	92.00	0.88	4.59	3.41	5.46	91.20	53.38	37.82
39/1/80	361.10	12.572	92.96	0.75	4.12	2.92	4.87	92.26	55.34	36.92
39/1/101	361.31	12.580	93.80	1.02	3.72	2.48	4.75	92.84	52.97	39.87
39/1/118	361.48	12.587	93.62	0.73	3.79	2.59	4.52	92.94	55.00	37.95
39/1/130	361.60	12.591	92.47	0.95	4.63	2.89	5.59	91.59	54.50	37.09
39/1/138	361.68	12.594	93.39	0.59	4.03	2.58	4.62	92.84	55.84	37.00
39/1/148	361.78	12.598	95.38	0.71	2.82	1.81	3.53	94.70	56.54	38.16
39/2/20	362.00	12.607	95.67	0.84	2.73	1.60	3.56	94.87	56.75	38.13
39/2/40	362.20	12.614	96.22	0.67	2.46	1.32	3.13	95.58	57.18	38.39
39/2/61	362.41	12.623	96.18	0.88	2.35	1.46	3.24	95.33	58.42	36.91
39/2/80	362.60	12.630	96.34	0.85	2.19	1.47	3.04	95.52	57.04	38.48
39/2/101	362.81	12.638	96.68	0.54	2.11	1.21	2.65	96.15	58.68	37.47
39/2/120	363.00	12.640	94.02	0.61	3.54	2.44	4.15	93.44	53.66	39.78
39/2/130	363.10	12.649	94.10	0.96	3.49	2.41	4.45	93.20	53.77	39.43
39/2/138	363.18	12.652	94.51	0.96	3.55	1.94	4.50	93.61	53.29	40.32
39/2/148	363.28	12.656	95.24	0.61	2.94	1.82	3.56	94.65	54.94	39.71
39/3/20	363.50	12.665	95.22	0.84	2.98	1.80	3.82	94.43	56.04	38.39
39/3/40	363.70	12.673	94.74	0.82	3.04	2.22	3.85	93.97	56.74	37.22
39/3/60	363.90	12.680	93.11	0.44	4.00	2.89	4.44	92.70	54.82	37.88
39/3/80	364.10	12.688	94.13	0.52	3.49	2.38	4.01	93.64	56.02	37.62
39/3/96	364.26	12.694	92.91	0.48	3.88	3.20	4.36	92.47	55.11	37.36
39/3/120	364.50	12.703	94.30	0.46	3.22	2.48	3.68	93.87	57.35	36.51

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
39/3/130	364.60	12.707	93.92	0.58	3.42	2.65	4.00	93.38	57.26	36.11
39/3/138	364.68	12.710	93.63	0.51	3.69	2.68	4.19	93.16	55.76	37.39
39/3/143	364.73	12.712	93.14	0.71	3.99	2.87	4.70	92.48	55.05	37.44
39/3/148	364.78	12.714	92.88	0.67	4.18	2.93	4.85	92.26	54.40	37.86
39/4/20	365.00	12.720	92.39	0.65	4.18	3.44	4.82	91.79	55.36	36.43
39/4/40	365.20	12.731	90.80	0.73	4.53	4.67	5.26	90.13	55.45	34.69
39/4/59	365.39	12.738	93.21	0.58	4.02	2.77	4.59	92.67	55.71	36.96
39/4/80	365.60	12.746	93.92	0.78	3.73	2.34	4.51	93.19	57.47	35.72
39/4/100	365.80	12.754	92.59	0.57	4.59	2.83	5.15	92.06	54.39	37.67
39/4/118	365.98	12.761	93.30	0.74	4.25	2.45	4.99	92.62	56.63	35.99
39/4/130	366.10	12.765	94.32	0.76	2.96	2.73	3.72	93.60	57.41	36.18
39/4/138	366.18	12.769	93.06	0.81	3.84	3.10	4.65	92.30	56.11	36.19
39/4/148	366.28	12.772	91.99	0.75	4.84	3.17	5.59	91.30	54.21	37.09
39/5/20	366.50	12.781	93.05	0.77	4.46	2.49	5.23	92.34	57.18	35.16
39/5/40	366.70	12.789	95.07	0.96	3.00	1.92	3.96	94.16	56.38	37.78
39/5/60	366.90	12.796	92.81	0.65	4.30	2.88	4.95	92.21	56.61	35.60
39/5/80	367.10	12.804	94.84	0.68	3.05	2.11	3.73	94.20	59.78	34.42
39/5/100	367.30	12.810	94.45	0.61	3.23	2.32	3.85	93.87	58.19	35.68
39/5/120	367.50	12.820	93.04	0.56	4.04	2.92	4.60	92.52	55.98	36.53
39/5/130	367.60	12.823	94.76	0.51	3.12	2.12	3.64	94.27	58.68	35.59
39/5/138	367.68	12.827	94.46	0.61	3.29	2.25	3.90	93.89	58.80	35.08
39/5/148	367.78	12.830	94.22	0.64	3.22	2.56	3.86	93.61	58.86	34.76
39/6/20	367.78	12.830	92.58	0.74	4.58	2.84	5.32	91.90	56.53	35.37
39/6/40	368.20	12.847	92.52	0.82	4.52	2.96	5.34	91.76	55.54	36.22
39/6/60	368.40	12.854	93.10	0.83	4.12	2.77	4.96	92.33	57.68	34.65
39/6/80	368.60	12.862	92.54	0.58	3.86	3.60	4.44	92.01	56.13	35.88
39/6/100	368.80	12.870	94.32	0.63	3.27	2.41	3.90	93.73	59.26	34.47
39/6/119	368.99	12.877	94.44	0.83	3.28	2.27	4.11	93.66	56.17	37.49
40/1/20	370.10	12.920	93.31	0.85	2.77	3.92	3.61	92.52	53.29	39.24
40/1/40	370.30	12.928	94.28	0.61	3.18	2.54	3.80	93.70	59.53	34.16
40/1/60	370.50	12.936	93.23	0.69	3.97	2.80	4.65	92.59	56.92	35.68
40/1/80	370.70	12.943	93.14	0.55	3.78	3.08	4.33	92.62	57.78	34.85
40/1/102	370.92	12.952	92.18	0.74	4.34	3.49	5.08	91.50	56.44	35.05
40/1/119	371.09	12.959	92.69	0.74	4.07	3.23	4.81	92.01	57.07	34.94
40/1/130	371.20	12.963	92.49	0.78	4.44	3.07	5.22	91.77	57.47	34.30
40/1/138	371.28	12.966	93.00	0.79	4.25	2.74	5.04	92.27	58.17	34.10
40/1/148	371.38	12.970	93.07	0.73	4.01	2.92	4.74	92.39	56.76	35.63
40/2/21	371.61	12.979	93.18	0.66	4.11	2.71	4.77	92.57	57.96	34.61
40/2/40	371.81	12.986	91.50	0.81	4.63	3.87	5.44	90.77	56.64	34.12
40/2/60	372.01	12.994	92.39	0.74	4.38	3.22	5.12	91.71	56.77	34.94
40/2/80	372.21	13.005	92.36	0.70	4.62	3.01	5.32	91.72	57.29	34.43
40/2/100	372.41	13.024	92.76	0.82	4.32	2.92	5.14	92.00	58.30	33.70
40/2/118	372.59	13.042	94.14	0.73	3.54	2.32	4.27	93.46	58.59	34.87
40/2/130	372.71	13.053	92.06	0.87	4.39	3.54	5.26	91.27	57.44	33.83
40/2/138	372.79	13.061	92.27	0.94	4.60	3.13	5.53	91.41	56.79	34.62
40/2/148	372.89	13.071	92.91	0.74	4.09	3.00	4.83	92.22	57.91	34.31
40/3/16	373.06	13.087	93.07	0.72	3.89	3.04	4.61	92.41	57.36	35.05
40/3/40	373.3	13.110	95.14	0.47	2.54	2.32	3.00	94.70	57.62	37.08
40/3/60	373.5	13.129	92.25	0.70	4.19	3.56	4.89	91.61	57.36	34.25
40/3/80	373.7	13.149	92.82	0.96	4.27	2.91	5.23	91.93	56.51	35.42
40/3/101	373.91	13.169	93.18	0.71	4.21	2.61	4.92	92.52	55.98	36.54
40/3/119	374.09	13.186	93.22	0.81	3.89	2.89	4.70	92.46	58.75	33.71
40/3/130	374.2	13.197	94.09	0.77	3.34	2.57	4.11	93.37	57.82	35.54
40/3/136	374.26	13.203	91.98	1.03	4.31	3.71	5.35	91.03	54.74	36.29
40/3/143	374.33	13.210	90.56	0.92	5.14	4.30	6.06	89.73	54.63	35.10
40/4/17	374.52	13.228	92.84	0.98	4.00	3.16	4.98	91.93	56.19	35.74
40/4/40	374.75	13.250	92.79	1.22	4.10	3.11	5.32	91.66	57.03	34.63
40/4/58	374.93	13.268	93.22	0.70	3.47	3.31	4.17	92.57	56.91	35.66
40/4/80	375.15	13.289	91.13	0.88	4.29	4.57	5.17	90.33	55.75	34.58
40/4/100	375.35	13.308	90.21	1.09	5.17	4.62	6.26	89.22	55.13	34.09
40/4/120	375.55	13.327	90.20	1.06	5.23	4.57	6.29	89.24	55.27	33.97
40/4/130	375.65	13.337	89.42	1.03	5.49	5.09	6.52	88.50	54.37	34.13

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
40/4/138	375.73	13.340	89.63	0.95	5.28	5.10	6.22	88.78	54.45	34.33
40/4/148	375.83	13.340	90.61	1.07	4.89	4.51	5.95	89.64	56.06	33.58
40/5/16	376.01	13.372	90.53	1.17	5.43	4.04	6.61	89.47	55.07	34.40
40/5/40	376.25	13.395	93.35	0.91	3.70	2.95	4.61	92.50	57.38	35.13
40/5/60	376.45	13.414	90.85	1.00	5.00	4.15	6.00	89.94	55.25	34.70
40/5/80	376.65	13.434	90.21	1.25	5.69	4.10	6.94	89.09	55.05	34.03
40/5/100	376.85	13.453	89.42	1.17	5.77	4.81	6.94	88.38	52.75	35.62
40/5/119	377.04	13.471	89.64	1.20	6.04	4.32	7.25	88.56	53.38	35.18
40/5/130	377.15	13.482	91.94	0.90	4.50	3.56	5.40	91.11	53.81	37.30
40/5/137	377.22	13.489	93.11	1.07	4.15	2.74	5.22	92.11	53.98	38.13
40/5/148	377.33	13.499	92.92	0.94	4.64	2.44	5.58	92.04	55.48	36.56
40/6/10	377.45	13.511	92.63	0.95	4.65	2.71	5.60	91.76	55.20	36.56
41/1/20	379.7	13.728	91.28	0.99	4.46	4.26	5.45	90.37	54.66	35.71
41/1/40	379.9	13.748	91.95	1.02	4.36	3.69	5.38	91.01	53.32	37.69
41/1/60	380.1	13.767	92.02	1.29	4.90	3.08	6.19	90.83	53.17	37.67
41/1/80	380.3	13.786	91.75	1.20	4.92	3.33	6.12	90.65	52.08	38.56
41/1/101	380.51	13.807	91.72	1.31	4.89	3.39	6.19	90.52	52.44	38.08
41/1/119	380.69	13.824	91.69	1.28	4.61	3.70	5.89	90.52	52.88	37.64
41/1/130	380.8	13.835	92.16	1.09	4.41	3.43	5.50	91.15	52.34	38.81
41/1/137	380.87	13.841	91.11	1.25	4.95	3.94	6.20	89.98	53.66	36.31
41/1/148	380.98	13.852	91.15	1.12	4.69	4.16	5.81	90.13	51.34	38.79
41/2/18	381.18	13.871	90.24	1.27	5.89	3.87	7.17	89.09	53.46	35.63
41/2/40	381.4	13.893	91.41	1.26	5.02	3.57	6.28	90.26	55.70	34.56
41/2/58	381.58	13.910	92.10	0.93	4.93	2.97	5.86	91.24	54.89	36.35
41/2/80	381.8	13.910	92.06	0.77	5.09	2.86	5.86	91.35	54.75	36.60
41/2/100	382	13.930	90.08	0.94	5.76	4.16	6.70	89.23	53.54	35.69
41/2/121	382.21	13.950	90.66	0.96	5.59	3.75	6.55	89.79	53.20	36.59
41/2/130	382.3	13.980	88.40	1.16	8.16	3.44	9.33	87.37	52.35	35.02
41/2/137	382.37	13.986	91.87	0.99	5.22	2.91	6.21	90.96	53.62	37.34
41/2/146	382.46	13.995	91.34	1.03	5.47	3.18	6.50	90.40	53.87	36.53
41/3/19	382.69	14.017	92.14	1.00	4.93	2.94	5.93	91.22	55.68	35.53
41/3/40	382.9	14.037	92.32	0.98	4.61	3.06	5.59	91.42	55.84	35.58
41/3/61	383.1	14.057	91.04	1.17	5.02	3.94	6.19	89.98	53.66	36.32
41/3/80	383.3	14.076	91.16	0.86	4.78	4.06	5.64	90.37	55.05	35.32
41/3/97	383.47	14.093	89.79	1.01	5.60	4.61	6.61	88.88	55.01	33.87
41/3/120	383.7	14.115	89.42	1.24	6.09	4.49	7.33	88.30	53.25	35.05
41/3/130	383.8	14.124	87.01	1.48	7.76	5.24	9.23	85.72	53.17	32.55
41/3/141	383.91	14.135	89.73	1.26	6.07	4.21	7.33	88.59	54.24	34.36
41/3/142	383.92	14.136	90.52	1.15	5.77	3.71	6.92	89.48	55.54	33.95
41/4/20	384.2	14.163	89.02	1.17	6.19	4.79	7.36	87.98	54.19	33.79
41/4/40	384.4	14.182	89.02	1.21	6.57	4.41	7.78	87.94	54.17	33.78
41/4/60	384.6	14.202	89.25	1.19	6.28	4.47	7.47	88.19	54.38	33.81
41/4/80	384.8	14.221	89.02	1.21	6.53	4.46	7.74	87.94	54.08	33.86
41/4/100	385	14.240	88.50	1.17	6.89	4.60	8.07	87.47	53.58	33.88
41/4/119	385.19	14.259	90.06	1.12	6.10	3.85	7.21	89.05	54.63	34.42
41/4/130	385.3	14.269	88.69	1.35	6.69	4.62	8.04	87.49	54.64	32.85
41/4/138	385.38	14.277	88.74	1.15	6.54	4.73	7.69	87.71	53.16	34.55
41/4/148	385.48	14.287	89.28	1.67	6.68	4.05	8.35	87.78	54.90	32.88
41/5/21	385.71	14.309	89.58	1.20	6.91	3.51	8.11	88.50	53.32	35.18
41/5/38	385.88	14.325	89.54	1.30	6.90	3.56	8.21	88.37	53.88	34.49
41/5/60	386.1	14.347	89.45	1.23	6.55	4.01	7.78	88.34	52.74	35.60
41/5/80	386.3	14.366	90.57	1.47	5.37	4.06	6.85	89.23	52.82	36.42
41/5/100	386.5	14.385	91.00	1.19	5.49	3.51	6.68	89.92	55.14	34.78
41/5/119	386.69	14.404	91.53	1.09	5.39	3.08	6.49	90.53	54.01	36.52
41/5/130	386.8	14.414	90.62	1.11	6.06	3.32	7.17	89.61	53.18	36.43
41/5/138	386.88	14.422	91.06	1.19	5.64	3.30	6.83	89.97	54.33	35.64
41/5/148	386.98	14.432	90.48	1.17	6.06	3.46	7.23	89.42	52.32	37.10
41/6/22	387.22	14.455	89.78	1.19	6.18	4.04	7.36	88.72	54.11	34.61
41/6/39	387.39	14.471	88.97	1.16	6.58	4.45	7.74	87.94	54.89	33.05
41/6/60	387.6	14.491	89.14	1.17	6.53	4.33	7.70	88.10	54.71	33.39
41/6/80	387.8	14.511	88.51	1.22	6.56	4.93	7.78	87.43	54.02	33.41
41/6/100	388	14.530	85.56	1.56	7.41	7.03	8.97	84.22	52.71	31.51

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
41/6/120	388.2	14.549	86.53	1.21	6.74	6.73	7.95	85.49	52.09	33.40
41/6/130	388.3	14.559	85.57	1.36	7.98	6.45	9.33	84.41	52.88	31.53
41/6/137	388.37	14.566	86.92	1.29	7.35	5.72	8.64	85.81	51.74	34.06
41/6/148	388.48	14.576	86.64	1.64	7.86	5.50	9.50	85.22	49.54	35.69
41/7/17	388.67	14.595	87.72	1.18	7.34	4.93	8.53	86.69	51.64	35.05
41/7/40	388.9	14.617	85.37	1.24	8.26	6.37	9.50	84.31	49.91	34.40
42/1/10A	389.2	14.646	84.19	1.11	8.01	7.80	9.13	83.25	47.77	35.48
42/1/10B	389.2	14.646	84.80	1.07	7.47	7.73	8.54	83.89	46.84	37.05
42/1/21	389.31	14.657	82.24	1.48	8.77	8.98	10.25	81.03	45.60	35.42
42/1/29	389.39	14.664	80.74	1.33	9.00	10.26	10.33	79.67	45.15	34.52
42/1/40	389.5	14.675	82.81	1.38	8.42	8.77	9.80	81.66	45.80	35.86
42/1/50	389.6	14.685	83.69	1.32	8.09	8.23	9.41	82.58	46.66	35.92
42/1/59	389.69	14.693	84.02	1.20	7.92	8.06	9.12	83.01	46.44	36.57
42/1/67	389.77	14.701	84.68	1.23	7.44	7.88	8.67	83.64	47.27	36.36
42/1/80	389.9	14.714	81.91	1.25	8.37	9.71	9.62	80.89	49.25	31.64
42/1/90	390	14.723	82.25	1.33	8.76	8.99	10.10	81.15	48.33	32.82
42/1/100	390.1	14.733	82.15	1.37	8.95	8.90	10.32	81.03	45.96	35.07
42/1/110	390.2	14.743	81.67	1.31	9.21	9.12	10.52	80.60	44.74	35.86
42/1/120	390.3	14.752	81.08	1.54	9.54	9.37	11.09	79.83	45.42	34.42
42/1/127	390.37	14.759	81.90	1.45	8.96	9.14	10.40	80.71	45.42	35.30
42/1/130	390.4	14.762	82.70	1.50	8.88	8.42	10.38	81.46	44.79	36.67
42/1/138	390.48	14.770	83.24	1.39	8.85	7.90	10.25	82.08	45.79	36.29
42/1/148	390.58	14.779	82.69	1.62	8.66	8.65	10.28	81.35	46.22	35.13
42/2/04	390.64	14.785	83.13	1.69	8.46	8.40	10.15	81.73	46.19	35.54
42/2/10	390.7	14.791	86.05	1.55	7.42	6.53	8.97	84.71	48.78	35.94
42/2/16	390.76	14.797	84.91	1.57	8.08	7.01	9.65	83.58	46.14	37.44
42/2/28	390.88	14.808	80.61	1.63	10.89	8.50	12.52	79.29	45.50	33.80
42/2/37	390.97	14.817	82.12	1.68	9.54	8.34	11.22	80.74	47.23	33.51
42/2/46	391.08	14.828	81.72	1.79	9.64	8.64	11.43	80.26	45.27	35.00
42/2/61	391.21	14.840	81.35	1.63	9.41	9.24	11.04	80.02	45.59	34.43
42/2/68	391.28	14.847	81.86	1.69	9.60	8.55	11.29	80.47	45.28	35.19
42/2/80	391.4	14.859	81.01	1.79	10.61	8.37	12.40	79.56	46.63	32.94
42/2/88	391.48	14.866	78.08	1.77	11.89	10.03	13.66	76.70	46.38	30.32
42/2/98	391.58	14.876	82.72	1.87	9.75	7.54	11.62	81.17	45.91	35.26
42/2/106	391.66	14.884	81.76	1.49	10.23	8.01	11.72	80.54	47.26	33.29
42/2/116	391.76	14.893	82.43	1.48	10.03	7.54	11.51	81.21	45.77	35.44
42/2/129	391.89	14.906	81.45	1.56	10.07	8.48	11.63	80.17	45.36	34.81
42/2/130	391.9	14.907	81.66	0.53	10.01	8.33	10.54	81.22	41.95	39.27
42/2/137	391.97	14.914	79.88	1.31	10.61	9.51	11.92	78.83	46.09	32.74
42/2/148	392.08	14.924	82.30	2.46	10.11	7.58	12.57	80.28	46.73	33.55
42/3/06	392.16	14.932	81.98	1.53	10.34	7.68	11.87	80.73	46.32	34.41
42/3/10	392.2	14.936	82.54	1.37	10.05	7.41	11.42	81.41	46.98	34.43
42/3/16	392.26	14.942	84.33	1.70	8.99	6.68	10.68	82.90	49.53	33.37
42/3/29	392.39	14.954	81.77	1.56	10.37	7.86	11.94	80.49	49.42	31.07
42/3/39	392.49	14.964	81.48	1.87	10.65	7.87	12.52	79.95	49.20	30.75
42/3/49	392.59	14.973	84.56	1.60	9.20	6.23	10.80	83.21	50.28	32.93
42/3/61	392.71	14.985	85.61	1.45	8.39	6.00	9.84	84.37	50.20	34.17
42/3/70	392.8	14.994	84.99	1.72	8.98	6.03	10.70	83.53	49.35	34.19
42/3/80	392.9	15.003	79.31	2.06	11.41	8.91	13.47	77.68	48.58	29.10
42/3/89	392.99	15.012	82.94	2.21	9.70	7.36	11.91	81.10	49.13	31.97
42/3/99	393.09	15.022	84.59	1.75	9.02	6.40	10.77	83.11	49.92	33.18
42/3/107	393.17	15.029	84.10	1.57	9.25	6.65	10.82	82.78	48.79	33.99
42/3/118	393.28	15.040	84.88	1.57	9.01	6.11	10.58	83.55	49.77	33.78
42/3/128	393.38	15.050	81.27	1.97	10.43	8.30	12.40	79.67	49.37	30.29
42/3/130	393.4	15.052	83.57	1.75	9.45	6.98	11.20	82.10	50.78	31.33
42/3/136	393.46	15.057	83.99	1.72	8.77	7.24	10.48	82.55	50.74	31.81
42/3/142	393.52	15.063	81.09	2.22	9.87	9.04	12.09	79.29	52.05	27.23
42/4/10	393.7	15.081	78.02	2.40	11.39	10.59	13.80	76.15	54.18	21.96
42/4/12	393.72	15.083	84.03	1.97	8.71	7.27	10.68	82.37	51.56	30.82
42/4/17	393.77	15.087	82.16	2.65	9.85	7.99	12.50	79.98	53.36	26.62
42/4/26	393.86	15.096	76.52	2.82	14.32	9.16	17.13	74.37	48.18	26.19
42/4/36	393.96	15.181	83.76	2.07	8.99	7.25	11.06	82.02	50.82	31.20

Sample No	Depth (mbsf)	Age (Ma)	% MUD of bulk	LS FS of mud	%F.sand of bulk	%c.sand of bulk	%FS + LS S	%Mud-LS FS	silt% of bulk	clay% of bulk
42/4/49	394.09	15.355	80.23	2.36	10.46	9.30	12.82	78.34	50.02	28.32
42/4/59	394.19	15.490	85.30	2.31	8.59	6.11	10.90	83.33	48.08	35.25
42/4/71	394.31	15.651	85.50	1.98	8.96	5.53	10.94	83.81	47.79	36.03
42/4/80	394.4	15.772	80.98	2.29	11.36	7.66	13.65	79.13	49.07	30.06
42/4/88	394.48	15.879	81.38	2.38	11.21	7.42	13.58	79.44	47.19	32.25
42/4/97	394.57	16.000	79.97	2.33	12.10	7.93	14.43	78.11	46.79	31.32
42/4/107	394.67	16.059	81.19	2.73	11.42	7.38	14.15	78.98	48.15	30.83
42/4/121	394.81	16.141	85.83	1.68	9.37	4.80	11.04	84.39	49.35	35.04
42/4/128	394.88	16.182	82.33	2.05	11.29	6.38	13.34	80.64	48.78	31.87
42/4/130	394.9	16.194	80.28	2.86	13.45	6.26	16.32	77.98	47.21	30.78
42/4/139	394.99	16.247	77.27	2.52	14.09	8.64	16.60	75.33	46.01	29.31
42/4/148	395.08	16.300	82.76	1.97	11.18	6.07	13.14	81.13	49.55	31.58
42/5/10	395.2	16.313	82.00	1.90	11.13	6.87	13.03	80.44	49.29	31.15
42/5/11	395.21	16.315	80.76	2.08	11.84	7.40	13.92	79.08	48.28	30.79
42/5/17	395.27	16.321	79.15	2.06	12.64	8.21	14.69	77.52	48.02	29.51
42/5/28	395.38	16.334	81.46	1.74	11.09	7.44	12.84	80.04	47.46	32.59
42/5/37	395.47	16.344	82.94	1.81	10.05	7.00	11.86	81.44	49.17	32.28
42/5/47	395.57	16.355	79.50	2.10	11.52	8.98	13.62	77.83	47.13	30.70
42/5/56	395.66	16.365	78.05	2.20	12.30	9.65	14.50	76.33	46.43	29.90
42/5/72	395.82	16.383	78.11	2.16	12.27	9.61	14.44	76.42	46.67	29.75
42/5/80	395.9	16.392	82.51	2.47	10.94	6.55	13.42	80.47	48.03	32.44
42/5/90	396	16.403	83.09	2.06	10.18	6.73	12.24	81.38	50.61	30.77
42/5/98	396.08	16.412	84.27	2.07	9.48	6.26	11.55	82.52	47.32	35.21
42/5/107	396.17	16.422	81.18	2.25	11.08	7.75	13.33	79.35	49.98	29.36
42/5/118	396.28	16.435	82.35	3.02	11.23	6.42	14.25	79.86	51.98	27.88
42/5/128	396.38	16.446	83.11	2.47	9.91	6.98	12.38	81.06	54.07	26.99
42/5/130	396.4	16.448	86.32	2.13	8.17	5.51	10.30	84.49	54.76	29.73
42/5/138	396.48	16.457	84.66	2.55	9.13	6.21	11.68	82.51	52.87	29.63
42/5/148	396.58	16.469	85.63	2.01	8.40	5.97	10.41	83.91	54.07	29.84
42/6/10	396.7	16.482	88.38	1.50	7.02	4.60	8.52	87.05	54.44	32.61
42/6/17	396.77	16.490	88.42	1.89	6.46	5.12	8.35	86.75	53.88	32.87
42/6/40	397	16.516	89.00	3.00	6.78	4.22	9.78	86.33	57.58	28.75
42/6/58	397.18	16.536	86.14	2.24	7.03	6.83	9.27	84.21	58.32	25.89

Appendix B Table 7: Hole 593 sediment texture data 392-427 mbsf. (File on CD: App B Table 7).

Sample No	Depth (m)	Age (Ma)	Mud%	TotalSnd%	Snd%	Fnsnd%	mud+fs
42/3/70	392.80	14.994	84.19	15.81	7.76	8.05	91.95
42/3/90	393.00	15.013	80.96	19.04	9.68	9.36	90.64
42/3/110	393.10	15.023	83.60	16.40	8.03	8.38	91.63
42/3/130	393.30	15.042	81.60	18.40	9.11	9.29	90.71
42/4/000	393.60	15.071	85.56	16.44	10.32	4.11	95.88
42/4/20	393.80	15.090	81.12	18.88	9.11	9.76	90.23
42/4/33	393.93	15.140	81.80	18.20	9.28	8.91	91.08
42/4/60	394.20	15.503	83.26	16.74	9.50	7.24	92.76
42/4/80	394.40	15.772	82.01	17.99	9.38	8.60	91.39
42/4/100	394.60	16.018	78.14	21.86	11.39	10.47	89.53
42/4/120	394.80	16.135	72.42	27.58	7.00	7.89	79.42
42/4/140	395.00	16.253	71.77	28.23	18.61	9.62	90.38
42/5/10	395.20	16.313	80.86	19.14	9.10	10.00	89.96
42/5/30	395.40	16.336	79.70	20.30	11.28	9.01	90.98
42/5/50	395.60	16.358	76.88	23.12	13.84	9.28	90.72
42/5/70	395.80	16.381	80.70	19.30	10.27	9.03	90.97
42/5/90	396.00	16.403	84.86	15.14	7.35	7.79	92.21
42/5/110	396.20	16.426	85.59	14.41	7.28	7.14	92.87
42/5/130	396.40	16.448	85.89	14.11	7.06	7.06	92.95
42/6/00	396.60	16.471	84.13	15.87	8.01	7.86	92.14
42/6/20	396.80	16.493	85.35	14.65	7.54	7.11	92.89
42/6/40	397.00	16.516	88.50	11.50	5.63	5.87	94.13

Sample No	Depth (m)	Age (Ma)	Mud%	TotalSnd%	Snd%	Fnsnd%	mud+fs
42/6/60	397.20	16.538	87.63	12.37	7.20	5.16	94.83
42/6/78	397.38	16.558	82.67	17.33	9.17	8.15	91.84
42/cc/12	397.52	16.574	79.55	10.45	11.00	9.45	90.55
43/1/00	398.70	16.707	87.06	12.94	7.00	5.94	94.06
43/1/20	398.90	16.729	88.93	11.07	5.90	5.16	94.83
43/1/40	399.10	16.752	84.67	15.33	8.67	6.66	93.34
43/1/60	399.30	16.774	83.96	16.04	7.00	9.04	90.96
43/1/80	399.50	16.797	88.64	11.36	4.80	6.57	93.44
43/1/100	399.70	16.819	82.10	17.90	8.58	9.31	90.68
43/1/120	399.90	16.842	81.24	18.76	8.63	10.14	89.87
43/1/140	400.10	16.864	86.79	13.21	7.11	6.10	93.90
43/2/10	400.30	16.887	89.89	10.11	5.60	4.51	95.49
43/2/30	400.50	16.909	89.69	10.31	6.32	4.00	96.01
43/2/50	400.70	16.931	87.03	12.97	6.88	6.09	93.91
43/2/70	400.90	16.954	89.76	10.24	5.27	4.97	95.03
43/2/90	401.10	16.976	86.42	13.58	7.26	6.32	93.68
43/2/110	401.30	16.999	91.15	8.85	3.81	5.04	94.96
43/2/130	401.50	17.021	87.15	12.85	6.62	6.23	93.77
43/3/00	401.70	17.044	90.96	9.04	5.00	4.05	95.96
43/3/21	401.91	17.067	87.65	12.35	6.89	5.46	94.54
43/3/38	402.08	17.087	89.81	10.19	5.09	5.09	94.90
43/3/57	402.27	17.108	93.03	6.97	3.59	3.37	96.62
43/3/77	402.47	17.130	89.22	10.78	5.44	5.39	94.66
43/3/102	402.72	17.158	84.98	15.02	6.63	8.39	91.61
43/3/117	402.87	17.175	92.58	7.42	3.41	4.01	95.99
43/3/141	403.11	17.202	89.31	10.69	4.95	5.74	94.26
43/4/12	403.32	17.226	88.35	11.65	3.97	7.68	92.32
43/4/30	403.50	17.246	89.01	10.99	3.70	7.28	92.71
43/4/48	403.68	17.266	92.62	7.38	3.36	4.03	95.98
43/4/68	403.88	17.289	92.24	7.76	3.01	4.75	95.25
43/4/90	404.10	17.313	89.26	10.74	5.11	5.63	94.37
43/4/110	404.30	17.336	90.93	9.07	4.25	4.83	95.18
43/4/132	404.52	17.361	87.73	12.27	5.97	6.30	93.70
43/5/00	404.70	17.381	90.40	9.60	5.31	4.29	95.71
43/5/22	404.92	17.406	88.26	11.74	5.93	5.82	94.19
43/5/38	405.08	17.424	88.66	11.34	4.98	6.36	93.64
43/5/61	405.31	17.449	87.56	12.44	6.55	5.89	94.11
43/5/82	405.52	17.473	86.10	13.90	6.70	7.20	92.80
43/5/102	405.72	17.496	87.08	12.92	6.83	6.09	93.91
43/5/118	405.88	17.513	88.55	11.45	6.64	4.81	95.19
43/5/140	406.10	17.538	80.46	19.54	11.38	8.15	91.84
43/6/12	406.32	17.563	89.99	10.01	5.36	4.65	95.35
43/6/32	406.52	17.585	87.35	12.65	7.22	5.43	94.57
43/6/47	406.67	17.601	91.40	8.60	3.48	5.11	94.88
43/6/70	406.90	17.618	87.67	12.33	7.37	4.95	95.04
43/6/91	407.11	17.633	87.67	12.33	5.62	6.71	93.29
43/6/112	407.32	17.648	91.70	8.30	3.87	4.43	95.57
43/6/132	407.52	17.663	89.97	10.03	4.99	3.82	94.96
43/cc/08	407.70	17.676	93.61	6.39	2.77	3.62	96.38
44/1/00	408.30	17.719	84.84	15.16	10.61	4.55	95.45
44/1/22	408.52	17.735	85.00	15.00	10.38	4.61	95.38
44/1/40	408.70	17.748	79.90	20.10	14.29	5.81	94.19
44/1/58	408.88	17.761	78.93	21.07	15.05	6.20	93.98
44/1/78	409.08	17.775	83.81	16.19	10.71	5.38	94.52
44/1/100	409.30	17.791	83.81	16.19	6.20	3.67	90.01
44/1/121	409.51	17.806	85.93	14.07	9.47	4.60	95.40
44/1/137	409.67	17.817	86.32	13.68	9.55	4.13	95.87
44/2/12	409.92	17.835	83.70	16.30	16.89	6.70	100.59
44/2/30	410.10	17.848	86.34	13.66	9.55	4.11	95.89
44/2/50	410.30	17.863	82.14	17.86	12.21	5.64	94.35
44/2/71	410.51	17.878	84.27	15.73	10.75	4.98	95.02
44/2/88	410.68	17.890	85.48	14.52	9.80	4.71	95.28
44/2/110	410.90	17.906	85.95	14.05	9.83	4.22	95.78

Sample No	Depth (m)	Age (Ma)	Mud%	TotalSnd%	Snd%	Fnsnd%	mud+fs
44/2/131	411.11	17.921	86.20	13.80	9.40	4.39	95.60
44/3/00	411.30	17.935	88.45	11.55	11.13	5.62	99.58
44/3/22	411.52	17.951	79.90	20.10	13.27	6.82	93.17
44/3/40	411.70	17.963	84.14	15.86	10.35	5.51	94.49
44/3/61	411.91	17.979	82.45	17.55	11.14	6.40	93.59
44/3/83	412.13	17.994	79.68	20.32	13.09	7.23	92.77
44/3/103	412.33	18.009	81.94	18.06	11.36	6.70	93.30
44/3/118	412.48	18.020	86.72	13.28	8.27	5.06	94.99
44/3/137	412.67	18.033	86.36	13.64	8.67	4.98	95.03
44/4/10	412.90	18.050	84.27	15.73	10.00	5.72	94.27
44/4/30	413.10	18.064	88.38	11.62	7.82	3.80	96.20
44/4/50	413.30	18.079	80.80	19.20	12.47	6.72	93.27
44/4/68	413.48	18.092	75.64	24.36	12.80	6.90	88.44
44/4/92	413.72	18.109	77.81	22.19	16.60	5.30	94.41
44/4/111	413.90	18.122	79.97	20.03	13.70	6.33	93.67
44/4/130	414.09	18.136	78.40	21.60	15.00	6.63	93.40
44/5/00	414.30	18.151	74.72	25.28	17.25	8.03	91.97
44/5/20	414.50	18.165	80.93	19.07	15.60	6.47	96.53
44/5/38	414.68	18.178	77.72	22.28	15.18	7.10	92.90
44/5/60	414.90	18.194	79.04	20.96	14.28	6.68	93.32
44/5/80	415.10	18.208	82.92	17.08	11.24	5.84	94.16
44/5/97	415.27	18.220	84.86	15.14	10.34	4.80	95.20
44/5/117	415.47	18.235	81.85	18.15	10.07	4.94	91.92
44/5/141	415.71	18.252	84.41	15.59	10.55	5.04	94.96
44/6/08	415.88	18.264	80.83	19.17	13.34	5.83	94.17
44/6/27	416.07	18.278	82.76	17.24	11.70	5.54	94.46
44/6/48	416.28	18.293	82.53	17.47	16.96	5.59	99.49
44/6/70	416.50	18.309	89.38	10.62	6.93	3.68	96.31
44/6/90	416.70	18.323	85.73	14.27	9.60	4.72	95.33
44/cc/14	417.18	18.358	85.44	14.56	10.35	4.21	95.79
45/1/10	418.00	18.417	89.03	10.97	7.05	4.65	96.08
45/1/30	418.20	18.431	89.75	10.25	6.58	3.67	96.33
45/1/50	418.40	18.446	88.12	11.88	7.84	4.75	95.96
45/1/68	418.58	18.459	89.66	10.34	9.89	5.06	99.55
45/1/87	418.77	18.472	89.15	10.85	7.13	3.72	96.28
45/1/111	419.01	18.490	83.59	16.41	11.15	5.27	94.74
45/1/128	419.18	18.502	83.72	16.28	10.79	5.10	94.51
45/2/00	419.40	18.518	81.37	18.63	12.62	6.01	93.99
45/2/20	419.60	18.532	82.34	17.66	12.14	5.52	94.48
45/2/41	419.81	18.547	83.30	16.70	11.19	5.51	94.49
45/2/60	420.00	18.561	84.43	15.57	9.99	5.58	94.42
45/2/78	420.18	18.574	85.08	14.92	9.76	5.16	94.84
45/2/100	420.40	18.590	86.40	13.60	9.04	4.55	95.44
45/2/120	420.60	18.604	84.62	15.38	10.12	5.15	94.74
45/2/140	420.80	18.619	84.93	15.07	9.90	5.17	94.83
45/3/07	420.97	18.631	83.88	16.12	10.00	6.12	93.88
45/3/30	421.20	18.647	89.55	10.45	6.50	3.95	96.05
45/3/50	421.40	18.662	88.74	11.26	6.89	4.37	95.63
45/3/68	421.58	18.675	87.08	12.92	8.02	4.90	95.10
45/3/88	421.78	18.689	91.22	8.78	5.42	3.35	96.64
45/3/111	422.01	18.706	93.14	6.86	4.28	2.57	97.42
45/3/127	422.17	18.717	92.39	7.61	4.63	2.98	97.02
45/4/00	422.40	18.734	91.42	8.58	5.07	3.51	96.49
45/4/19	422.59	18.747	94.36	5.64	3.53	2.11	97.89
45/4/37	422.77	18.760	91.60	8.40	5.38	3.01	96.98
45/4/60	423.00	18.777	93.24	6.76	4.39	2.37	97.63
45/4/78	423.18	18.790	91.62	8.38	5.39	2.99	97.01
45/4/98	423.38	18.804	88.26	11.74	9.25	2.49	97.51
45/4/120	423.50	18.813	91.67	8.33	5.52	2.81	97.19
45/4/138	423.78	18.833	93.13	6.87	4.45	2.42	97.58
45/5/12	424.02	18.850	89.44	10.56	6.63	3.93	96.07
45/5/30	424.20	18.863	92.81	7.19	4.66	2.52	97.47
45/5/48	424.38	18.876	91.97	8.03	5.03	2.79	97.00

Sample No	Depth (m)	Age (Ma)	Mud%	TotalSnd%	Snd%	Fnsnd%	mud+fs
45/5/67	424.57	18.890	92.41	7.59	4.92	2.67	97.33
45/5/88	424.78	18.905	91.25	8.75	5.56	3.18	96.81
45/5/111	425.01	18.922	91.59	8.41	5.32	3.09	96.91
45/5/128	425.18	18.934	93.43	6.57	4.26	2.32	97.69
45/6/00	425.40	18.950	90.04	9.96	6.10	3.43	96.14
45/6/18	425.68	18.970	88.40	11.60	7.96	4.20	96.36
45/6/36	425.76	18.976	86.90	13.10	8.45	4.65	95.35
45/6/60	426.00	18.993	87.93	12.07	7.82	4.24	95.75
45/6/78	426.18	19.006	92.15	7.25	4.83	3.02	96.98
45/6/100	426.40	19.022	87.47	12.53	8.22	4.31	95.69
45/6/120	426.60	19.036	93.45	6.55	3.98	2.56	97.43
45/6/140	426.80	19.050	89.33	10.67	6.91	3.76	96.24
45/7/10	427.00	19.065	92.23	7.77	4.85	2.91	97.08
45/7/27	427.17	19.077	90.20	9.80	6.00	3.80	96.20
45/7/46	427.36	19.091	91.96	8.04	4.95	3.09	96.91
45/cc/18	427.48	19.099	92.10	7.90	4.76	3.15	96.86

Appendix B Table 8: Hole 593 clay data for 392-428 mbsf. (File on CD: App B Table 8).

Hole 593 Sample No	Depth (m)	Age (Ma)	Mud%	% bulk 3.6 µm	% bulk 4.2 µm
42/3/70	392.80	14.994	84.19	36.8	41.5
42/3/90	393.00	15.013	80.96	33.4	37.7
42/3/110	393.10	15.023	83.60	34.4	39.0
42/3/130	393.30	15.042	81.60	34.2	38.6
42/4/000	393.60	15.071	85.56	34.5	38.9
42/4/20	393.80	15.090	81.12	31.5	35.8
42/4/33	393.93	15.140	81.80	33.5	38.0
42/4/60	394.20	15.503	83.26	29.2	33.3
42/4/100	394.60	16.018	78.14	29.5	33.2
42/4/120	394.80	16.135	72.42	30.2	33.7
42/4/140	395.00	16.253	71.77	27.8	31.2
42/5/10	395.20	16.313	80.86	28.8	32.7
42/5/30	395.40	16.336	79.70	30.6	34.7
42/5/50	395.60	16.358	76.88	24.9	28.1
42/5/70	395.80	16.381	80.70	28.0	31.5
42/5/90	396.00	16.403	84.86	33.2	37.1
42/5/110	396.20	16.426	85.59	33.1	37.2
42/5/130	396.40	16.448	85.89	26.1	29.5
42/6/00	396.60	16.471	84.13	29.5	33.3
42/6/20	396.80	16.493	85.35	37.1	41.5
42/6/60	397.20	16.538	87.63	32.4	36.4
42/6/78	397.38	16.558	82.67	31.3	35.3
42/cc/12	397.52	16.574	79.55	25.5	29.0
43/1/00	398.70	16.707	87.06	37.9	42.2
43/1/20	398.90	16.729	88.93	39.4	44.0
43/1/40	399.10	16.752	84.67	36.5	40.9
43/1/60	399.30	16.774	83.96	30.1	33.7
43/1/80	399.50	16.797	88.64	33.9	38.0
43/1/100	399.70	16.819	82.10	23.5	26.6
43/1/120	399.90	16.842	81.24	29.3	33.1
43/1/140	400.10	16.864	86.79	34.4	38.8
43/2/10	400.30	16.887	89.89	33.5	37.6
43/2/30	400.50	16.909	89.69	36.7	41.2
43/2/50	400.70	16.931	87.03	29.9	33.7

Hole 593 Sample No	Depth (m)	Age (Ma)	Mud%	% bulk 3.6 µm	% bulk 4.2 µm
43/2/70	400.90	16.954	89.76	30.9	34.7
43/2/90	401.10	16.976	86.42	32.7	36.7
43/2/110	401.30	16.999	91.15	33.4	37.5
43/2/130	401.50	17.021	87.15	38.2	42.6
43/3/00	401.70	17.044	90.96	38.5	43.7
43/3/21	401.91	17.067	87.65	30.8	34.9
43/3/38	402.08	17.087	89.81	30.5	34.9
43/3/57	402.27	17.108	93.03	39.8	45.6
43/3/77	402.47	17.130	89.22	29.3	33.6
43/3/102	402.72	17.158	84.98	28.7	33.0
43/3/117	402.87	17.175	92.58	33.1	38.0
43/3/141	403.11	17.202	89.31	36.2	41.5
43/4/12	403.32	17.226	88.35	34.2	39.3
43/4/30	403.50	17.246	89.01	34.9	40.1
43/4/48	403.68	17.266	92.62	38.4	44.0
43/4/68	403.88	17.289	92.24	38.2	43.6
43/4/90	404.10	17.313	89.26	35.2	40.3
43/4/110	404.30	17.336	90.93	41.3	46.8
43/4/132	404.52	17.361	87.73	35.0	40.1
43/5/00	404.70	17.381	90.40	37.5	43.0
43/5/22	404.92	17.406	88.26	34.0	39.4
43/5/38	405.08	17.424	88.66	34.6	39.4
43/5/61	405.31	17.449	87.56	28.1	32.3
43/5/82	405.52	17.473	86.10	34.3	39.1
43/5/102	405.72	17.496	87.08	33.3	38.1
43/5/118	405.88	17.513	88.55	32.9	37.6
43/5/140	406.10	17.538	80.46	29.2	33.5
43/6/12	406.32	17.563	89.99	35.0	40.0
43/6/32	406.52	17.585	87.35	32.4	37.1
43/6/47	406.67	17.601	91.40	33.5	38.2
43/6/70	406.90	17.618	87.67	34.4	39.1
43/6/91	407.11	17.633	87.67	35.2	39.9
43/6/112	407.32	17.648	91.70	38.0	43.2
43/6/132	407.52	17.663	89.97	34.9	40.0
43/cc/08	407.70	17.676	93.61	37.6	42.8
44/1/00	408.30	17.719	84.84	35.3	40.0
44/1/22	408.52	17.735	85.00	33.4	37.9
44/1/40	408.70	17.748	79.90	29.8	33.8
44/1/58	408.88	17.761	78.93	30.0	34.0
44/1/78	409.08	17.775	83.81	33.8	38.2
44/1/100	409.30	17.791	83.81	34.3	38.7
44/1/121	409.51	17.806	85.93	35.0	39.5
44/1/137	409.67	17.817	86.32	35.9	40.3
44/2/12	409.92	17.835	83.70	28.4	32.2
44/2/30	410.10	17.848	86.34	36.3	40.5
44/2/50	410.30	17.863	82.14	35.2	39.4
44/2/71	410.51	17.878	84.27	35.5	40.3
44/2/88	410.68	17.890	85.48	35.8	40.7
44/2/110	410.90	17.906	85.95	35.6	40.7
44/2/131	411.11	17.921	86.20	35.4	40.6
44/3/00	411.30	17.935	88.45	37.4	42.8
44/3/22	411.52	17.951	79.90	33.5	38.2

Hole 593 Sample No	Depth (m)	Age (Ma)	Mud%	% bulk 3.6 µm	% bulk 4.2 µm
44/3/40	411.70	17.963	84.14	34.6	39.4
44/3/61	411.91	17.979	82.45	34.1	38.7
44/3/83	412.13	17.994	79.68	32.0	36.2
44/3/103	412.33	18.009	81.94	32.5	36.8
44/3/118	412.48	18.020	86.72	35.1	39.8
44/3/137	412.67	18.033	86.36	34.0	38.7
44/4/10	412.90	18.050	84.27	34.9	39.6
44/4/30	413.10	18.064	88.38	34.7	39.3
44/4/50	413.30	18.079	80.80	33.8	38.1
44/4/68	413.48	18.092	75.64	29.5	33.4
44/4/92	413.72	18.109	77.81	30.5	34.7
44/4/111	413.90	18.122	79.97	30.0	34.1
44/4/130	414.09	18.136	78.40	28.9	32.9
44/5/00	414.30	18.151	74.72	27.7	31.5
44/5/20	414.50	18.165	80.93	31.5	35.5
44/5/38	414.68	18.178	77.72	28.5	32.1
44/5/60	414.90	18.194	79.04	24.6	27.8
44/5/80	415.10	18.208	82.92	30.8	34.7
44/5/97	415.27	18.220	84.86	31.5	35.4
44/5/117	415.47	18.235	81.85	30.4	34.2
44/5/141	415.71	18.252	84.41	33.4	37.3
44/6/08	415.88	18.264	80.83	32.1	36.0
44/6/27	416.07	18.278	82.76	34.4	38.6
44/6/48	416.28	18.293	82.53	33.7	37.9
44/6/70	416.50	18.309	89.38	38.6	43.1
44/6/90	416.70	18.323	85.73	33.8	38.0
44/cc/14	417.18	18.358	85.44	32.8	37.1
45/1/10	418.00	18.417	89.03	37.2	41.8
45/1/30	418.20	18.431	89.75	36.1	40.3
45/1/50	418.40	18.446	88.12	35.5	39.5
45/1/68	418.58	18.459	89.66	37.7	41.8
45/1/87	418.77	18.472	89.15	37.8	42.3
45/1/111	419.01	18.490	83.59	34.9	39.4
45/1/128	419.18	18.502	83.72	36.3	41.0
45/2/00	419.40	18.518	81.37	33.0	37.5
45/2/20	419.60	18.532	82.34	32.2	36.5
45/2/41	419.81	18.547	83.30	35.6	39.9
45/2/60	420.00	18.561	84.43	36.9	41.2
45/2/78	420.18	18.574	85.08	34.5	38.7
45/2/100	420.40	18.590	86.40	32.0	36.1
45/2/120	420.60	18.604	84.62	32.1	36.2
45/2/140	420.80	18.619	84.93	33.7	37.7
45/3/07	420.97	18.631	83.88	33.2	36.9
45/3/30	421.20	18.647	89.55	37.0	41.4
45/3/50	421.40	18.662	88.74	35.4	39.7
45/3/68	421.58	18.675	87.08	35.9	40.3
45/3/88	421.78	18.689	91.22	37.5	42.0
45/3/111	422.01	18.706	93.14	38.8	43.5
45/3/127	422.17	18.717	92.39	37.9	42.5
45/4/00	422.40	18.734	91.42	36.4	41.0
45/4/19	422.59	18.747	94.36	38.0	42.8
45/4/37	422.77	18.760	91.60	35.9	40.5

Hole 593 Sample No	Depth (m)	Age (Ma)	Mud%	% bulk 3.6 µm	% bulk 4.2 µm
45/4/60	423.00	18.777	93.24	35.6	40.1
45/4/78	423.18	18.790	91.62	34.2	38.6
45/4/98	423.38	18.804	88.26	35.2	39.5
45/4/120	423.50	18.813	91.67	35.7	40.2
45/4/138	423.78	18.833	93.13	39.4	44.1
45/5/12	424.02	18.850	89.44	36.8	41.3
45/5/30	424.20	18.863	92.81	39.2	43.8
45/5/48	424.38	18.876	91.97	40.1	44.7
45/5/67	424.57	18.890	92.41	39.4	44.1
45/5/88	424.78	18.905	91.25	38.8	43.5
45/5/111	425.01	18.922	91.59	38.1	42.8
45/5/128	425.18	18.934	93.43	40.4	45.3
45/6/00	425.40	18.950	90.04	37.3	42.0
45/6/18	425.68	18.970	88.40	38.4	43.0
45/6/36	425.76	18.976	86.90	34.7	39.1
45/6/60	426.00	18.993	87.93	35.0	39.5
45/6/78	426.18	19.006	92.15	38.5	43.4
45/6/100	426.40	19.022	87.47	33.8	38.2
45/6/120	426.60	19.036	93.45	39.8	44.4
45/6/140	426.80	19.050	89.33	36.7	41.0
45/7/10	427.00	19.065	92.23	38.3	43.2
45/7/27	427.17	19.077	90.20	37.3	42.2
45/7/46	427.36	19.091	91.96	39.3	44.1
45/cc/18	427.48	19.099	92.10	39.0	43.8

Appendix B Table 9: Hole 593 sediment texture data (120-329 mbsf) used to calculate Folk and Ward statistics in phi. G = graphical calculations, sd = standard deviation, skew = skewness, kurt = kurtosis. LS mud = lasersizer mud fraction. (File on CD: App B Table 9)

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
14/1/0-3	120.30	5.1273	91.99	2.29	0.92	42.21	56.87	9.00	1.91	0.00	1.23
14/1/21-24	120.51	5.1326	92.40	2.28	0.79	40.93	58.27	9.00	1.76	0.10	1.02
14/1/39-42	120.69	5.1372	91.38	2.59	0.71	41.81	57.49	9.00	1.91	0.00	1.23
14/1/60-63	120.90	5.1425	93.24	2.31	0.77	43.81	55.42	9.00	1.91	0.00	1.23
14/1/81-84	121.11	5.1479	93.30	2.26	0.55	45.58	53.88	9.00	1.91	0.00	1.23
14/1/96-99	121.26	5.1517	91.90	3.10	0.28	44.49	55.23	9.00	1.76	0.10	1.02
14/1/119-122	121.49	5.1576	90.46	3.31	0.81	43.81	55.38	9.00	1.76	0.10	1.02
14/1/139-142	121.69	5.1626	90.86	3.12	0.24	44.91	54.85	9.00	1.91	0.00	1.23
14/2/10-13	121.90	5.1680	90.49	3.05	0.53	42.71	56.76	9.00	1.91	0.00	1.23
14/2/29-32	122.09	5.1728	91.79	2.47	0.66	41.27	58.07	9.00	1.76	0.10	1.23
14/2/46-49	122.26	5.1771	91.80	2.96	0.46	43.08	56.47	9.00	1.91	0.00	1.23
14/2/71-75	122.51	5.1835	92.48	2.60	0.33	42.30	57.37	9.00	1.91	0.00	1.23
14/2/91-94	122.71	5.1886	93.64	2.09	0.03	41.88	58.10	9.00	1.91	0.00	1.23
14/2/112-115	122.92	5.1939	93.16	2.21	0.01	39.18	60.81	9.33	1.51	0.27	1.02
14/2/130-133	123.10	5.1979	93.11	2.32	0.11	43.67	56.21	9.00	1.91	0.00	1.23
14/3/0-3	123.30	5.2009	93.26	2.24	0.08	39.80	60.12	9.33	1.51	0.27	1.02
14/3/23-26	123.53	5.2044	93.37	2.01	0.50	42.83	56.67	9.00	1.91	0.00	1.23
14/3/39-42	123.69	5.2069	93.37	2.04	0.34	39.82	59.84	9.33	1.51	0.27	1.02
14/3/58-61	123.88	5.2098	93.43	1.87	0.86	41.71	57.43	9.00	1.91	0.00	1.23
14/3/81-84	124.11	5.2132	92.64	2.51	0.76	40.79	58.45	9.00	1.91	0.00	1.23
14/3/100-103	124.30	5.2161	91.25	3.10	1.11	43.31	55.58	9.00	1.91	0.00	1.23
14/3/120-123	124.50	5.2192	92.47	2.62	1.91	42.43	55.66	9.00	2.06	-0.07	1.43
14/3/138-141	124.68	5.2219	92.51	2.40	0.34	42.81	56.85	9.00	1.91	0.00	1.23
14/4/10-13	124.90	5.2252	92.30	2.96	0.37	40.67	58.96	9.33	1.51	0.27	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
14/4/30-33	125.10	5.2283	90.05	3.49	0.68	41.81	57.51	9.00	1.91	0.00	1.23
14/4/50-53	125.30	5.2313	92.41	2.64	0.32	38.64	61.04	9.33	1.66	0.17	1.23
14/4/68-71	125.48	5.2340	95.13	1.14	0.12	37.11	62.77	9.33	1.66	0.17	1.23
14/4/91-94	125.71	5.2375	93.70	1.86	0.24	36.46	63.30	9.33	1.51	0.27	1.02
14/4/111-114	125.91	5.2406	93.14	1.83	0.25	39.04	60.72	9.33	1.51	0.27	1.02
14/4/130-133	126.10	5.2435	94.34	1.85	0.32	35.98	63.70	9.33	1.51	0.27	1.02
14/5/0-3	126.30	5.2465	93.65	2.23	0.27	40.59	59.14	9.33	1.51	0.27	1.02
14/5/26-29	126.56	5.2504	93.66	2.27	0.28	44.14	55.58	9.00	1.91	0.00	1.23
14/5/40-43	126.70	5.2526	94.47	1.98	0.16	41.78	58.06	9.33	1.51	0.27	1.02
14/5/60-63	126.90	5.2556	94.19	1.88	1.81	43.31	54.88	9.00	2.10	-0.09	1.49
14/5/82-85	127.12	5.2589	92.78	2.45	0.10	40.92	58.99	9.33	1.51	0.27	1.02
14/5/100-103	127.30	5.2617	90.85	2.85	0.55	43.47	55.98	9.00	1.91	0.00	1.23
14/5/121-124	127.51	5.2649	90.24	3.26	0.62	43.30	56.08	9.00	1.76	0.10	1.02
14/5/140-143	127.70	5.2678	92.35	2.60	0.34	45.35	54.31	9.00	1.91	0.00	1.23
14/6/10-13	127.90	5.2708	93.08	2.61	0.20	43.27	56.53	9.00	1.76	0.10	1.02
14/6/30-33	128.10	5.2738	92.30	2.84	0.74	45.30	53.96	9.00	1.91	0.00	1.23
14/6/49-52	128.29	5.2767	92.10	2.64	0.20	44.34	55.46	9.00	1.76	0.10	1.02
14/6/69-72	128.49	5.2798	90.24	3.38	0.05	45.12	54.83	9.00	1.91	0.00	1.23
14/6/92-95	128.72	5.2832	90.35	3.51	0.29	44.66	55.06	9.00	1.76	0.10	1.02
14/6/112-115	128.92	5.2863	90.88	3.67	0.04	42.01	57.96	9.33	1.51	0.27	1.02
14/6/130-133	129.10	5.2890	91.57	3.46	0.07	43.05	56.88	9.00	1.76	0.10	1.02
14/7/0-3	129.30	5.2921	92.51	3.20	1.48	44.42	54.10	9.00	2.06	-0.07	1.43
14/7/20-23	129.50	5.2951	91.84	2.91	0.14	43.25	56.60	9.00	1.91	0.00	1.23
14 CC/10-13	129.69	5.2980	91.13	3.48	0.14	42.40	57.46	9.00	1.91	0.00	1.23
15/1/0-3	129.90	5.3012	92.01	3.54	0.12	40.66	59.22	9.33	1.66	0.17	1.23
15/1/22-25	130.12	5.3045	91.25	3.51	0.61	42.45	56.95	9.33	1.51	0.27	1.02
15/1/39-42	130.29	5.3071	91.42	3.52	1.64	42.60	55.76	9.00	2.06	-0.07	1.43
15/1/60-63	130.50	5.3103	93.10	2.85	0.59	41.96	57.46	9.33	1.51	0.27	1.02
15/1/79-82	130.69	5.3132	93.67	2.07	0.46	43.09	56.46	9.33	1.51	0.27	1.02
15/1/99-102	130.89	5.3162	93.11	3.12	0.19	44.64	55.17	9.33	1.51	0.27	1.02
15/1/120-123	131.10	5.3194	93.77	2.47	0.12	42.13	57.75	9.33	1.51	0.27	1.02
15/1/140-143	131.30	5.3224	93.31	2.61	0.10	41.68	58.22	9.33	1.51	0.27	1.02
15/2/11-14	131.51	5.3256	94.07	2.05	0.19	40.38	59.43	9.33	1.51	0.27	1.02
15/2/30-33	131.70	5.3285	94.72	2.22	0.12	40.63	59.25	9.33	1.51	0.27	1.02
15/2/51-53	131.91	5.3317	93.99	2.53	0.10	43.60	56.29	9.33	1.51	0.27	1.02
15/2/71-74	132.11	5.3347	93.10	3.00	0.17	42.73	57.10	9.33	1.51	0.27	1.02
15/2/93-96	132.33	5.3381	92.94	2.96	0.26	43.51	56.23	9.33	1.51	0.27	1.02
15/2/113-116	132.53	5.3411	93.59	2.83	0.15	44.05	55.80	9.33	1.51	0.27	1.02
15/2/134-136	132.74	5.3443	93.70	2.82	0.31	42.62	57.07	9.33	1.51	0.27	1.02
15/3/0-3	132.90	5.3467	93.30	2.88	0.19	39.67	60.14	9.67	1.76	0.35	0.68
15/3/17-20	133.07	5.3493	93.63	2.65	0.24	41.54	58.21	9.33	1.51	0.27	1.02
15/3/39-42	133.29	5.3526	93.29	2.67	0.04	42.86	57.10	9.33	1.51	0.27	1.02
15/3/56-59	133.46	5.3552	93.24	2.79	0.16	42.71	57.13	9.33	1.51	0.27	1.02
15/3/78-81	133.68	5.3586	94.65	1.84	0.13	41.39	58.48	9.33	1.51	0.27	1.02
15/3/99-102	133.89	5.3617	93.03	2.73	0.08	40.78	59.14	9.33	1.51	0.27	1.02
15/3/120-123	134.10	5.3649	93.27	2.37	0.30	42.52	57.19	9.00	1.76	0.10	1.02
15/3/140-143	134.30	5.3680	93.27	2.55	0.25	41.95	57.81	9.33	1.51	0.27	1.02
15/4/10-13	134.50	5.3710	94.46	2.07	0.14	38.29	61.57	9.67	1.76	0.35	0.68
15/4/30-33	134.70	5.3740	95.29	1.40	0.16	39.86	59.98	9.33	1.51	0.27	1.02
15/4/50-53	134.90	5.3771	93.97	2.43	0.19	40.21	59.60	9.33	1.51	0.27	1.02
15/4/70-73	135.10	5.3801	91.46	4.18	0.35	40.27	59.39	9.67	1.76	0.35	1.02
15/4/90-93	135.30	5.3832	90.80	3.76	0.25	40.18	59.58	9.33	1.51	0.27	0.68
15/4/110-113	135.50	5.3862	92.06	3.61	0.28	43.46	56.26	9.33	1.51	0.27	1.02
15/4/130-133	135.70	5.3892	92.63	2.94	0.25	39.99	59.76	9.33	1.51	0.27	1.02
15/5/0-3	135.90	5.3923	93.33	2.49	0.28	40.86	58.86	9.33	1.51	0.27	1.02
15/5/16-19	136.06	5.3947	92.72	2.60	0.31	42.61	57.08	9.33	1.51	0.27	1.02
15/5/42-45	136.32	5.3986	91.92	3.27	0.20	40.98	58.82	9.33	1.51	0.27	1.02
15/5/61-63	136.51	5.4015	92.99	2.61	0.06	39.69	60.26	9.33	1.51	0.27	1.02
15/5/102-105	136.92	5.4078	92.01	3.35	0.33	40.41	59.26	9.67	1.76	0.35	0.68
15/5/123-126	137.13	5.4109	90.94	3.55	0.54	40.42	59.03	9.67	1.76	0.35	0.68
15/5/142-145	137.32	5.4138	90.39	3.96	0.53	37.58	61.89	9.67	1.76	0.35	0.68
15/6/12-15	137.52	5.4169	94.08	2.45	0.15	36.34	63.51	9.67	1.76	0.35	0.68

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
15/6/31-34	137.71	5.4197	94.52	2.74	0.46	35.84	63.71	9.67	1.76	0.35	0.68
15/6/51-54	137.91	5.4228	94.81	2.08	0.31	36.43	63.26	9.67	1.76	0.35	0.68
15/6/65-68	138.05	5.4249	94.18	2.50	0.14	38.00	61.86	9.67	1.76	0.35	0.68
15/6/87-90	138.27	5.4282	94.48	2.41	0.18	37.98	61.84	9.67	1.76	0.35	0.68
15/6/107-110	138.47	5.4313	93.92	2.59	0.22	39.49	60.30	9.67	1.76	0.35	1.02
15/6/126-129	138.66	5.4342	93.88	2.78	0.17	40.18	59.65	9.33	1.51	0.27	1.02
15/7/0-3	138.90	5.4378	94.55	2.26	0.06	40.07	59.87	9.33	1.51	0.27	1.02
15/7/17-20	139.07	5.4404	94.95	1.82	0.09	40.02	59.89	9.67	1.76	0.35	0.68
15 CC/9-11	139.22	5.4427	94.62	2.01	0.40	38.89	60.71	9.33	1.51	0.27	1.02
16/1/0-3	139.50	5.4469	94.86	1.84	0.45	37.67	61.88	9.67	1.76	0.35	0.68
16/1/25-28	139.75	5.4507	94.90	1.82	0.49	39.53	59.98	9.67	1.76	0.35	0.68
16/1/67-70	140.17	5.4571	94.00	2.52	0.15	39.47	60.38	9.33	1.51	0.27	1.02
16/1/84-87	140.34	5.4597	93.32	2.53	0.47	41.73	57.80	9.67	1.76	0.35	1.02
16/1/104-107	140.54	5.4627	94.70	1.81	0.28	39.63	60.08	9.33	1.51	0.27	1.02
16/1/123-126	140.73	5.4656	94.02	1.86	0.22	41.05	58.74	9.33	1.51	0.27	1.02
16/1/142-145	140.92	5.4685	94.60	1.70	0.25	37.62	62.14	9.67	1.76	0.35	0.68
16/2/13-16	141.13	5.4717	93.78	2.33	0.30	38.21	61.49	9.67	1.76	0.35	0.68
16/2/36-39	141.36	5.4752	94.58	2.24	0.05	37.98	61.97	9.67	1.76	0.35	0.68
16/2/54-57	141.54	5.4779	95.57	1.60	0.20	40.67	59.13	9.33	1.51	0.27	1.02
16/2/79-82	141.79	5.4817	95.97	1.39	0.12	43.25	56.63	9.00	1.76	0.10	1.02
16/2/92-95	141.92	5.4837	95.53	1.62	0.13	40.93	58.94	9.33	1.51	0.27	1.02
16/2/112-114	142.12	5.4867	95.74	1.52	0.39	41.83	57.78	9.33	1.51	0.27	1.02
16/2/132-135	142.32	5.4897	94.51	2.13	0.21	39.88	59.91	9.67	1.76	0.35	1.02
16/3/0-3	142.50	5.4925	95.22	1.67	0.14	39.28	60.58	9.33	1.51	0.27	1.02
16/3/25-28	142.75	5.4963	94.08	2.31	0.12	39.71	60.16	9.33	1.51	0.27	1.02
16/3/43-46	142.93	5.4990	94.16	2.15	0.10	39.65	60.25	9.33	1.51	0.27	1.02
16/3/65-68	143.15	5.5023	92.60	2.52	0.10	40.89	59.00	9.33	1.51	0.27	1.02
16/3/82-85	143.32	5.5049	93.86	2.07	0.24	39.98	59.78	9.33	1.51	0.27	1.02
16/3/103-106	143.53	5.5081	92.61	3.05	0.20	37.58	62.21	9.67	1.76	0.35	1.02
16/3/124-127	143.74	5.5116	92.03	2.72	0.10	39.40	60.50	9.33	1.51	0.27	1.02
16/3/134-137	143.84	5.5145	90.79	3.56	0.21	42.13	57.66	9.33	1.51	0.27	1.02
16/4/7-10	144.07	5.5211	93.49	2.17	0.22	39.76	60.02	9.33	1.51	0.27	1.02
16/4/26-29	144.26	5.5266	93.24	2.80	0.42	38.12	61.47	9.33	1.51	0.27	1.02
16/4/46-49	144.46	5.5324	93.36	2.56	0.16	36.51	63.33	9.67	1.76	0.35	0.68
16/4/67-70	144.67	5.5385	87.81	5.20	0.28	40.24	59.48	9.33	1.51	0.27	1.02
16/4/93-96	144.93	5.5460	93.45	1.94	0.46	42.40	57.14	9.33	1.51	0.27	1.02
16/4/113-116	145.13	5.5518	94.77	1.76	0.22	43.23	56.55	9.33	1.51	0.27	1.02
16/4/132-135	145.32	5.5573	94.09	1.94	0.31	43.18	56.51	9.33	1.51	0.27	1.02
16/5/0-3	145.50	5.5626	94.78	1.69	0.34	41.17	58.49	9.33	1.51	0.27	1.02
16/5/14-17	145.64	5.5666	95.11	1.51	0.29	44.71	55.00	9.33	1.51	0.27	1.02
16/5/43-46	145.93	5.5750	95.43	1.61	0.23	43.38	56.39	9.33	1.51	0.27	1.02
16/5/63-66	146.13	5.5808	95.14	1.67	0.13	45.31	54.56	9.33	1.51	0.27	1.02
16/5/86-88	146.36	5.5875	94.39	2.11	0.40	47.10	52.50	9.00	1.76	0.10	1.02
16/5/102-105	146.52	5.5921	95.02	1.65	0.46	49.09	50.46	9.00	1.91	0.00	1.23
16/5/121-124	146.71	5.5976	93.60	2.33	0.23	44.45	55.32	9.33	1.51	0.27	1.02
16/5/142-145	146.92	5.6037	92.39	3.07	0.50	42.15	57.36	9.00	1.76	0.10	1.02
16/6/6-9	147.06	5.6077	93.71	2.27	0.50	40.40	59.10	9.33	1.66	0.17	1.23
16/6/26-29	147.26	5.6135	94.09	2.06	0.20	36.53	63.27	9.33	1.51	0.27	1.02
16/6/47-50	147.47	5.6196	93.61	2.19	0.12	44.47	55.42	9.00	1.91	0.00	1.23
16/6/64-66	147.64	5.6245	93.58	2.60	0.19	42.47	57.33	9.33	1.51	0.27	1.02
16/6/93-96	147.93	5.6329	93.02	2.73	0.48	45.45	54.07	9.33	1.51	0.27	1.02
16/6/115-117	148.15	5.6393	92.86	2.69	0.56	44.77	54.68	9.00	1.76	0.10	1.02
16/6/133-136	148.33	5.6445	91.29	3.23	0.32	45.97	53.72	9.00	1.91	0.00	1.23
16/7/0-3	148.50	5.6494	91.69	3.30	0.61	44.15	55.24	9.00	1.76	0.10	1.02
16/7/17-19	148.67	5.6544	92.10	3.00	0.19	43.38	56.42	9.33	1.51	0.27	1.02
16 CC/8-11	148.77	5.6573	89.71	4.06	0.63	43.88	55.49	9.00	1.91	0.00	1.23
17/1/0-3	149.10	5.6668	92.48	2.47	0.50	43.87	55.64	9.00	1.76	0.10	1.02
17/1/26-28	149.36	5.6743	93.45	2.35	0.62	43.24	56.14	9.00	1.76	0.10	1.02
17/1/42-45	149.52	5.6790	91.99	2.16	0.54	43.62	55.84	9.00	1.91	0.00	1.23
17/1/82-85	149.92	5.6906	93.33	3.12	0.19	39.39	60.42	9.33	1.51	0.27	1.02
17/1/101-104	150.11	5.6961	93.52	2.62	0.65	40.56	58.79	9.00	1.91	0.00	1.23
17/1/121-124	150.31	5.7019	91.29	3.85	0.50	40.81	58.69	9.00	2.06	-0.07	1.43

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
17/1/141-144	150.51	5.7076	90.52	3.97	0.89	38.95	60.16	9.00	2.06	-0.07	1.43
17/2/7-10	150.67	5.7123	90.98	3.78	0.31	44.91	54.78	9.33	1.51	0.27	1.02
17/2/27-30	150.87	5.7181	92.13	3.13	0.86	47.72	51.41	9.00	1.91	0.00	1.23
17/2/47-50	151.07	5.7239	92.60	2.44	0.69	44.11	55.20	9.00	1.91	0.00	1.23
17/2/73-76	151.33	5.7314	92.67	2.57	1.11	42.54	56.35	9.00	1.91	0.00	1.23
17/2/92-95	151.52	5.7369	92.52	2.06	0.24	41.70	58.06	9.00	1.91	0.00	1.23
17/2/115-118	151.75	5.7436	92.62	2.48	0.88	41.77	57.35	9.00	1.91	0.00	1.23
17/2/136-138	151.96	5.7496	91.09	3.56	0.67	46.24	53.08	9.00	1.91	0.00	1.23
17/3/0-3	152.10	5.7537	92.93	2.74	0.42	38.37	61.21	9.33	1.51	0.27	1.02
17/3/15-18	152.25	5.7580	94.30	2.05	0.64	40.56	58.81	9.00	1.91	0.00	1.23
17/3/37-40	152.47	5.7644	94.93	1.66	0.36	43.16	56.48	9.00	1.91	0.00	1.23
17/3/65-67	152.75	5.7725	94.45	1.86	0.43	43.25	56.33	9.33	1.51	0.27	1.02
17/3/81-84	152.91	5.7772	94.38	1.91	0.35	43.17	56.49	9.00	1.91	0.00	1.23
17/3/102-105	153.12	5.7832	93.48	2.56	0.23	40.24	59.54	9.33	1.51	0.27	1.02
17/3/116-119	153.26	5.7873	93.41	2.60	0.48	45.05	54.47	9.00	1.91	0.00	1.23
17/3/135-138	153.45	5.7928	93.28	2.35	0.39	43.05	56.56	9.00	1.91	0.00	1.23
17/4/6-9	153.66	5.7989	94.22	2.27	0.59	41.94	57.47	9.00	2.06	-0.07	1.43
17/4/37-39	153.97	5.8079	96.18	1.37	0.77	38.91	60.31	9.33	1.66	0.17	1.23
17/4/53-56	154.13	5.8125	95.67	1.64	0.29	40.03	59.69	9.33	1.66	0.17	1.23
17/4/72-75	154.32	5.8180	95.78	1.54	0.33	40.36	59.31	9.33	1.66	0.17	1.23
17/4/94-97	154.54	5.8244	95.12	1.71	0.44	42.83	56.74	9.00	1.91	0.00	1.23
17/4/117-119	154.77	5.8310	94.55	2.29	0.45	38.07	61.49	9.33	1.51	0.27	1.02
17/4/135-138	154.95	5.8362	94.01	2.37	0.28	40.22	59.50	9.33	1.66	0.17	1.23
17/5/0-3	155.10	5.8406	93.10	3.15	0.22	37.92	61.87	9.33	1.51	0.27	1.02
17/5/14-17	155.24	5.8446	93.71	2.84	0.36	41.60	58.03	9.33	1.51	0.27	1.02
17/5/38-40	155.48	5.8516	93.31	2.98	0.42	42.37	57.21	9.00	1.91	0.00	1.23
17/5/57-60	155.67	5.8571	94.99	2.06	0.27	40.89	58.84	9.33	1.66	0.17	1.23
17/5/84-87	155.94	5.8649	95.89	1.76	0.43	41.60	57.98	9.33	1.51	0.27	1.02
17/5/103-106	156.13	5.8704	95.07	2.02	0.09	41.30	58.61	9.33	1.66	0.17	1.23
17/5/117-120	156.27	5.8745	94.34	2.14	0.31	41.23	58.46	9.33	1.66	0.17	1.23
17/5/137-140	156.47	5.8803	94.35	1.98	1.00	38.03	60.97	9.67	1.91	0.25	0.82
17/6/11-14	156.71	5.8872	94.25	2.08	0.69	43.47	55.83	9.00	1.91	0.00	1.23
17/6/35-38	156.95	5.8942	94.77	2.35	0.24	44.33	55.42	9.00	1.76	0.10	1.02
17/6/52-55	157.12	5.8991	94.14	2.32	0.25	45.02	54.72	9.00	1.91	0.00	1.23
17/6/77-79	157.37	5.9063	94.15	2.31	0.04	44.72	55.24	9.00	1.91	0.00	1.23
17/6/92-95	157.52	5.9107	93.47	2.57	0.29	45.49	54.22	9.00	1.91	0.00	1.23
17/6/116-119	157.76	5.9176	93.92	2.81	0.36	39.41	60.23	9.33	1.51	0.27	1.02
17/6/133-136	157.93	5.9225	95.51	2.02	0.23	41.68	58.08	9.33	2.16	0.10	1.23
17/7/0-3	158.10	5.9275	93.60	2.35	1.23	41.17	57.60	9.00	1.91	0.00	1.23
17/7/17-20	158.27	5.9324	93.37	2.45	1.58	41.96	56.46	9.00	1.91	0.00	1.23
17 CC/6-9	158.52	5.9396	92.39	3.42	0.11	41.42	58.47	9.00	1.91	0.00	1.23
18/1/0-3	158.70	5.9448	92.24	4.13	0.16	37.37	62.47	9.33	1.51	0.27	0.68
18/1/25-28	158.95	5.9521	95.51	1.39	0.62	41.72	57.66	9.00	1.76	0.10	0.68
18/1/43-46	159.13	5.9573	93.72	2.15	0.15	41.43	58.42	9.33	1.51	0.27	1.02
18/1/65-68	159.35	5.9637	93.36	2.28	0.76	45.41	53.83	9.00	1.91	0.00	1.23
18/1/79-82	159.49	5.9677	92.14	2.76	1.79	45.29	52.92	9.00	1.91	0.00	1.23
18/1/102-105	159.72	5.9744	91.76	3.38	0.51	41.10	58.39	9.67	1.76	0.35	0.68
18/1/116-119	159.86	5.9784	91.73	3.42	0.19	39.69	60.12	9.67	1.76	0.35	0.68
18/1/141-144	160.11	5.9857	91.04	3.72	0.47	45.46	54.07	9.00	1.91	0.00	1.23
18/2/13-16	160.33	5.9921	91.05	4.10	0.61	40.89	58.50	9.00	1.91	0.00	1.23
18/2/34-37	160.54	5.9981	90.12	4.75	0.47	43.02	56.51	9.00	2.06	-0.07	1.43
18/2/53-56	160.73	6.0036	90.64	4.72	0.17	39.63	60.20	9.33	1.51	0.27	1.02
18/2/79-82	160.99	6.0112	91.07	4.18	0.22	36.69	63.10	9.67	1.76	0.35	0.68
18/2/96-99	161.16	6.0161	93.25	2.33	0.85	43.26	55.89	9.33	2.16	0.10	1.23
18/2/112-114	161.32	6.0207	93.80	2.61	0.04	40.84	59.12	9.67	1.76	0.35	0.68
18/2/133-136	161.53	6.0268	94.04	2.23	0.22	40.13	59.65	9.33	1.51	0.27	1.02
18/3/0-3	161.70	6.0317	94.43	2.64	0.48	40.78	58.74	9.33	2.31	0.17	0.69
18/3/14-17	161.84	6.0358	92.12	3.54	0.21	40.93	58.86	9.00	2.21	0.00	1.64
18/3/42-45	162.12	6.0439	93.06	2.60	0.76	44.19	55.05	9.67	1.61	0.50	0.55
18/3/56-59	162.26	6.0479	93.97	2.45	0.28	42.02	57.69	9.33	1.51	0.27	1.02
18/3/85-88	162.55	6.0563	92.85	3.07	0.38	41.14	58.48	9.33	1.51	0.27	1.02
18/3/117-120	162.87	6.0656	93.28	2.53	0.10	40.20	59.70	9.33	1.51	0.27	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
18/3/135-137	163.05	6.0708	92.18	3.25	0.42	40.22	59.35	9.33	1.51	0.27	1.02
18/4/13-16	163.33	6.0789	93.08	3.15	0.41	43.02	56.57	9.33	1.51	0.27	1.02
18/4/36-39	163.56	6.0856	91.97	3.01	0.41	42.62	56.97	9.33	1.51	0.27	1.02
18/4/53-56	163.73	6.0905	91.27	3.38	0.28	43.30	56.42	9.33	1.51	0.27	1.02
18/4/73-76	163.93	6.0963	91.18	4.07	0.29	41.93	57.79	9.33	1.51	0.27	1.02
18/4/93-96	164.13	6.1021	90.80	3.90	0.83	43.99	55.18	9.33	1.51	0.27	1.02
18/4/111-113	164.31	6.1073	92.79	3.06	0.45	46.93	52.63	9.33	1.51	0.27	1.02
18/4/132-135	164.52	6.1134	93.81	2.63	0.62	44.49	54.89	9.33	1.51	0.27	1.02
18/5/0-3	164.70	6.1186	93.33	3.12	0.42	45.41	54.17	9.33	1.51	0.27	1.02
18/5/26-29	164.96	6.1261	91.95	3.69	0.36	44.64	55.01	9.33	1.51	0.27	1.02
18/5/43-46	165.13	6.1311	93.20	2.73	0.17	41.50	58.34	9.33	1.51	0.27	1.02
18/5/65-67	165.35	6.1374	93.94	2.41	0.13	42.74	57.13	9.33	1.51	0.27	1.02
18/5/80-83	165.50	6.1418	93.18	2.73	0.17	40.85	58.98	9.33	1.51	0.27	1.02
18/5/104-106	165.74	6.1487	92.21	4.03	0.45	45.13	54.41	9.00	1.76	0.10	1.02
18/5/125-127	165.95	6.1548	93.17	2.71	0.19	44.58	55.23	9.33	1.51	0.27	1.02
18/5/141-144	166.11	6.1594	92.96	3.22	0.33	45.64	54.03	9.33	1.51	0.27	1.02
18/6/6-9	166.26	6.1638	91.69	4.19	0.12	45.59	54.29	9.33	1.51	0.27	1.02
18/6/26-29	166.46	6.1696	91.99	3.42	0.21	45.06	54.74	9.33	1.51	0.27	1.02
18/6/46-49	166.66	6.1754	92.93	3.31	0.09	48.28	51.63	9.33	1.51	0.27	1.02
18/6/66-68	166.86	6.1812	92.53	3.11	0.16	48.06	51.78	9.33	1.51	0.27	1.02
18/6/86-89	167.06	6.1870	91.09	4.35	0.15	46.24	53.61	9.33	1.51	0.27	1.02
18/6/104-106	167.24	6.1922	90.94	4.85	0.22	46.48	53.30	9.33	1.51	0.27	1.02
18/6/124-127	167.44	6.1980	90.08	3.91	0.17	47.96	51.87	9.33	1.51	0.27	1.02
18 CC/7-10	167.57	6.2017	89.77	4.66	0.54	46.30	53.16	9.33	1.51	0.27	1.02
19/1/0-3	168.30	6.2229	93.33	2.51	0.65	47.86	51.49	9.33	1.51	0.27	1.02
19/1/22-24	168.52	6.2292	91.94	3.42	1.00	49.27	49.73	8.67	1.76	0.55	1.02
19/1/41-44	168.71	6.2347	90.70	3.21	0.27	44.90	54.82	9.33	1.51	0.27	1.02
19/1/62-65	168.92	6.2408	92.70	3.15	0.57	48.91	50.52	9.00	1.76	0.10	1.02
19/1/83-85	169.13	6.2469	92.28	3.09	0.75	46.58	52.67	9.00	1.76	0.10	1.02
19/1/104-107	169.34	6.2530	91.90	3.43	0.36	44.53	55.12	9.33	1.51	0.27	1.02
19/1/121-124	169.51	6.2579	91.73	3.16	0.50	44.57	54.93	9.00	1.76	0.10	1.02
19/1/142-145	169.72	6.2640	93.01	3.68	0.52	42.18	57.30	9.33	1.51	0.27	1.02
19/2/5-8	169.85	6.2678	93.15	3.04	0.28	44.94	54.78	9.33	1.51	0.27	1.02
19/2/26-28	170.06	6.2738	91.45	3.83	0.79	45.38	53.83	9.00	1.76	0.10	1.02
19/2/52-55	170.32	6.2814	90.99	3.72	0.27	46.58	53.15	9.00	1.76	0.10	1.02
19/2/72-74	170.52	6.2872	93.19	3.61	0.52	49.15	50.33	9.00	1.76	0.10	1.02
19/2/93-96	170.73	6.2933	93.26	3.39	0.51	47.90	51.60	9.00	1.76	0.10	1.02
19/2/114-117	170.94	6.2993	92.45	2.72	0.51	48.52	50.97	9.00	1.76	0.10	1.02
19/2/135-138	171.15	6.3054	92.02	2.91	0.78	46.44	52.78	9.33	1.51	0.27	1.02
19/3/0-3	171.30	6.3098	91.59	4.74	0.56	44.27	55.17	9.33	1.51	0.27	1.02
19/3/27-29	171.57	6.3176	92.17	2.36	0.27	48.07	51.66	9.33	1.51	0.27	1.02
19/3/42-45	171.72	6.3219	91.78	3.13	0.76	49.68	49.56	8.67	1.91	0.42	1.23
19/3/62-64	171.92	6.3277	93.51	2.37	0.75	46.21	53.04	9.00	1.76	0.10	1.02
19/3/83-86	172.13	6.3338	92.28	3.30	0.44	47.30	52.26	9.00	1.76	0.10	1.02
19/3/102-105	172.32	6.3393	92.46	2.98	0.49	47.30	52.22	9.00	1.76	0.10	1.02
19/3/117-120	172.47	6.3436	88.99	3.70	1.01	47.44	51.55	9.00	1.91	0.00	1.23
19/3/136-138	172.66	6.3491	92.67	3.15	0.58	47.57	51.85	9.33	1.51	0.27	1.02
19/4/6-9	172.86	6.3549	91.82	3.37	0.80	49.98	49.22	8.67	1.76	0.55	1.02
19/4/27-29	173.07	6.3610	92.06	3.29	0.77	48.34	50.89	9.00	1.91	0.00	1.23
19/4/47-50	173.27	6.3668	92.04	3.15	0.61	48.57	50.82	9.00	1.76	0.10	1.02
19/4/72-74	173.52	6.3741	92.22	3.12	0.55	51.31	48.14	8.67	1.91	0.42	1.23
19/4/92-95	173.72	6.3798	94.38	1.96	0.36	47.89	51.76	9.00	1.76	0.10	1.02
19/4/113-115	173.93	6.3859	93.46	2.26	0.41	45.83	53.77	9.33	1.51	0.27	1.02
19/4/134-137	174.14	6.3920	93.60	2.32	0.71	45.07	54.23	9.00	1.76	0.10	1.02
19/5/0-3	174.30	6.3966	93.79	2.39	0.42	43.60	55.97	9.33	1.51	0.27	1.02
19/5/24-27	174.54	6.4036	95.36	1.63	0.41	45.57	54.02	9.33	1.51	0.27	1.02
19/5/42-45	174.72	6.4088	95.26	1.77	0.41	49.77	49.82	8.67	1.76	0.55	1.02
19/5/56-59	174.86	6.4129	95.10	1.73	0.42	47.56	52.02	9.33	1.51	0.27	1.02
19/5/96-99	175.26	6.4244	96.38	1.00	0.44	48.79	50.77	9.33	1.51	0.27	1.02
19/5/117-120	175.47	6.4305	95.88	1.34	0.43	46.09	53.49	9.33	1.51	0.27	1.02
19/5/141-144	175.71	6.4375	95.86	1.43	0.43	45.13	54.44	9.33	1.51	0.27	1.02
19/6/6-9	175.86	6.4418	94.96	1.86	0.51	48.00	51.49	9.33	1.51	0.27	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
19/6/26-29	176.06	6.4476	94.61	2.04	0.70	49.10	50.21	9.00	1.76	0.10	1.02
19/6/52-55	176.32	6.4551	95.95	1.55	0.78	45.95	53.28	9.33	1.51	0.27	1.02
19/6/67-69	176.47	6.4595	94.87	2.15	0.40	46.79	52.81	9.33	1.51	0.27	1.02
19/6/84-87	176.64	6.4644	94.32	2.39	0.38	47.49	52.13	9.33	1.51	0.27	1.02
19/6/112-114	176.92	6.4725	96.35	1.29	0.73	46.20	53.08	9.00	1.76	0.10	1.02
19/6/134-137	177.14	6.4789	97.48	0.83	0.26	44.05	55.69	9.33	1.51	0.27	1.02
19/7/0-3	177.30	6.4835	96.07	0.91	0.45	46.95	52.60	9.33	1.51	0.27	1.02
19/7/22-25	177.52	6.4899	96.88	0.78	0.36	43.93	55.71	9.33	1.51	0.27	1.02
19 CC/0-3	177.82	6.4986	94.95	1.84	0.46	45.45	54.09	9.33	1.51	0.27	1.02
20/1/0-3	177.90	6.5009	95.81	1.66	0.64	44.30	55.05	9.33	1.51	0.27	1.02
20/1/15-18	178.05	6.5052	96.16	1.46	0.43	46.82	52.74	9.33	1.51	0.27	1.02
20/1/37-40	178.27	6.5116	96.42	1.33	0.39	43.18	56.44	9.33	1.51	0.27	1.02
20/1/58-60	178.48	6.5177	95.81	1.62	0.36	43.49	56.14	9.33	1.51	0.27	1.02
20/1/78-80	178.68	6.5235	96.30	1.30	0.43	41.59	57.98	9.33	1.51	0.27	1.02
20/1/97-99	178.87	6.5290	96.60	1.30	0.35	45.17	54.48	9.33	1.51	0.27	1.02
20/1/118-120	179.08	6.5351	96.56	1.01	0.35	43.35	56.30	9.33	1.51	0.27	1.02
20/1/137-139	179.27	6.5406	97.48	0.86	0.31	42.90	56.79	9.33	1.51	0.27	1.02
20/2/5-7	179.45	6.5458	97.66	0.70	0.32	45.38	54.30	9.33	1.51	0.27	1.02
20/2/27-29	179.67	6.5522	95.86	1.42	0.30	44.55	55.15	9.33	1.51	0.27	1.02
20/2/46-48	179.86	6.5577	96.34	1.34	0.33	44.79	54.88	9.33	1.51	0.27	1.02
20/2/77-79	180.17	6.5666	96.96	1.10	0.59	44.61	54.80	9.33	1.51	0.27	1.02
20/2/93-95	180.33	6.5713	95.78	1.63	0.41	46.36	53.22	9.33	1.51	0.27	1.02
20/2/106-108	180.46	6.5750	95.39	1.90	0.36	47.81	51.83	9.33	1.51	0.27	1.02
20/2/133-135	180.73	6.5829	94.76	2.58	0.44	43.54	56.02	9.33	1.51	0.27	1.02
20/3/1-3	180.91	6.5881	94.91	2.17	0.46	42.79	56.74	9.33	1.51	0.27	1.02
20/3/24-26	181.14	6.5947	97.34	1.11	0.41	41.57	58.02	9.33	1.51	0.27	1.02
20/3/42-44	181.32	6.6000	96.74	1.39	0.39	42.55	57.06	9.33	1.51	0.27	1.02
20/3/67-69	181.57	6.6072	97.21	0.92	0.43	46.77	52.80	9.33	1.51	0.27	1.02
20/3/82-84	181.72	6.6115	96.93	1.04	0.35	44.85	54.81	9.33	1.51	0.27	1.02
20/3/96-98	181.86	6.6156	96.95	0.97	0.30	43.65	56.05	9.33	1.51	0.27	1.02
20/3/116-118	182.06	6.6214	97.11	1.01	0.23	41.82	57.95	9.33	1.51	0.27	1.02
20/3/133-135	182.23	6.6263	97.51	1.00	0.72	43.14	56.14	9.33	1.51	0.27	1.02
20/4/7-9	182.47	6.6333	96.11	1.36	0.52	42.21	57.28	9.33	1.51	0.27	1.02
20/4/28-30	182.68	6.6393	95.44	1.77	0.45	43.75	55.80	9.33	1.51	0.27	1.02
20/4/48-50	182.88	6.6451	95.39	1.72	0.43	43.52	56.05	9.33	1.51	0.27	1.02
20/4/68-70	183.08	6.6509	93.90	2.99	0.42	41.85	57.72	9.33	1.51	0.27	1.02
20/4/86-88	183.26	6.6561	96.43	1.30	0.48	42.41	57.11	9.33	1.51	0.27	1.02
20/4/105-107	183.45	6.6616	95.76	1.43	0.50	45.87	53.63	9.33	1.51	0.27	1.02
20/4/132-135	183.72	6.6695	94.26	2.05	0.43	43.65	55.91	9.33	1.51	0.27	1.02
20/5/1-3	183.91	6.6750	94.24	2.13	0.49	46.54	52.97	9.33	1.51	0.27	1.02
20/5/25-27	184.15	6.6819	94.59	1.88	0.51	42.67	56.82	9.33	1.51	0.27	1.02
20/5/42-44	184.32	6.6868	94.64	1.80	0.52	47.80	51.69	9.33	1.51	0.27	1.02
20/5/61-63	184.51	6.6923	92.45	3.06	0.90	46.17	52.94	9.33	1.51	0.27	1.02
20/5/82-84	184.72	6.6984	94.11	2.05	0.51	47.08	52.41	9.33	1.51	0.27	1.02
20/5/101-103	184.91	6.7039	92.66	3.21	0.41	47.48	52.11	9.33	1.51	0.27	1.02
20/5/117-119	185.07	6.7086	91.87	2.78	0.47	48.89	50.64	9.33	1.51	0.27	1.02
20/5/137-139	185.27	6.7144	93.33	3.23	0.51	45.83	53.67	9.33	1.51	0.27	1.02
20/6/7-9	185.47	6.7201	94.94	1.84	0.45	47.98	51.58	9.33	1.51	0.27	1.02
20/6/34-36	185.74	6.7280	95.91	1.22	0.59	47.21	52.20	9.33	1.51	0.27	1.02
20/6/52-54	185.92	6.7332	95.12	1.86	0.47	47.02	52.51	9.33	1.51	0.27	1.02
20/6/68-70	186.08	6.7378	93.97	2.42	0.71	48.01	51.29	9.33	1.51	0.27	1.02
20/6/92-94	186.32	6.7448	94.77	1.92	0.53	47.28	52.20	9.33	1.51	0.27	1.02
20/6/111-113	186.51	6.7503	95.79	1.71	0.44	44.72	54.84	9.33	1.51	0.27	1.02
20/6/132-134	186.72	6.7563	96.01	1.48	0.33	43.48	56.19	9.33	1.51	0.27	1.02
20/7/0-2	186.90	6.7616	94.52	2.16	0.25	42.07	57.69	9.33	1.51	0.27	1.02
20/7/17-19	187.07	6.7665	93.86	2.57	0.22	44.19	55.59	9.33	1.51	0.27	1.02
20 CC/7-9	187.22	6.7708	93.18	3.66	0.22	42.21	57.58	9.33	1.51	0.27	1.02
21/1/1-3	187.51	6.7792	94.80	2.07	0.22	41.38	58.40	9.33	1.51	0.27	1.02
21/1/26-28	187.76	6.7865	96.49	1.34	0.37	39.84	59.79	9.33	1.51	0.27	1.02
21/1/43-45	187.93	6.7914	96.30	1.24	0.35	44.18	55.47	9.33	1.51	0.27	1.02
21/1/58-60	188.08	6.7957	95.89	1.47	0.21	41.07	58.71	9.33	1.51	0.27	1.02
21/182-84	188.32	6.8027	95.67	1.76	0.34	43.80	55.86	9.33	1.51	0.27	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
21/1/102-104	188.52	6.8085	96.00	1.76	0.34	45.86	53.80	9.33	1.51	0.27	1.02
21/1/117-119	188.67	6.8128	96.20	1.49	0.34	42.15	57.51	9.33	1.51	0.27	1.02
21/1142-144	188.92	6.8201	95.98	1.61	0.35	41.17	58.48	9.33	1.51	0.27	1.02
21/2/8-10	189.08	6.8247	91.42	2.85	0.42	45.20	54.38	9.33	1.51	0.27	1.02
21/2/33-35	189.33	6.8319	95.88	1.34	0.32	44.50	55.17	9.33	1.51	0.27	1.02
21/2/46-48	189.46	6.8357	96.52	0.94	0.31	44.49	55.20	9.33	1.51	0.27	1.02
21/2/75-77	189.75	6.8441	95.98	1.23	0.39	45.12	54.49	9.33	1.51	0.27	1.02
21/2/93-96	189.93	6.8493	95.64	1.56	0.23	44.50	55.27	9.33	1.51	0.27	1.02
21/2/117-119	190.17	6.8563	95.41	1.78	0.36	44.73	54.91	9.33	1.51	0.27	1.02
21/2/142-144	190.42	6.8635	96.67	0.90	0.42	43.58	56.00	9.33	1.51	0.27	1.02
21/3/1-3	190.51	6.8661	96.41	1.13	0.37	43.82	55.81	9.33	1.51	0.27	1.02
21/3/16-18	190.66	6.8705	96.03	1.17	0.35	42.89	56.77	9.33	1.51	0.27	1.02
21/3/37-39	190.87	6.8765	96.37	1.07	0.26	43.50	56.24	9.33	1.51	0.27	1.02
21/3/62-64	191.12	6.8838	95.03	1.79	0.39	42.72	56.89	9.33	1.51	0.27	1.02
21/3/82-84	191.32	6.8896	95.10	1.74	0.42	42.41	57.17	9.33	1.51	0.27	1.02
21/3/102-104	191.52	6.8954	94.55	1.94	0.40	45.77	53.83	9.33	1.51	0.27	1.02
21/3/121-123	191.71	6.9009	95.50	1.64	0.45	42.29	57.26	9.33	1.51	0.27	1.02
21/3/136-139	191.86	6.9052	95.14	1.59	0.31	45.31	54.38	9.33	1.51	0.27	1.02
21/4/7-9	192.07	6.9113	95.64	1.52	0.39	45.47	54.14	9.33	1.51	0.27	1.02
21/4/36-38	192.36	6.9197	95.28	1.40	0.38	42.56	57.06	9.33	1.51	0.27	1.02
21/4/52-54	192.52	6.9243	95.37	1.52	0.36	49.16	50.49	9.33	1.51	0.27	1.02
21/4/73-75	192.73	6.9304	95.02	1.88	0.38	47.42	52.20	9.33	1.51	0.27	1.02
21/4/96-98	192.96	6.9371	94.07	2.35	0.26	46.60	53.14	9.33	1.51	0.27	1.02
21/4/112-114	193.12	6.9417	93.40	2.67	0.25	42.96	56.79	9.33	1.51	0.27	1.02
21/4/133-135	193.33	6.9478	95.39	1.59	0.38	42.96	56.67	9.33	1.51	0.27	1.02
21/5/0-2	193.50	6.9527	93.91	2.19	0.35	43.34	56.31	9.33	1.51	0.27	1.02
21/5/22-24	193.72	6.9591	93.92	2.51	0.42	44.59	54.99	9.33	1.51	0.27	1.02
21/5/42-44	193.92	6.9649	94.98	2.08	0.41	41.11	58.49	9.33	1.51	0.27	1.02
21/5/62-64	194.12	6.9707	94.73	2.46	0.48	46.19	53.33	9.33	1.51	0.27	1.02
21/5/84-86	194.34	6.9770	88.84	5.39	0.55	43.04	56.41	9.33	1.51	0.27	1.02
21/5/102-104	194.52	6.9822	91.46	3.63	1.02	43.40	55.58	9.33	1.51	0.27	1.02
21/5/122-124	194.72	6.9880	94.49	2.08	0.51	48.12	51.38	9.33	1.51	0.27	1.02
21/5/140-142	194.90	6.9932	93.70	2.07	0.59	46.17	53.24	9.33	1.51	0.27	1.02
21/6/7-9	195.07	6.9982	93.18	2.98	0.52	47.04	52.44	9.33	1.51	0.27	1.02
21/6/33-35	195.33	7.0057	95.25	2.04	0.51	46.71	52.78	9.33	1.51	0.27	1.02
21/6/49-51	195.49	7.0103	93.76	2.49	0.45	43.90	55.65	9.33	1.51	0.27	1.02
21/6/66-68	195.66	7.0153	94.36	2.15	0.51	44.91	54.57	9.33	1.51	0.27	1.02
21/6/87-89	195.87	7.0213	93.40	2.42	0.57	45.38	54.05	9.33	1.51	0.27	1.02
21/6/107-109	196.07	7.0271	93.11	2.73	0.62	47.85	51.54	9.00	1.76	0.10	1.02
21/6/134-136	196.34	7.0350	92.80	2.83	0.52	45.69	53.79	9.33	1.51	0.27	1.02
21/7/0-2	196.50	7.0396	93.27	2.95	0.93	47.07	52.00	9.00	1.91	0.00	1.23
21/7/22-24	196.72	7.0460	94.89	1.90	0.54	46.15	53.31	9.00	1.76	0.10	1.02
21 CC/6-8	197.00	7.0541	93.67	2.54	1.01	45.20	53.79	9.00	1.91	0.00	1.23
22/1/1-3	197.11	7.0573	94.73	1.97	0.42	45.74	53.83	9.33	1.51	0.27	1.02
22/1/16-18	197.26	7.0616	94.88	1.80	0.48	43.61	55.92	9.33	1.51	0.27	1.02
22/1/38-40	197.48	7.0680	94.25	1.77	0.50	45.89	53.61	9.33	1.51	0.27	1.02
22/1/58-60	197.68	7.0738	94.60	1.70	0.73	46.08	53.20	9.33	1.51	0.27	1.02
22/1/84-86	197.94	7.0813	95.17	1.45	0.47	46.31	53.22	9.33	1.51	0.27	1.02
22/1/104-106	198.14	7.0871	94.68	1.44	0.58	45.07	54.35	9.33	1.51	0.27	1.02
22/1/122-124	198.32	7.0923	96.82	1.10	0.49	44.69	54.81	9.33	1.51	0.27	1.02
22/1/142-144	198.52	7.0981	94.26	2.19	0.64	42.81	56.55	9.33	1.51	0.27	1.02
22/2/13-15	198.73	7.1042	94.02	2.18	0.71	43.98	55.31	9.33	1.51	0.27	1.02
22/2/32-34	198.92	7.1097	92.71	2.96	0.99	48.21	50.80	9.00	1.76	0.10	1.02
22/2/54-56	199.14	7.1160	94.12	2.03	0.89	51.78	47.33	8.67	1.76	0.55	1.02
22/2/74-77	199.34	7.1218	92.75	2.87	0.74	48.64	50.62	9.00	1.76	0.10	1.02
22/2/93-95	199.53	7.1273	93.83	1.98	0.47	47.27	52.26	9.33	1.51	0.27	1.02
22/2/112-114	199.72	7.1328	94.27	2.07	0.71	49.07	50.22	9.00	1.76	0.10	1.02
22/2/133-135	199.93	7.1389	92.77	2.41	0.57	48.70	50.74	9.00	1.76	0.10	1.02
22/3/1-3	200.11	7.1441	94.52	1.71	0.84	49.09	50.07	9.00	1.76	0.10	1.02
22/3/15-17	200.25	7.1482	92.85	2.50	0.71	48.80	50.49	9.00	1.76	0.10	1.02
22/3/42-44	200.52	7.1560	93.46	2.34	0.78	44.29	54.93	9.33	1.51	0.27	1.02
22/3/56-58	200.66	7.1601	93.16	2.61	0.99	49.88	49.12	8.67	1.76	0.55	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
22/3/82-84	200.92	7.1676	92.98	2.75	0.86	49.85	49.28	8.67	1.76	0.55	1.02
22/3/95-97	201.05	7.1714	93.68	2.09	0.80	47.16	52.04	9.33	1.51	0.27	1.02
22/3/117-119	201.27	7.1777	93.85	2.47	0.49	48.86	50.65	9.33	1.51	0.27	1.02
22/3/132-134	201.42	7.1821	93.60	2.47	0.46	46.63	52.91	9.33	1.51	0.27	1.02
22/4/7-9	201.67	7.1893	93.67	2.51	0.51	44.48	55.00	9.33	1.51	0.27	1.02
22/4/33-35	201.93	7.1968	94.00	2.06	0.70	46.49	52.82	9.33	1.51	0.27	1.02
22/4/73-75	202.33	7.2084	94.65	1.54	0.72	51.32	47.96	8.67	1.76	0.55	1.02
22/4/92-95	202.52	7.2139	94.36	1.69	0.58	51.34	48.08	8.67	1.76	0.55	1.02
22/4/113-115	202.73	7.2200	94.49	1.91	0.67	55.71	43.62	8.67	1.76	0.55	1.02
22/4/133-135	202.93	7.2258	95.10	1.69	0.67	58.22	41.11	8.67	1.76	0.55	1.02
22 CC/7-10	203.17	7.2328	93.23	1.98	0.51	37.96	61.53	9.33	1.51	0.27	1.02
23/1/1-3	206.71	7.3502	95.55	1.38	0.36	46.30	53.34	9.33	1.51	0.27	1.02
23/1/15-17	206.85	7.3549	94.94	1.70	0.45	49.87	49.69	8.67	1.76	0.55	1.02
23/1/43-45	207.13	7.3643	93.86	1.96	0.68	49.17	50.15	8.67	1.76	0.55	1.02
23/1/58-60	207.28	7.3693	94.29	1.95	0.69	47.25	52.06	9.00	1.76	0.10	1.02
23/1/78-80	207.48	7.3760	94.46	1.91	0.70	46.81	52.49	9.33	1.51	0.27	1.02
23/1/103-105	207.73	7.3844	93.62	2.43	0.74	47.95	51.31	9.00	1.76	0.10	1.02
23/1/118-120	207.88	7.3894	93.98	2.49	0.59	48.79	50.62	9.33	1.51	0.27	1.02
23/1/142-144	208.12	7.3974	95.72	1.62	0.50	51.46	48.05	8.67	1.76	0.55	1.02
23/2/6-8	208.26	7.4021	96.41	1.26	0.45	48.73	50.83	9.33	1.51	0.27	1.02
23/2/32-34	208.52	7.4108	95.93	1.24	0.36	50.15	49.49	9.00	1.51	0.80	1.02
23/2/53-55	208.73	7.4179	95.80	1.39	0.64	50.52	48.84	8.67	1.76	0.55	1.02
23/2/86-88	209.06	7.4289	94.54	2.38	0.57	50.51	48.92	8.67	1.76	0.55	1.02
23/2/107-109	209.27	7.4360	95.02	1.78	0.37	50.12	49.50	9.00	1.76	0.55	1.02
23/2/134-136	209.54	7.4450	95.83	1.55	0.44	49.51	50.04	8.67	1.76	0.55	1.02
23/3/0-2	209.70	7.4504	96.30	1.19	0.45	50.01	49.53	8.67	1.76	0.55	1.02
23/3/15-17	209.85	7.4554	96.26	1.13	0.48	51.72	47.80	8.67	1.76	0.55	1.02
23/3/42-44	210.12	7.4644	95.05	1.70	0.43	49.70	49.86	8.67	1.76	0.55	1.02
23/3/63-65	210.33	7.4715	94.85	1.69	0.86	49.68	49.46	8.67	1.91	0.42	1.23
23/3/83-85	210.53	7.4782	95.77	1.45	0.35	46.63	53.02	9.33	1.51	0.27	1.02
23/3/102-104	210.72	7.4845	95.81	1.70	0.24	49.55	50.21	9.00	1.76	0.10	1.02
23/3/117-119	210.87	7.4896	96.09	1.23	0.24	46.28	53.48	9.33	1.51	0.27	1.02
23/3/136-138	211.06	7.4959	95.07	1.60	0.41	48.74	50.85	9.00	1.76	0.10	1.02
23/4/7-9	211.27	7.5030	94.02	2.12	0.62	48.32	51.06	9.00	1.76	0.10	1.02
23/4/32-34	211.52	7.5113	94.29	1.93	0.55	50.25	49.20	8.67	1.76	0.55	1.02
23/4/52-54	211.72	7.5180	94.10	2.32	0.42	49.88	49.70	8.67	1.76	0.55	1.02
23/4/73-75	211.93	7.5251	93.43	2.48	0.52	49.67	49.81	8.67	1.76	0.55	1.02
23/4/93-95	212.13	7.5318	92.84	2.71	0.59	47.81	51.60	9.00	1.76	0.10	1.02
23/4/112-114	212.32	7.5381	92.91	2.31	0.48	50.07	49.45	8.67	1.76	0.55	1.02
23/4/133-135	212.53	7.5452	92.05	3.19	0.48	52.59	46.93	8.67	1.76	0.55	1.02
23/5/1-3	212.71	7.5512	94.71	1.82	0.54	50.06	49.40	8.67	1.76	0.55	1.02
23/5/24-26	212.94	7.5589	93.77	2.13	0.55	51.82	47.62	8.67	1.76	0.55	1.02
23/5/42-44	213.12	7.5649	95.08	1.55	0.55	51.56	47.89	8.67	1.76	0.55	1.02
23/5/83-85	213.53	7.5787	94.26	1.86	0.54	50.92	48.54	8.67	1.76	0.55	1.02
23/5/102-104	213.72	7.5850	93.01	2.49	0.24	51.97	47.79	8.67	1.76	0.55	1.02
23/5/122-124	213.92	7.5917	91.34	3.54	0.49	51.80	47.71	8.67	1.76	0.55	1.02
23/5/142-144	214.12	7.5984	93.06	2.66	0.45	48.66	50.89	9.00	1.76	0.10	1.02
23/6/7-9	214.27	7.6034	93.25	2.36	0.52	49.94	49.54	8.67	1.76	0.55	1.02
23/6/31-33	214.51	7.6115	92.26	2.93	0.48	51.61	47.91	8.67	1.76	0.55	1.02
23/6/52-54	214.72	7.6185	93.08	2.72	0.56	51.51	47.93	8.67	1.76	0.55	1.02
23/6/85-87	215.05	7.6296	94.61	1.55	0.46	51.19	48.35	8.67	1.76	0.55	1.02
23/6/111-113	215.31	7.6383	92.99	2.65	0.45	53.22	46.34	8.67	1.76	0.55	1.02
23/6/133-135	215.53	7.6456	93.85	2.35	0.55	54.52	44.92	8.67	1.76	0.55	1.02
23/7/1-3	215.71	7.6517	93.40	2.52	0.49	51.95	47.56	8.67	1.76	0.55	1.02
23/7/23-25	215.93	7.6590	93.81	2.13	0.80	52.52	46.68	8.67	1.76	0.55	1.02
23 CC/7-10	216.22	7.6688	92.06	2.98	0.91	52.58	46.52	8.67	1.76	0.55	1.02
24/1/1-3	216.31	7.6718	95.09	1.56	0.56	48.06	51.39	9.00	1.76	0.10	1.02
24/1/27-29	216.57	7.6805	94.67	1.57	0.58	50.06	49.36	8.67	1.76	0.55	1.02
24/1/43-45	216.73	7.6858	94.87	1.72	0.47	50.29	49.24	8.67	1.76	0.55	1.02
24/1/64-66	216.94	7.6929	87.88	3.71	0.68	54.52	44.81	8.67	1.76	0.55	1.02
24/1/82-84	217.12	7.6989	91.92	2.76	0.64	54.85	44.51	8.67	1.76	0.55	1.02
24/1/104-106	217.34	7.7063	91.09	3.25	0.35	57.18	42.47	8.33	1.51	0.47	2.05

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
24/1/123-125	217.53	7.7126	91.38	3.25	0.57	60.19	39.24	8.33	1.51	0.47	2.05
24/1/142-144	217.72	7.7190	94.11	1.97	0.59	57.81	41.60	8.33	1.51	0.47	2.05
24/2/12-14	217.92	7.7257	93.60	2.48	0.60	56.60	42.80	8.33	1.51	0.47	2.05
24/2/28-30	218.08	7.7311	94.35	1.68	0.52	56.61	42.87	8.33	1.51	0.47	2.05
24/2/46-48	218.26	7.7371	94.57	1.57	0.49	55.81	43.70	8.33	1.51	0.47	2.05
24/2/72-74	218.52	7.7458	95.58	1.34	0.43	55.75	43.81	8.67	1.76	0.55	1.02
24/2/87-89	218.67	7.7508	95.25	1.60	0.46	53.71	45.83	8.67	1.76	0.55	1.02
24/2/107-109	218.87	7.7575	94.83	1.70	0.55	52.93	46.52	8.67	1.76	0.55	1.02
24/2/135-137	219.15	7.7669	93.67	2.63	0.62	52.63	46.76	8.67	1.76	0.55	1.02
24/3/1-3	219.31	7.7723	93.39	2.22	0.57	56.22	43.21	8.33	1.51	0.47	2.05
24/3/23-25	219.53	7.7796	93.46	2.24	0.44	58.71	40.86	8.33	1.51	0.47	2.05
24/3/42-44	219.72	7.7860	94.46	1.85	0.44	58.44	41.12	8.33	1.51	0.47	2.05
24/3/56-58	219.86	7.7907	93.84	1.94	0.35	57.94	41.71	8.33	1.51	0.47	2.05
24/3/82-84	220.12	7.7994	94.44	1.82	0.53	57.44	42.03	8.33	1.51	0.47	2.05
24/3/102-104	220.32	7.8061	93.53	2.30	0.54	59.23	40.23	8.33	1.51	0.47	2.05
24/3/116-118	220.46	7.8108	93.25	2.27	0.59	55.57	43.84	8.33	1.51	0.47	2.05
24/3/133-135	220.63	7.8165	92.72	2.74	0.59	53.55	45.86	8.67	1.76	0.55	1.02
24/4/7-9	220.87	7.8245	93.19	2.45	0.62	55.20	44.18	8.33	1.51	0.47	2.05
24/4/32-34	221.12	7.8329	94.26	2.04	0.44	56.07	43.49	8.33	1.51	0.47	2.05
24/4/47-49	221.27	7.8379	93.32	2.03	0.50	57.87	41.62	8.33	1.51	0.47	2.05
24/4/72-74	221.52	7.8463	92.86	2.53	0.58	56.15	43.26	8.67	1.76	0.55	2.05
24/4/86-88	221.66	7.8510	93.59	2.13	0.45	55.55	44.00	8.67	1.76	0.55	2.05
24/4/112-114	221.92	7.8597	92.67	2.66	0.48	55.47	44.05	8.67	1.76	0.55	2.05
24/4/133-135	222.13	7.8667	92.42	2.76	0.50	54.18	45.32	8.67	1.76	0.55	1.02
24/5/1-3	222.31	7.8728	91.92	3.25	0.49	52.72	46.79	8.67	1.76	0.55	1.02
24/5/15-17	222.45	7.8774	92.54	2.71	0.44	52.07	47.48	8.67	1.76	0.55	1.02
24/5/43-45	222.73	7.8868	92.72	2.79	0.48	52.39	47.13	8.67	1.76	0.55	1.02
24/5/63-65	222.93	7.8935	92.94	2.92	0.30	55.97	43.73	8.67	1.76	0.55	2.05
24/5/84-86	223.14	7.9006	95.61	1.83	0.33	56.66	43.01	8.33	1.51	0.47	2.05
24/5/103-105	223.33	7.9069	95.17	2.06	0.46	54.96	44.58	8.67	1.76	0.55	1.02
24/5/118-120	223.48	7.9119	93.71	2.45	0.54	53.95	45.51	8.67	1.76	0.55	1.02
24/5/142-144	223.72	7.9200	93.32	2.57	0.46	55.63	43.91	8.67	1.76	0.55	2.05
24/6/7-9	223.87	7.9250	93.30	2.48	0.52	53.25	46.23	8.67	1.76	0.55	2.05
24/6/27-29	224.07	7.9317	90.85	3.50	0.55	55.76	43.69	8.33	1.51	0.47	2.05
24/6/47-49	224.27	7.9384	91.51	2.73	0.65	56.01	43.35	8.33	1.51	0.47	2.05
24/6/67-69	224.47	7.9451	94.30	1.81	0.53	53.95	45.52	8.67	1.76	0.55	1.02
24/6/86-88	224.66	7.9515	93.37	2.76	0.51	55.95	43.54	8.33	1.51	0.47	2.05
24/6/107-109	224.87	7.9585	96.09	1.38	0.47	56.29	43.23	8.33	1.51	0.47	2.05
24/6/132-134	225.12	7.9669	91.69	2.68	0.59	55.17	44.25	8.67	1.76	0.55	1.02
24 CC/9-11	225.36	7.9749	87.96	4.47	1.06	53.11	45.83	8.67	1.76	0.55	1.02
25/1/1-3	225.91	7.9933	88.40	4.00	0.72	51.00	48.28	8.67	1.76	0.55	1.02
25/1/23-25	226.13	8.0007	89.26	3.99	0.88	55.09	44.03	8.67	1.91	0.42	1.23
25/1/42-44	226.32	8.0071	87.96	4.57	0.86	54.99	44.15	8.67	1.91	0.42	1.23
25/1/63-65	226.53	8.0141	89.34	3.24	0.93	51.25	47.83	8.67	1.91	0.42	1.23
25/1/85-87	226.75	8.0215	88.75	3.51	1.07	52.01	46.92	8.67	1.91	0.42	1.23
25/1/103-105	226.93	8.0275	90.01	3.65	1.03	50.92	48.05	8.67	1.91	0.42	1.23
25/1/125-123	227.13	8.0342	90.86	3.52	0.58	49.94	49.48	8.67	1.76	0.55	1.02
25/1/144-146	227.34	8.0412	91.15	3.47	1.10	51.32	47.58	8.67	1.91	0.42	1.23
25/2/5-7	227.45	8.0449	91.10	3.15	0.97	50.22	48.81	8.67	1.91	0.42	1.23
25/2/-32-34	227.72	8.0540	90.87	3.22	0.90	51.75	47.36	8.67	1.91	0.42	1.23
25/2/53-55	227.93	8.0610	91.81	2.54	0.59	52.29	47.12	8.67	1.91	0.42	1.23
25/2/72-74	228.12	8.0674	88.50	4.33	1.02	51.86	47.13	8.67	1.91	0.42	1.23
25/2/95-97	228.35	8.0751	85.87	5.76	1.20	52.51	46.28	8.67	1.91	0.42	1.23
25/2/112-114	228.52	8.0808	83.24	8.34	1.08	54.16	44.76	8.67	1.91	0.42	1.23
25/2/134-136	228.74	8.0881	87.69	4.64	1.10	51.69	47.21	8.67	1.91	0.42	1.23
25/3/0-2	228.90	8.0935	85.96	5.36	1.19	50.32	48.48	8.67	1.91	0.42	1.23
25/3/23-25	229.13	8.1012	86.76	5.08	1.11	50.07	48.83	8.67	1.91	0.42	1.23
25/3/43-45	229.33	8.1079	88.18	4.39	1.10	51.18	47.72	8.67	1.91	0.42	1.23
25/3/63-65	229.53	8.1146	87.92	4.43	1.02	52.36	46.61	8.67	1.91	0.42	1.23
25/3/95-97	229.85	8.1253	88.52	4.47	0.97	52.48	46.55	8.67	1.91	0.42	1.23
25/3/118-120	230.08	8.1330	92.53	2.94	1.06	52.94	46.00	8.67	1.91	0.42	1.23
25/3/137-139	230.27	8.1394	89.97	3.88	1.06	52.58	46.36	8.67	1.91	0.42	1.23

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
25/4/7-9	230.47	8.1461	91.52	2.43	1.11	52.07	46.82	8.67	1.91	0.42	1.23
25/4/32-34	230.72	8.1545	93.35	1.93	0.46	51.43	48.11	8.67	1.76	0.55	1.02
25/4/53-55	230.93	8.1615	93.60	2.26	0.62	50.89	48.48	8.67	1.76	0.55	1.02
25/4/74-76	231.14	8.1685	92.53	3.20	0.54	52.49	46.97	8.67	1.76	0.55	1.02
25/4/93-95	231.33	8.1749	93.07	2.29	0.69	56.97	42.34	8.67	1.76	0.55	1.02
25/4/112-114	231.52	8.1813	94.34	1.79	0.53	51.07	48.40	8.67	1.76	0.55	1.02
25/4/133-135	231.73	8.1883	95.40	1.41	0.53	51.22	48.24	8.67	1.76	0.55	1.02
25/5/1-3	231.91	8.1943	94.31	1.92	0.59	49.94	49.47	8.67	1.76	0.55	1.02
25/5/16-18	232.06	8.1994	92.50	2.63	0.63	51.46	47.90	8.67	1.76	0.55	1.02
25/5/38-40	232.28	8.2067	91.08	2.81	0.94	52.07	47.00	8.67	1.91	0.42	1.23
25/5/62-64	232.52	8.2148	92.36	2.34	0.72	52.77	46.51	8.67	1.76	0.55	1.02
25/5/82-84	232.72	8.2215	90.34	3.64	0.97	51.53	47.50	8.67	1.91	0.42	1.23
25/5/102-104	232.92	8.2282	91.93	3.04	0.85	54.09	45.06	8.67	1.76	0.55	1.02
25/5/117-119	233.07	8.2332	89.04	4.88	0.85	54.58	44.57	8.67	1.91	0.42	1.23
25/5137-139	233.27	8.2399	92.14	3.18	0.59	53.82	45.60	8.67	1.76	0.55	1.02
25/6/7-9	233.47	8.2466	90.79	3.74	0.90	52.01	47.09	8.67	1.76	0.55	1.02
25/6/27-29	233.67	8.2533	91.82	2.70	0.93	54.44	44.63	8.67	1.76	0.55	1.02
25/6/48-50	233.88	8.2603	93.41	2.32	0.55	51.77	47.68	8.67	1.76	0.55	1.02
25/6/75-77	234.15	8.2694	89.88	3.77	1.25	53.56	45.19	8.67	1.91	0.42	1.23
25/6/93-95	234.33	8.2754	90.54	3.39	1.09	52.76	46.15	8.67	1.91	0.42	1.23
25/6/112-114	234.52	8.2818	92.11	2.74	1.01	52.21	46.78	8.67	1.91	0.42	1.23
25/6/133-135	234.73	8.2888	92.50	2.43	0.68	51.35	47.97	8.67	1.76	0.55	1.02
25/7/1-3	234.91	8.2948	91.73	2.78	1.13	52.56	46.31	8.67	1.91	0.42	1.23
25/7/17-19	235.07	8.3002	90.97	3.31	1.13	50.43	48.44	8.67	1.91	0.42	1.23
25 CC/10-22	235.26	8.3065	90.41	3.25	0.87	50.77	48.36	8.67	1.91	0.42	1.23
26/1/1-3	235.51	8.3149	94.76	1.48	0.97	54.02	45.01	8.33	1.66	0.33	1.23
26/1/23-25	235.73	8.3223	95.09	1.43	0.83	52.78	46.39	8.67	1.76	0.55	1.02
26/1/41-43	235.91	8.3283	95.44	1.62	0.57	50.12	49.31	8.67	1.76	0.55	1.02
26/1/58-60	236.08	8.3340	95.54	1.57	0.85	53.79	45.37	8.67	1.91	0.42	1.23
26/1/82-84	236.32	8.3420	94.33	2.12	0.84	51.33	47.82	8.67	1.76	0.55	1.02
26/1/102-104	236.52	8.3487	94.19	2.10	0.83	51.92	47.25	8.67	1.91	0.42	1.23
26/1/117-119	236.67	8.3538	93.67	2.29	0.61	52.90	46.49	8.67	1.91	0.42	1.23
26/1/142-144	236.92	8.3621	93.23	2.14	0.94	52.15	46.91	8.67	1.91	0.42	1.23
26/2/13-15	237.13	8.3692	93.22	2.17	0.91	51.40	47.69	8.67	1.91	0.42	1.23
26/2/32-34	237.32	8.3755	94.84	1.51	0.64	52.56	46.80	8.67	1.91	0.42	1.23
26/2/56-58	237.56	8.3836	94.01	1.79	0.88	52.19	46.93	8.67	1.91	0.42	1.23
26/2/93-95	237.93	8.3960	93.20	1.97	0.94	51.92	47.15	8.67	1.91	0.42	1.23
26/2/112-114	238.12	8.4023	90.57	2.92	1.27	51.19	47.53	8.67	1.91	0.42	1.23
26/2/133-135	238.33	8.4094	90.75	2.91	1.25	53.65	45.10	8.33	1.81	0.24	1.43
26/3/1-3	238.51	8.4154	92.75	1.83	1.08	51.41	47.51	8.67	1.91	0.42	1.23
26/3/22-24	238.72	8.4224	91.27	2.66	0.64	54.28	45.09	8.67	1.91	0.42	1.23
26/3/43-45	238.93	8.4295	91.15	2.96	0.64	53.30	46.06	8.67	1.91	0.42	1.23
26/3/56-58	239.06	8.4338	89.79	3.84	0.55	53.83	45.62	8.67	1.76	0.55	1.02
26/3/82-84	239.32	8.4425	91.72	2.52	1.12	55.01	43.86	8.67	1.91	0.42	1.23
26/3/102-104	239.52	8.4492	89.82	3.93	1.12	54.58	44.31	8.67	1.91	0.42	1.23
26/3/117-119	239.67	8.4543	90.21	3.70	1.05	54.97	43.98	8.67	1.91	0.42	1.23
26/3/133-135	239.83	8.4596	87.52	3.90	0.77	54.36	44.87	8.67	1.91	0.42	1.23
26/4/7-9	240.07	8.4677	85.08	4.83	1.36	55.79	42.85	8.67	2.06	0.32	1.43
26/4/32-34	240.32	8.4760	88.18	4.26	1.30	59.80	38.90	8.33	1.66	0.33	1.23
26/4/52-54	240.52	8.4827	95.27	1.72	0.63	58.80	40.58	8.33	1.51	0.47	1.02
26/4/72-74	240.72	8.4894	93.63	2.21	0.61	56.61	42.78	8.33	1.51	0.47	2.05
26/4/92-94	240.92	8.4961	88.43	4.81	1.03	58.10	40.87	8.33	1.66	0.33	1.23
26/4/112-114	241.12	8.5028	90.23	3.41	0.92	57.52	41.57	8.33	1.66	0.33	2.46
26/4/132-134	241.32	8.5095	92.46	2.53	0.80	55.87	43.33	8.67	1.91	0.42	1.23
26/5/0-2	241.50	8.5156	87.87	4.56	1.18	57.41	41.41	8.33	1.66	0.33	1.23
26/5/15-17	241.65	8.5206	91.58	2.30	1.22	56.12	42.67	8.33	1.66	0.33	2.46
26/5/42-44	241.92	8.5296	90.22	3.03	1.36	55.46	43.18	8.33	1.66	0.33	1.23
26/5/63-65	242.13	8.5367	92.98	1.80	1.09	55.29	43.62	8.33	1.66	0.33	1.23
26/5/82-84	242.32	8.5430	93.53	1.73	0.72	57.34	41.94	8.33	1.66	0.33	2.46
26/5/102-104	242.52	8.5497	95.94	1.02	1.02	54.56	44.42	8.67	1.76	0.55	1.02
26/5/117-119	242.67	8.5548	94.22	0.99	0.54	52.80	46.66	8.67	1.76	0.55	1.02
26/5/142-144	242.92	8.5631	91.69	2.55	0.71	54.00	45.29	8.67	1.76	0.55	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
26/6/7-9	243.07	8.5682	92.53	2.47	0.51	50.84	48.65	8.67	1.76	0.55	1.02
26/6/26-28	243.26	8.5745	85.63	6.08	1.13	58.19	40.68	8.67	1.91	0.42	1.23
26/6/47-49	243.47	8.5816	91.43	3.44	0.77	47.83	51.40	9.00	1.76	0.10	1.02
26/6/63-65	243.63	8.5869	92.50	3.31	0.53	43.91	55.56	9.00	1.76	0.10	1.02
26 CC/13-15	243.86	8.5946	89.95	3.83	0.79	48.46	50.74	9.00	1.91	0.00	1.23
27/1/1-3	245.11	8.6365	91.40	3.53	0.86	47.82	51.32	9.00	1.76	0.10	1.02
27/1/25-27	245.35	8.6445	92.89	2.26	0.95	47.77	51.28	9.00	1.91	0.00	1.23
27/1/43-45	245.53	8.6506	92.63	2.41	1.00	48.01	50.99	9.00	1.91	0.00	1.23
27/1/65-67	245.75	8.6579	94.86	1.60	0.75	42.29	56.97	9.00	1.76	0.10	1.02
27/1/81-83	245.91	8.6633	94.84	1.59	0.35	43.40	56.25	9.00	1.76	0.10	1.02
27/1/96-98	246.06	8.6683	95.05	1.65	0.59	41.11	58.30	9.00	1.76	0.10	1.02
27/1/117-119	246.27	8.6753	94.68	1.63	0.39	43.15	56.46	9.00	1.76	0.10	1.02
27/1/142-144	246.52	8.6837	94.99	1.33	0.47	42.26	57.27	9.00	1.76	0.10	1.02
27/2/5-7	246.65	8.6881	94.10	1.79	0.89	43.14	55.97	9.00	1.76	0.10	1.02
27/2/27-29	246.87	8.6954	94.52	1.61	0.64	41.49	57.87	9.00	1.76	0.10	1.02
27/2/53-55	247.13	8.7041	89.61	3.54	0.90	47.31	51.79	9.00	1.91	0.00	1.23
27/2/73-76	247.33	8.7108	86.92	4.66	1.22	52.55	46.24	8.67	1.91	0.42	1.43
27/2/93-95	247.53	8.7175	85.02	6.10	1.43	52.66	45.91	8.67	2.06	0.32	1.43
27/2/107-109	247.67	8.7222	88.33	4.05	1.13	52.30	46.56	8.67	1.91	0.42	1.23
27/2/132-134	247.92	8.7306	90.44	3.05	0.94	50.11	48.94	8.67	1.91	0.42	1.23
27/3/1-3	248.11	8.7370	85.50	5.33	1.26	52.23	46.51	8.67	2.06	0.32	1.43
27/3/16-18	248.26	8.7420	85.64	5.32	1.20	52.76	46.05	8.67	1.91	0.42	1.23
27/3/37-39	248.47	8.7490	87.00	4.39	1.32	53.47	45.21	8.67	2.06	0.32	1.43
27/3/56-58	248.66	8.7554	89.54	3.10	1.38	53.66	44.96	8.67	2.06	0.32	0.96
27/3/83-85	248.93	8.7644	89.85	3.46	1.29	50.63	48.09	8.67	1.91	0.42	1.23
27/3/104-106	249.14	8.7715	89.28	4.01	1.24	48.78	49.98	8.67	2.06	0.32	1.43
27/3/117-119	249.27	8.7758	90.51	3.09	1.26	47.45	51.29	9.00	1.91	0.00	1.23
27/7/142-144	249.52	8.7842	90.35	3.62	1.20	48.20	50.60	9.00	1.91	0.00	1.23
27/4/7-9	249.67	8.7892	90.51	3.07	1.24	46.67	52.08	9.00	1.91	0.00	1.23
27/4/32-34	249.92	8.7976	94.27	1.50	0.42	43.15	56.43	9.00	1.76	0.10	1.02
27/4/52-54	250.12	8.8043	94.44	1.70	0.51	45.20	54.29	9.00	1.76	0.10	1.02
27/4/67-69	250.27	8.8093	93.81	2.08	1.06	48.42	50.53	9.00	1.91	0.00	1.23
27/4/86-88	250.46	8.8157	95.51	1.27	1.02	42.90	56.08	9.00	1.91	0.00	1.23
27/4/112-114	250.72	8.8244	95.03	1.68	0.49	46.55	52.96	9.00	1.76	0.10	1.02
27/4/132-134	250.92	8.8311	94.58	2.02	0.56	47.26	52.19	9.00	1.76	0.10	1.02
27/5/0-2	251.10	8.8371	94.03	2.05	0.69	46.52	52.79	9.00	1.76	0.10	1.02
27/5/23-26	251.33	8.8448	91.21	3.54	1.00	46.94	52.07	9.00	1.76	0.10	1.02
27/5/38-40	251.48	8.8499	91.99	3.38	1.03	47.76	51.22	9.00	1.91	0.00	1.23
27/5/57-59	251.67	8.8562	93.48	2.23	0.69	45.29	54.01	9.00	1.76	0.10	1.02
27/5/83-85	251.93	8.8649	93.41	2.08	0.49	46.31	53.19	9.00	1.91	0.00	1.23
27/5/103-105	252.13	8.8716	92.90	2.72	0.95	46.30	52.75	9.00	1.91	0.00	1.23
27/5/118-120	252.28	8.8767	93.41	2.23	0.48	45.08	54.44	9.00	1.76	0.10	1.02
27/5/143-145	252.53	8.8850	93.27	2.35	0.58	46.24	53.18	9.00	1.76	0.10	1.02
27/6/7-9	252.67	8.8897	91.95	3.11	0.65	47.21	52.15	9.00	1.76	0.10	1.02
27/6/32-34	252.92	8.8981	92.31	2.81	0.44	48.66	50.90	9.00	1.91	0.00	1.23
27/6/53-55	253.13	8.9051	93.36	2.20	0.58	49.21	50.21	9.00	1.76	0.10	1.02
27/6/73-75	253.33	8.9118	93.20	2.30	0.56	49.99	49.45	8.67	1.76	0.55	1.02
27/6/87-89	253.47	8.9165	92.37	3.04	0.70	49.11	50.19	9.00	1.76	0.10	1.02
27/6/107-109	253.67	8.9232	90.75	3.93	0.60	49.88	49.52	8.67	1.76	0.55	1.02
27/6/132-134	253.92	8.9316	94.44	1.94	0.59	50.07	49.34	8.67	1.76	0.55	1.02
27/7/0-2	254.10	8.9376	91.84	3.19	0.96	52.75	46.29	8.67	1.76	0.55	1.02
27/7/17-19	254.27	8.9433	92.16	2.89	0.90	53.33	45.78	8.67	1.76	0.55	1.02
27 CC/10-12	254.49	8.9533	91.68	2.75	0.86	53.12	46.02	8.67	1.76	0.55	1.02
28/1/4-6	254.74	8.9675	94.08	1.97	0.63	51.55	47.81	8.67	1.76	0.55	1.02
28/1/23-25	254.93	8.9783	95.09	1.66	0.56	55.25	44.19	8.33	1.51	0.47	2.05
28/1/42-44	255.12	8.9891	94.66	1.86	0.50	51.56	47.95	8.67	1.76	0.55	1.02
28/1/58-60	255.28	8.9982	94.75	1.83	0.53	51.82	47.65	8.67	1.76	0.55	1.02
28/1/83-85	255.53	9.0124	95.00	1.61	0.80	52.11	47.09	8.67	1.76	0.55	1.02
28/1/103-105	255.73	9.0237	94.39	2.04	0.82	51.80	47.39	8.67	1.76	0.55	1.02
28/1/121-123	255.91	9.0340	95.20	1.58	0.75	53.50	45.76	8.67	1.76	0.55	1.02
28/1/141-143	256.11	9.0453	95.39	1.48	0.61	52.35	47.04	8.67	1.76	0.55	1.02
28/2/7-9	256.27	9.0544	96.32	1.27	0.59	53.02	46.39	8.67	1.76	0.55	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
28/2/33-35	256.53	9.0692	94.82	1.70	0.65	54.33	45.03	8.67	1.76	0.55	1.02
28/2/54-56	256.74	9.0811	95.38	1.58	0.62	55.29	44.09	8.33	1.51	0.47	1.02
28/2/83-85	257.03	9.0976	95.24	1.96	0.79	55.43	43.78	8.67	1.76	0.55	1.02
28/2/98-100	257.18	9.1062	95.86	1.41	0.61	54.63	44.76	8.67	1.76	0.55	1.02
28/2/113-115	257.33	9.1147	94.06	2.22	0.54	55.58	43.88	8.33	1.51	0.47	1.02
28/2/133-135	257.53	9.1261	94.00	2.33	0.64	54.34	45.02	8.67	1.76	0.55	1.02
28/3/1-3	257.71	9.1363	93.48	2.57	0.92	53.40	45.68	8.67	1.76	0.55	1.02
28/3/25-27	257.95	9.1499	93.30	2.36	0.63	55.10	44.26	8.33	1.51	0.47	1.02
28/3/42-44	258.12	9.1596	94.26	2.06	0.61	56.18	43.20	8.33	1.51	0.47	2.05
28/3/55-57	258.25	9.1670	96.07	1.07	0.80	56.12	43.08	8.33	1.51	0.47	2.05
28/3/84-86	258.54	9.1835	95.69	1.44	0.56	54.47	44.98	8.33	1.51	0.47	1.02
28/3/118-120	258.88	9.2028	95.92	1.23	0.84	55.91	43.26	8.67	1.76	0.55	1.02
28/3/137-139	259.07	9.2136	95.99	1.16	0.70	55.65	43.66	8.67	1.76	0.55	1.02
28/4/6-8	259.26	9.2244	94.64	1.81	0.70	56.10	43.21	8.33	1.51	0.47	1.02
28/4/33-35	259.53	9.2397	94.44	1.80	0.55	55.44	44.01	8.67	1.76	0.55	1.02
28/4/47-49	259.67	9.2477	93.04	2.65	0.56	55.39	44.05	8.67	1.76	0.55	1.02
28/4/66-68	259.86	9.2585	94.51	1.86	0.67	53.32	46.01	8.67	1.76	0.55	1.02
28/4/93-95	260.13	9.2738	92.82	2.72	0.57	54.76	44.67	8.67	1.76	0.55	1.02
28/4/108-110	260.28	9.2824	93.95	2.02	0.62	54.11	45.27	8.67	1.76	0.55	1.02
28/4/134-136	260.54	9.2971	95.26	1.91	0.61	53.43	45.96	8.67	1.76	0.55	1.02
28/5/1-3	260.71	9.3068	96.03	1.51	0.39	58.06	41.56	8.33	1.51	0.47	2.05
28/5/16-18	260.86	9.3153	95.91	1.42	0.56	54.23	45.21	8.67	1.76	0.55	1.02
28/5/42-44	261.12	9.3301	95.96	1.48	0.63	54.31	45.06	8.67	1.76	0.55	1.02
28/5/61-63	261.31	9.3409	95.31	1.72	1.19	56.48	42.33	8.33	1.66	0.33	1.23
28/5/85-87	261.55	9.3546	90.37	3.61	0.56	54.11	45.33	8.67	1.76	0.55	1.02
28/5/102-104	261.72	9.3642	92.02	2.91	0.65	57.32	42.03	8.33	1.66	0.33	1.23
28/5/121-123	261.91	9.3750	91.07	3.10	1.29	57.49	41.22	8.33	1.66	0.33	1.23
28/5/141-143	262.11	9.3864	91.67	3.06	1.20	56.53	42.27	8.33	1.66	0.33	1.23
28/6/8-10	262.28	9.3960	94.06	2.17	0.82	55.62	43.56	8.33	1.51	0.47	2.05
28 CC/8-10	262.45	9.4057	92.56	2.76	0.90	54.03	45.07	8.67	1.76	0.55	1.02
29/1/0-2	264.30	9.5109	91.34	3.22	1.00	52.89	46.11	8.67	1.91	0.42	1.23
29/1/34-36	264.64	9.5302	92.20	2.97	0.64	55.19	44.17	8.33	1.51	0.47	1.02
29/1/58-60	264.88	9.5438	92.00	2.94	0.67	55.47	43.86	8.67	1.76	0.55	2.05
29/1/80-82	265.10	9.5563	88.12	4.49	1.15	54.07	44.77	8.33	1.66	0.33	2.46
29/1/96-98	265.26	9.5654	89.25	3.87	0.84	54.80	44.36	8.33	1.66	0.33	2.46
29/1/117-119	265.47	9.5774	89.64	4.07	0.79	55.08	44.14	8.33	1.66	0.33	2.46
29/1/142-144	265.72	9.5916	91.56	3.35	1.09	53.47	45.44	8.67	1.76	0.55	1.02
29/2/12-14	265.92	9.6029	90.73	3.56	0.65	53.60	45.75	8.67	1.76	0.55	1.02
29/2/32-34	266.12	9.6143	92.37	2.60	0.95	53.03	46.01	8.33	1.51	0.47	1.02
29/2/46-48	266.26	9.6223	95.17	1.41	0.78	51.50	47.72	8.67	1.76	0.55	1.02
29/2/64-66	266.44	9.6325	93.96	1.83	0.66	54.63	44.70	8.33	1.51	0.47	1.02
29/2/85-87	266.65	9.6444	94.30	1.93	0.70	54.81	44.48	8.33	1.51	0.47	1.02
29/2/107-109	266.87	9.6569	94.94	1.84	0.59	53.78	45.63	8.67	1.76	0.55	1.02
29/2/133-135	267.13	9.6717	96.29	1.17	0.66	55.90	43.44	8.33	1.66	0.33	1.23
29/3/1-3	267.31	9.6820	96.22	1.15	0.59	54.15	45.27	8.67	1.76	0.55	1.02
29/3/23-25	267.53	9.6945	96.52	1.07	0.43	54.69	44.88	8.33	1.51	0.47	1.02
29/3/42-44	267.72	9.7053	96.46	1.12	0.49	63.11	36.40	8.33	1.66	0.33	1.23
29/3/57-59	267.87	9.7138	96.03	1.05	0.54	53.30	46.16	8.67	1.76	0.55	1.02
29/3/84-86	268.14	9.7291	94.28	1.68	0.60	55.17	44.24	8.33	1.51	0.47	2.05
29/3/104-106	268.34	9.7405	93.93	2.12	0.46	54.09	45.45	8.33	1.51	0.47	2.05
29/3/117-119	268.47	9.7479	95.34	1.50	0.49	54.77	44.74	8.33	1.51	0.47	2.05
29/3/138-140	268.68	9.7598	95.83	1.31	0.41	51.62	47.97	8.67	1.76	0.55	1.02
29/4/6-8	268.86	9.7701	93.83	2.32	0.76	53.51	45.74	8.33	1.51	0.47	1.02
29/4/48-50	269.28	9.7885	93.93	2.11	0.49	53.50	46.01	8.33	1.51	0.47	1.02
29/4/72-74	269.52	9.7959	95.27	1.44	0.52	50.32	49.15	8.67	1.76	0.55	1.02
29/4/95-97	269.75	9.8030	94.86	1.64	0.60	52.22	47.18	8.67	1.76	0.55	1.02
29/4/107-109	269.87	9.8067	94.82	1.94	0.48	51.28	48.24	8.67	1.76	0.55	1.02
29/4/135-137	270.15	9.8153	95.25	1.57	0.46	51.75	47.78	8.33	1.51	0.47	1.02
29/5/1-3	270.31	9.8203	94.66	1.86	0.60	51.25	48.15	8.67	1.76	0.55	1.02
29/5/15-17	270.45	9.8246	92.65	2.88	0.85	54.00	45.15	8.33	1.66	0.33	2.46
29/5/42-44	270.72	9.8329	95.32	1.40	0.52	53.65	45.84	8.67	1.76	0.55	1.02
29/5/61-63	270.91	9.8384	91.43	2.86	0.92	59.03	40.06	8.33	1.81	0.24	1.43

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
29/5/85-87	271.15	9.8447	97.06	0.75	2.28	55.54	42.18	8.33	1.89	0.20	1.54
29/5/104-106	271.34	9.8498	96.70	0.76	1.07	58.44	40.49	8.33	1.85	0.22	1.49
29/5/118-120	271.48	9.8535	93.24	1.28	2.34	59.94	37.72	8.00	2.14	0.03	1.54
29/5/142-144	271.72	9.8598	94.45	2.13	0.48	48.52	51.00	9.00	1.76	0.10	1.02
29/6/14-16	271.94	9.8657	92.21	2.23	1.19	53.88	44.93	8.67	1.91	0.42	1.23
29 CC/17-19	272.19	9.8723	94.91	1.70	0.43	52.28	47.29	8.67	1.76	0.55	1.02
30/1/1- 3	273.91	9.9179	94.29	1.69	0.51	48.02	51.47	9.33	1.51	0.27	1.02
30/1/14-16	274.04	9.9213	95.00	1.40	0.44	51.48	48.07	8.67	1.76	0.55	1.02
30/1/42-44	274.32	9.9287	96.58	0.89	0.32	50.60	49.08	9.00	1.51	0.80	1.02
30/1/58-60	274.48	9.9330	95.53	1.25	0.42	53.20	46.38	8.67	1.76	0.55	1.02
30/1/82-84	274.72	9.9393	96.56	0.95	0.52	49.90	49.58	9.00	1.51	0.80	1.02
30/1/103-105	274.93	9.9449	96.52	0.95	0.94	51.83	47.22	8.67	1.76	0.55	1.02
30/1/122-124	275.12	9.9499	95.90	1.49	0.39	49.99	49.63	9.00	1.51	0.80	1.02
30/1/141-143	275.31	9.9550	93.39	2.81	0.54	51.54	47.92	8.67	1.76	0.55	1.02
30/2/5- 7	275.45	9.9587	93.79	2.58	0.43	51.61	47.96	8.67	1.76	0.55	1.02
30/2/32-34	275.72	9.9658	94.64	1.89	0.49	52.68	46.83	8.67	1.76	0.55	1.02
30/2/53-55	275.93	9.9714	93.78	2.41	0.74	54.80	44.46	8.33	1.51	0.47	1.02
30/2/92-94	276.32	9.9817	93.65	2.13	0.44	53.82	45.74	8.33	1.51	0.47	1.02
30/2/112-114	276.52	9.9870	95.78	1.10	0.45	53.30	46.26	8.33	1.51	0.47	1.02
30/2/133-135	276.73	9.9926	94.46	1.61	0.48	52.23	47.29	8.67	1.76	0.55	1.02
30/3/1- 3	276.91	9.9974	94.47	1.67	0.52	54.24	45.23	8.33	1.51	0.47	1.02
30/3/15-17	277.05	10.0011	95.93	0.83	0.44	54.10	45.47	8.67	1.76	0.55	1.02
30/3/43-45	277.33	10.0085	94.06	1.89	0.67	54.61	44.72	8.67	1.76	0.55	1.02
30/3/65-67	277.55	10.0143	94.90	1.58	0.45	54.52	45.03	8.33	1.51	0.47	2.05
30/3/84-86	277.74	10.0194	95.02	1.68	0.59	54.13	45.28	8.33	1.51	0.47	2.05
30/3/103-105	277.93	10.0244	93.85	2.06	0.56	53.55	45.88	8.67	1.76	0.55	1.02
30/3/117-119	278.07	10.0281	93.99	2.00	0.54	53.06	46.40	8.67	1.76	0.55	1.02
30/3/138-140	278.28	10.0337	94.62	1.75	0.56	53.39	46.06	8.67	1.76	0.55	1.02
30/4/9- 11	278.49	10.0392	94.47	1.82	0.51	56.68	42.81	8.33	1.51	0.47	2.05
30/4/32-34	278.72	10.0453	95.77	1.47	0.44	53.02	46.53	8.67	1.76	0.55	1.02
30/4/48-50	278.88	10.0496	95.19	1.48	0.55	52.05	47.40	8.67	1.76	0.55	1.02
30/4/73-75	279.13	10.0562	95.20	1.54	0.39	51.95	47.67	8.67	1.76	0.55	1.02
30/4/93-95	279.33	10.0615	95.41	1.47	0.47	50.94	48.58	8.67	1.76	0.55	1.02
30/4/113-115	279.53	10.0668	92.26	3.19	0.71	52.86	46.43	8.67	1.76	0.55	1.02
30/4/135-137	279.75	10.0726	95.74	1.24	0.44	49.10	50.46	9.33	1.51	0.27	1.02
30/5/6- 8	279.96	10.0782	95.57	1.36	0.42	49.97	49.61	8.33	1.51	0.47	2.05
30/5/15-17	280.05	10.0806	95.58	1.11	0.44	48.53	51.03	9.00	1.51	0.80	1.02
30/5/35-37	280.25	10.0859	95.77	1.22	0.53	50.57	48.89	9.33	1.51	0.27	1.02
30/5/84-86	280.74	10.0989	95.27	1.51	0.45	49.75	49.80	8.67	1.76	0.55	1.02
30/5/102-104	280.92	10.1036	96.33	1.18	0.44	52.85	46.72	9.00	1.51	0.80	1.02
31/1/1- 3	283.51	10.1723	94.64	1.96	0.48	46.21	53.31	9.33	1.51	0.27	1.02
31/1/17-19	283.67	10.1765	93.48	2.27	0.56	52.14	47.30	8.67	1.76	0.55	1.02
31/1/44-46	283.94	10.1837	93.54	2.16	0.50	51.22	48.28	8.67	1.76	0.55	1.02
31/1/58-60	284.08	10.1874	94.80	1.63	0.44	51.97	47.59	8.67	1.26	0.80	1.02
31/1/83-85	284.33	10.1940	94.78	1.63	0.55	53.52	45.93	8.33	1.51	0.47	1.02
31/1/105-107	284.55	10.1998	94.46	1.88	0.39	51.12	48.49	9.00	1.51	0.80	1.02
31/1/118-120	284.68	10.2033	93.65	2.14	0.51	50.45	49.04	8.67	1.76	0.55	1.02
31/1/138-140	284.88	10.2086	94.91	1.60	0.55	50.80	48.65	9.00	1.51	0.80	1.02
31/2/9- 11	285.09	10.2141	94.41	1.97	0.57	52.67	46.76	8.67	1.76	0.55	1.02
31/2/29-31	285.29	10.2194	94.45	1.85	0.50	51.48	48.02	8.67	1.76	0.55	1.02
31/2/48-50	285.48	10.2245	93.49	2.22	0.51	52.47	47.02	8.67	1.76	0.55	1.02
31/2/73-75	285.73	10.2311	93.11	2.41	0.66	55.02	44.32	8.33	1.51	0.47	2.05
31/2/88-90	285.88	10.2351	93.25	2.55	0.61	55.64	43.75	8.33	1.51	0.47	2.05
31/2/110-112	286.10	10.2409	94.96	1.60	0.66	53.53	45.81	8.67	1.76	0.55	1.02
31/2/134-136	286.34	10.2473	94.81	1.69	0.61	51.36	48.03	8.67	1.76	0.55	1.02
31/3/1- 3	286.51	10.2518	95.03	1.75	0.54	53.33	46.14	8.33	1.51	0.47	2.05
31/3/23-25	286.73	10.2576	95.06	1.80	0.85	51.33	47.82	8.67	1.76	0.55	1.02
31/3/38-40	286.88	10.2616	93.65	2.43	0.56	52.43	47.01	8.67	1.76	0.55	1.02
31/3/57-59	287.04	10.2658	95.69	1.20	0.58	52.26	47.16	8.67	1.76	0.55	1.02
31/3/82-84	287.32	10.2732	95.40	1.49	0.81	51.58	47.61	8.67	1.76	0.55	1.02
31/3/102-104	287.52	10.2785	95.25	1.75	0.48	50.63	48.89	8.67	1.76	0.55	1.02
31/3/117-119	287.67	10.2825	96.32	1.26	0.44	52.47	47.08	8.67	1.76	0.55	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
31/3/141-143	287.91	10.2889	94.29	2.20	0.48	55.07	44.45	8.33	1.51	0.47	2.05
31/4/8- 10	288.08	10.2934	95.83	1.34	0.44	55.10	44.46	8.33	1.51	0.47	2.05
31/4/30-32	288.30	10.2992	96.74	1.18	0.48	55.24	44.28	8.33	1.51	0.47	2.05
31/4/55-57	288.55	10.3058	95.86	1.27	0.73	53.62	45.65	8.67	1.76	0.55	1.02
31/4/70-72	288.70	10.3098	95.83	1.22	0.49	58.15	41.36	8.33	1.51	0.47	2.05
31/4/89-91	288.89	10.3148	96.80	0.98	0.39	57.43	42.18	8.33	1.51	0.47	2.05
31/4/110-112	289.10	10.3204	95.72	1.41	0.51	57.49	42.00	8.33	1.51	0.47	2.05
31/4/134-136	289.34	10.3267	96.82	0.96	0.49	56.78	42.74	8.33	1.51	0.47	2.05
31/5/0-2	289.50	10.3310	95.37	1.48	0.56	54.96	44.48	8.67	1.76	0.55	1.02
31/5/23-25	289.73	10.3371	96.21	1.08	0.46	53.54	46.01	8.67	1.76	0.55	1.02
31/5/43-45	289.93	10.3424	96.30	0.95	0.43	52.21	47.35	8.67	1.76	0.55	1.02
31/5/62-64	290.12	10.3474	94.88	1.76	0.51	53.11	46.38	8.67	1.76	0.55	1.02
31/5/83-85	290.33	10.3530	96.45	1.01	0.51	52.28	47.22	8.67	1.76	0.55	1.02
31/5/101-103	290.51	10.3577	95.14	1.80	0.45	53.26	46.29	8.67	1.76	0.55	1.02
31/5/120-122	290.70	10.3628	96.84	0.83	0.31	51.22	48.47	9.00	1.51	0.80	1.02
31 CC/0-2	290.74	10.3638	95.51	1.54	0.44	53.95	45.61	8.33	1.51	0.47	2.05
32/1/1- 3	293.11	10.4266	95.89	1.28	0.37	47.10	52.53	9.33	1.51	0.27	1.02
32/1/23-25	293.33	10.4325	96.20	1.22	0.41	54.98	44.61	8.67	1.76	0.55	2.05
32/1/41-43	293.51	10.4372	97.00	1.04	0.40	53.35	46.25	8.67	1.76	0.55	1.02
32/1/61-63	293.71	10.4425	96.85	0.91	0.47	53.83	45.69	8.67	1.76	0.55	1.02
32/1/83-85	293.93	10.4484	97.15	0.94	0.58	53.91	45.50	8.33	1.51	0.47	1.02
32/1/102-104	294.12	10.4534	96.29	1.17	0.51	53.59	45.90	8.67	1.76	0.55	2.05
32/1/121-123	294.31	10.4584	96.23	1.19	0.48	51.97	47.55	8.67	1.76	0.55	1.02
32/1/141-143	294.51	10.4637	96.34	1.08	0.41	49.90	49.69	8.67	1.76	0.55	1.02
32/2/11- 13	294.71	10.4690	97.21	0.87	0.41	52.62	46.97	8.33	1.51	0.47	2.05
32/2/30-32	294.90	10.4741	98.19	0.63	0.32	52.15	47.54	8.67	1.76	0.55	1.02
32/2/52-54	295.12	10.4799	97.59	0.81	0.35	49.45	50.20	9.33	1.51	0.27	1.02
32/2/73-75	295.33	10.4855	96.89	0.92	0.44	50.28	49.28	8.67	1.76	0.55	1.02
32/2/93-95	295.53	10.4908	96.14	1.50	0.43	51.36	48.21	8.67	1.76	0.55	1.02
32/2/113-115	295.73	10.4961	97.32	0.75	0.51	52.08	47.41	8.67	1.76	0.55	1.02
32/2/133-135	295.93	10.5014	93.74	3.41	0.53	52.51	46.97	8.67	1.76	0.55	1.02
32/3/1- 3	296.11	10.5061	97.00	0.83	0.40	54.68	44.92	8.33	1.51	0.47	2.05
32/3/40-42	296.50	10.5165	94.37	2.17	0.61	52.72	46.68	8.67	1.76	0.55	1.02
32/3/62-64	296.72	10.5223	96.48	0.89	0.48	49.14	50.38	9.33	1.51	0.27	1.02
32/3/83-85	296.93	10.5279	95.43	1.39	0.54	49.53	49.93	8.67	1.76	0.55	1.02
32/3/102-104	297.12	10.5329	93.66	2.48	0.61	54.95	44.44	8.33	1.51	0.47	2.05
32/3/123-125	297.33	10.5385	94.69	1.56	0.81	55.97	43.22	8.33	1.51	0.47	2.05
32/3/140-142	297.50	10.5430	95.53	1.40	0.61	53.77	45.63	8.67	1.76	0.55	1.02
32/4/10- 12	297.70	10.5483	96.15	1.29	0.44	56.06	43.51	8.33	1.51	0.47	2.05
32/4/30-32	297.90	10.5536	96.28	1.18	0.52	55.12	44.36	8.33	1.51	0.47	2.05
32/4/48-50	298.08	10.5583	96.98	0.91	0.44	52.92	46.64	8.67	1.76	0.55	1.02
32/4/68-70	298.28	10.5636	96.25	1.11	0.54	55.37	44.09	8.67	1.76	0.55	1.02
32/4/92-94	298.52	10.5700	95.11	1.83	0.70	55.51	43.80	8.67	1.76	0.55	1.02
32/4/110-112	298.70	10.5748	96.43	1.09	0.73	54.46	44.81	8.33	1.51	0.47	1.02
32/4/133-135	298.93	10.5809	96.23	1.39	0.48	53.24	46.28	8.67	1.76	0.55	1.02
32/5/1- 3	299.11	10.5856	95.86	1.27	0.58	53.89	45.53	8.67	1.76	0.55	1.02
32/5/28-30	299.38	10.5928	95.12	1.64	0.52	55.29	44.19	8.33	1.51	0.47	2.05
32/5/40-42	299.50	10.5960	95.55	1.27	0.70	50.68	48.61	8.67	1.76	0.55	1.02
32 CC/2- 4	299.67	10.6005	96.37	0.97	0.35	49.37	50.28	9.00	1.76	0.10	1.02
33/1/1- 3	302.71	10.6810	96.19	1.26	0.44	47.79	51.77	9.33	1.51	0.27	1.02
33/1/27-29	302.97	10.6879	97.05	0.67	0.43	53.97	45.60	8.67	1.76	0.55	1.02
33/1/40-42	303.10	10.6914	97.30	0.59	0.55	53.07	46.38	8.67	1.76	0.55	1.02
33/1/59-61	303.29	10.6964	97.47	0.48	0.41	53.92	45.67	8.67	1.76	0.55	1.02
33/1/83-85	303.53	10.7028	97.53	0.56	0.49	53.09	46.42	8.67	1.76	0.55	1.02
33/1/107-109	303.77	10.7091	97.27	0.71	0.41	52.15	47.44	8.67	1.76	0.55	1.02
33/1/121-123	303.91	10.7128	97.79	0.45	0.55	51.88	47.57	8.67	1.76	0.55	1.02
33/1/143-145	304.13	10.7187	97.34	0.60	0.57	54.63	44.80	8.67	1.76	0.55	1.02
33/2/9- 11	304.29	10.7229	97.26	0.61	0.40	51.92	47.67	8.67	1.76	0.55	1.02
33/2/27-29	304.47	10.7277	96.76	0.73	0.44	53.51	46.06	8.67	1.76	0.55	1.02
33/2/46-48	304.66	10.7327	96.49	0.83	0.50	53.17	46.32	8.67	1.76	0.55	1.02
33/2/82-84	305.02	10.7422	96.89	0.77	0.48	51.18	48.34	8.67	1.76	0.55	1.02
33/2/95-97	305.15	10.7457	96.90	0.74	0.68	50.03	49.29	8.67	1.76	0.55	1.02

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
33/2/114-116	305.34	10.7507	95.42	1.44	0.71	51.56	47.74	8.67	1.76	0.55	1.02
33/2/135-137	305.55	10.7563	97.49	0.60	0.51	50.58	48.91	8.67	1.76	0.55	1.02
33/3/1- 3	305.71	10.7605	96.73	1.11	0.42	54.22	45.36	8.33	1.51	0.47	1.02
33/3/23-25	305.93	10.7664	97.08	0.82	0.62	51.23	48.15	8.67	1.76	0.55	1.02
33/3/41-43	306.11	10.7711	96.68	0.81	0.63	51.49	47.88	8.67	1.76	0.55	1.02
33/3/57-59	306.27	10.7754	96.79	0.96	0.46	51.80	47.74	8.67	1.76	0.55	1.02
33/3/84-86	306.54	10.7825	97.47	0.72	0.51	51.62	47.87	8.67	1.76	0.55	1.02
33/3/105-107	306.75	10.7881	97.76	0.59	0.31	51.44	48.26	8.67	1.76	0.55	1.02
33/3/116-118	306.86	10.7910	97.49	0.66	0.50	53.75	45.75	8.33	1.51	0.47	1.02
33/3/138-140	307.08	10.7968	97.68	0.67	0.77	51.95	47.28	8.67	1.76	0.55	1.02
33/4/10- 12	307.30	10.8027	97.16	0.92	0.41	52.37	47.22	8.67	1.76	0.55	1.02
33/4/29-31	307.49	10.8077	97.32	0.70	0.54	53.77	45.69	8.33	1.51	0.47	1.02
33/4/50-52	307.70	10.8133	96.95	0.83	0.56	53.81	45.63	8.33	1.51	0.47	1.02
33/4/73-75	307.93	10.8193	96.36	1.19	0.52	52.94	46.54	8.33	1.51	0.47	1.02
33/4/94-96	308.14	10.8249	97.19	0.73	0.40	52.65	46.95	8.67	1.76	0.55	1.02
33/4/110-112	308.30	10.8292	96.58	0.83	0.48	53.00	46.52	8.33	1.51	0.47	2.05
33/4/133/135	308.53	10.8352	96.54	0.93	0.46	51.45	48.10	8.67	1.76	0.55	1.02
33/5/1- 3	308.71	10.8400	95.73	1.30	0.50	52.61	46.89	8.67	1.76	0.55	1.02
33/5/29-31	308.99	10.8474	96.43	0.95	0.50	54.19	45.31	8.33	1.51	0.47	1.02
33/5/41-43	309.11	10.8516	96.10	1.27	0.45	51.70	47.85	8.67	1.76	0.55	1.02
33/5/58-60	309.28	10.8543	96.49	1.23	0.42	51.61	47.97	8.67	1.76	0.55	1.02
33/5/84-86	309.54	10.8583	96.24	1.07	0.47	50.57	48.96	8.67	1.76	0.55	1.02
33/5/104-106	309.74	10.8615	95.63	1.31	0.55	53.96	45.50	8.33	1.51	0.47	2.05
34/1/1- 3	312.31	10.9018	96.68	1.03	0.43	50.37	49.19	8.67	1.76	0.55	1.02
34/1/24-26	312.54	10.9054	96.90	0.97	0.40	56.67	42.93	8.33	1.51	0.47	2.05
34/1/37-39	312.67	10.9075	96.63	1.04	0.53	56.97	42.51	8.33	1.51	0.47	2.05
34/1/57-59	312.87	10.9106	96.61	0.89	0.48	56.76	42.76	8.33	1.51	0.47	2.05
34/1/77-79	313.07	10.9138	96.71	0.81	0.61	56.60	42.79	8.33	1.51	0.47	2.05
34/1/101-103	313.31	10.9175	95.30	1.88	0.45	56.69	42.86	8.33	1.51	0.47	2.05
34/1/123-125	313.53	10.9210	96.07	1.24	0.58	60.17	39.25	8.33	1.51	0.47	1.02
34/1/141-143	313.71	10.9238	96.11	1.26	0.47	56.02	43.51	8.33	1.51	0.47	2.05
34/2/10- 12	313.90	10.9268	96.57	1.05	0.43	55.42	44.15	8.33	1.51	0.47	1.02
34/2/29-31	314.09	10.9298	96.85	0.98	0.58	55.28	44.14	8.33	1.51	0.47	2.05
34/2/49-51	314.29	10.9329	95.48	1.25	0.52	56.00	43.48	8.33	1.51	0.47	2.05
34/2/65-67	314.45	10.9354	95.64	1.43	0.85	55.33	43.82	8.33	1.51	0.47	1.02
34/2/89-91	314.69	10.9392	96.96	1.13	0.43	55.76	43.81	8.33	1.51	0.47	2.05
34/2/110-112	314.90	10.9425	96.01	1.32	0.37	56.37	43.26	8.33	1.51	0.47	2.05
34/2/133-135	315.13	10.9461	96.31	1.00	0.41	53.43	46.16	8.67	1.76	0.55	1.02
34/3/0- 2	315.30	10.9496	95.67	1.48	0.48	53.72	45.80	8.67	1.76	0.55	1.02
34/3/22-24	315.52	10.9569	96.57	1.05	0.67	53.44	45.89	8.33	1.51	0.47	1.02
34/3/41-43	315.71	10.9631	95.63	1.36	0.33	53.38	46.29	8.67	1.76	0.55	1.02
34/3/76-78	316.06	10.9746	96.99	0.87	0.64	55.35	44.01	8.33	1.51	0.47	2.05
34/3/97-99	316.27	10.9815	97.71	0.60	0.39	53.26	46.35	8.33	1.51	0.47	1.02
34/3/118-120	316.48	10.9884	97.24	0.74	0.29	52.37	47.34	8.67	1.51	0.55	1.02
34/3/137-139	316.67	10.9947	97.17	0.81	0.20	51.05	48.75				
34/4/8- 10	316.88	11.0016	98.07	0.47	0.23	56.49	43.28	8.33	1.51	0.47	2.05
34/4/30-32	317.10	11.0088	97.02	0.80	0.41	56.05	43.54	8.33	1.51	0.47	2.05
34/4/50-52	317.30	11.0154	97.19	0.62	0.46	53.22	46.32	8.67	1.76	0.55	1.02
34/4/70-72	317.50	11.0220	95.91	1.18	0.60	55.42	43.99	8.33	1.51	0.47	2.05
34/4/88-90	317.68	11.0279	97.93	0.54	0.42	54.19	45.38	8.33	1.51	0.47	1.02
34/4/110-112	317.90	11.0351	97.07	0.93	0.44	53.79	45.77	8.33	1.51	0.47	1.02
34/4/133-135	318.13	11.0427	98.29	0.41	0.28	50.80	48.92	9.00	1.51	0.80	1.02
34/5/5- 7	318.35	11.0499	97.57	0.53	0.37	54.86	44.77	8.33	1.51	0.47	2.05
34/5/30-32	318.60	11.0582	97.87	0.47	0.76	53.87	45.37	8.67	1.76	0.55	1.02
35/1/1- 3	321.91	11.1670	96.75	1.15	0.21	49.59	50.20	9.33	1.51	0.27	1.02
35/1/23-25	322.13	11.1742	96.17	1.34	0.43	58.09	41.48	8.33	1.51	0.47	2.05
35/1/43-45	322.33	11.1808	96.39	1.13	0.24	57.25	42.51	8.33	1.51	0.47	2.05
35/1/64-66	322.54	11.1877	97.27	0.71	0.32	56.89	42.79	8.33	1.51	0.47	2.05
35/1/82-84	322.72	11.1936	97.07	0.77	0.39	55.92	43.69	8.33	1.51	0.47	2.05
35/1/100-102	322.90	11.1996	96.57	0.94	0.46	55.43	44.10	8.33	1.51	0.47	2.05
35/1/119-121	323.09	11.2058	96.30	1.08	0.39	54.50	45.11	8.33	1.51	0.47	2.05
35/1/141-143	323.31	11.2130	97.26	0.69	0.32	56.66	43.02	8.33	1.51	0.47	2.05

Sample No.	depth (mbsf)	Age (Ma)	% mud	% c. sand <4 phi	% <4 phi of LS mud	% Silt 4-8 phi of LS mud	% Clay 8->12 phi of LS mud	G mean	G sd	G skew	G kurt
35/2/8- 10	323.48	11.2186	97.75	0.49	0.38	52.92	46.70	8.67	1.76	0.55	1.02
35/2/32-34	323.72	11.2265	95.99	1.16	0.59	53.69	45.72	8.33	1.51	0.47	1.02
35/2/51-53	323.91	11.2328	97.15	0.74	0.45	53.98	45.57	8.67	1.76	0.55	1.02
35/2/90-92	324.30	11.2456	96.47	1.04	0.41	55.17	44.42	8.33	1.51	0.47	1.02
35/2/110-112	324.50	11.2522	98.37	0.31	0.39	56.53	43.08	8.33	1.51	0.47	2.05
35/2/130-132	324.70	11.2587	97.86	0.50	0.49	53.79	45.72	8.33	1.51	0.47	1.02
35/3/1- 3	324.91	11.2657	98.24	0.46	0.32	54.43	45.25	8.33	1.51	0.47	1.02
35/3/22-24	325.12	11.2726	97.85	0.69	0.35	55.51	44.14	8.33	1.51	0.47	2.05
35/3/43-45	325.33	11.2795	98.31	0.46	0.23	53.12	46.65	8.33	1.51	0.47	1.02
35/3/67-69	325.57	11.2874	98.38	0.33	0.27	52.71	47.02	8.67	1.26	0.80	1.02
35/3/81-83	325.71	11.2920	97.36	0.62	0.22	52.36	47.42	9.00	1.51	0.80	1.02
35/3/104-106	325.94	11.2995	98.63	0.27	0.21	54.50	45.29	8.33	1.51	0.47	2.05
35/3/117-119	326.07	11.3038	98.43	0.26	0.14	52.31	47.55	8.67	1.76	0.55	1.02
35/3/138-140	326.28	11.3107	97.19	0.63	0.38	57.22	42.40	8.33	1.51	0.47	2.05
35/4/10- 12	326.50	11.3179	98.15	0.48	0.25	54.63	45.12	8.33	1.51	0.47	1.02
35/4/30-32	326.70	11.3245	98.03	0.59	0.36	53.88	45.76	8.33	1.51	0.47	1.02
35/4/48-50	326.88	11.3304	98.01	0.59	0.34	54.45	45.21	8.67	1.76	0.55	1.02
35/4/69-71	327.09	11.3373	98.12	0.60	0.15	55.47	44.37	8.33	1.51	0.47	2.05
35/4/88-90	327.28	11.3436	97.33	0.78	0.21	55.26	44.53	8.33	1.51	0.47	2.05
35/4/110-112	327.50	11.3508	97.73	0.53	0.30	52.92	46.78	8.67	1.76	0.55	1.02
35/4/134-136	327.74	11.3587	97.13	0.78	0.40	52.68	46.92	8.33	1.51	0.47	1.02
35/5/1- 3	327.91	11.3643	95.12	1.65	0.53	50.47	49.00	9.00	1.51	0.80	1.02
35/5/16-18	328.06	11.3692	97.46	0.71	0.35	49.46	50.19	9.33	1.51	0.27	1.02
35/5/37-39	328.27	11.3761	96.73	0.80	0.40	48.80	50.79	9.33	1.51	0.27	1.02
35/5/57-59	328.47	11.3827	96.00	1.35	0.11	48.69	51.20	9.33	1.51	0.27	1.02
35/5/82-84	328.72	11.3909	96.72	1.19	0.00	50.88	49.12	9.00	1.51	0.80	1.02

Appendix B Table 10: Hole 593 sediment texture data (from lasersizer mud data only) (120-329 mbsf) at one phi intervals as amounts in each size class, then cumulatively. (File on CD: App B Table 10).

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
14/1/0-3	120.30	5.1273	0.921	2.603	1.448	11.711	26.443	22.718	12.099	9.019	10.649	2.389	3.524	4.972	16.683	43.126	65.844	77.943	86.962	97.611	100.0
14/1/21-24	120.51	5.1326	0.792	2.309	1.385	11.526	25.716	22.305	12.580	9.662	10.697	3.031	3.101	4.485	16.011	41.727	64.031	76.611	86.273	96.970	100.0
14/1/39-42	120.69	5.1372	0.708	3.013	1.769	11.234	25.792	22.568	12.030	9.090	11.033	2.764	3.721	5.490	16.724	42.516	65.084	77.114	86.204	97.237	100.0
14/1/60-63	120.90	5.1425	0.773	3.059	1.559	10.946	28.241	23.709	10.847	8.372	10.328	2.167	3.832	5.391	16.337	44.578	68.287	79.134	87.506	97.834	100.0
14/1/81-84	121.11	5.1479	0.546	3.155	1.666	11.962	28.793	22.757	10.346	7.968	9.859	2.948	3.701	5.367	17.329	46.122	68.879	79.225	87.193	97.052	100.0
14/1/96-99	121.26	5.1517	0.280	2.698	1.451	11.700	28.640	23.225	10.972	8.134	9.928	2.973	2.978	4.429	16.129	44.769	67.994	78.966	87.100	97.028	100.0
14/1/119-122	121.49	5.1576	0.809	2.696	1.213	11.842	28.064	23.211	11.132	7.899	10.029	3.106	3.505	4.718	16.560	44.624	67.835	78.967	86.866	96.895	100.0
14/1/139-142	121.69	5.1626	0.243	2.399	2.938	13.237	26.337	21.605	10.895	7.789	10.579	3.979	2.642	5.580	18.817	45.154	66.759	77.654	85.443	96.022	100.0
14/2/10-13	121.90	5.1680	0.527	2.789	1.824	11.533	26.566	22.777	11.904	8.512	10.833	2.737	3.316	5.140	16.673	43.239	66.016	77.920	86.432	97.265	100.0
14/2/29-32	122.09	5.1728	0.662	2.794	1.496	11.025	25.951	22.437	12.016	9.137	11.500	2.982	3.456	4.952	15.977	41.928	64.365	76.381	85.518	97.018	100.0
14/2/46-49	122.26	5.1771	0.455	3.440	1.369	11.465	26.806	22.838	11.761	8.769	10.063	3.034	3.895	5.264	16.729	43.535	66.373	78.134	86.903	96.966	100.0
14/2/71-75	122.51	5.1835	0.334	3.574	2.072	10.941	25.711	23.306	12.285	8.812	10.430	2.536	3.908	5.980	16.921	42.632	65.938	78.223	87.035	97.465	100.0
14/2/91-94	122.71	5.1886	0.027	2.665	2.678	10.915	25.619	23.398	12.251	8.391	10.028	4.027	2.692	5.370	16.285	41.904	65.302	77.553	85.944	95.972	100.0
14/2/112-115	122.92	5.1939	0.011	0.713	0.658	10.816	26.997	24.689	12.712	8.765	11.147	3.493	0.724	1.382	12.198	39.195	63.884	76.596	85.361	96.508	100.0
14/2/130-133	123.10	5.1979	0.111	3.125	2.551	11.350	26.649	23.105	11.225	8.020	10.551	3.313	3.236	5.787	17.137	43.786	66.891	78.116	86.136	96.687	100.0
14/3/0-3	123.30	5.2009	0.078	2.081	1.622	9.998	26.102	24.954	12.217	8.399	11.091	3.457	2.159	3.781	13.779	39.881	64.835	77.052	85.451	96.542	100.0
14/3/23-26	123.53	5.2044	0.499	4.227	1.821	10.712	26.070	24.121	11.530	7.854	10.055	3.111	4.726	6.547	17.259	43.329	67.450	78.980	86.834	96.889	100.0
14/3/39-42	123.69	5.2069	0.336	2.715	0.551	9.472	27.085	25.300	11.926	8.088	10.680	3.847	3.051	3.602	13.074	40.159	65.459	77.385	85.473	96.153	100.0
14/3/58-61	123.88	5.2098	0.859	3.725	1.472	9.986	26.529	23.896	11.376	8.082	10.375	3.700	4.584	6.056	16.042	42.571	66.467	77.843	85.925	96.300	100.0
14/3/81-84	124.11	5.2132	0.759	3.370	2.041	10.381	24.996	23.174	11.805	8.560	10.926	3.988	4.129	6.170	16.551	41.547	64.721	76.526	85.086	96.012	100.0
14/3/100-103	124.30	5.2161	1.110	2.948	2.859	11.936	25.564	22.481	11.310	7.991	10.154	3.647	4.058	6.917	18.853	44.417	66.898	78.208	86.199	96.353	100.0
14/3/120-123	124.50	5.2192	1.905	3.420	1.582	11.513	25.915	22.477	11.294	7.791	9.933	4.169	5.325	6.907	18.420	44.335	66.812	78.106	85.897	95.830	100.0
14/3/138-141	124.68	5.2219	0.339	2.657	2.008	11.796	26.348	23.300	11.332	7.578	10.260	4.381	2.996	5.004	16.800	43.148	66.448	77.780	85.358	95.618	100.0
14/4/10-13	124.90	5.2252	0.368	2.205	1.618	10.729	26.116	24.238	11.631	8.074	10.629	4.392	2.573	4.191	14.920	41.036	65.274	76.905	84.979	95.608	100.0
14/4/30-33	125.10	5.2283	0.676	3.827	2.325	11.358	24.305	23.790	12.118	7.974	10.039	3.588	4.503	6.828	18.186	42.491	66.281	78.399	86.373	96.412	100.0
14/4/50-53	125.30	5.2313	0.323	3.630	2.067	8.770	24.172	26.040	12.551	7.873	10.661	3.915	3.953	6.020	14.790	38.962	65.002	77.553	85.426	96.087	100.0
14/4/68-71	125.48	5.2340	0.120	2.611	2.690	7.984	23.827	26.736	12.562	8.580	12.115	2.776	2.731	5.421	13.405	37.232	63.968	76.530	85.110	97.225	100.0
14/4/91-94	125.71	5.2375	0.242	2.056	1.261	7.906	25.237	27.496	12.656	8.545	11.897	2.705	2.298	3.559	11.465	36.702	64.198	76.854	85.399	97.296	100.0
14/4/111-114	125.91	5.2406	0.247	2.445	2.115	8.453	26.024	26.664	11.811	7.993	10.849	3.399	2.692	4.807	13.260	39.284	65.948	77.759	85.752	96.601	100.0
14/4/130-133	126.10	5.2435	0.324	2.274	1.597	7.847	24.261	27.216	13.191	9.211	11.755	2.324	2.598	4.195	12.042	36.303	63.519	76.710	85.921	97.676	100.0
14/5/0-3	126.30	5.2465	0.268	2.478	1.790	10.047	26.273	25.180	11.628	8.191	10.732	3.412	2.746	4.536	14.583	40.856	66.036	77.664	85.855	96.587	100.0
14/5/26-29	126.56	5.2504	0.283	3.018	4.324	11.306	25.494	23.892	11.040	7.717	10.112	2.814	3.301	7.625	18.931	44.425	68.317	79.357	87.074	97.186	100.0
14/5/40-43	126.70	5.2526	0.163	1.319	1.123	10.588	28.753	24.846	11.200	8.440	11.350	2.220	1.482	2.605	13.193	41.946	66.792	77.992	86.432	97.782	100.0
14/5/60-63	126.90	5.2556	1.806	4.273	1.681	11.362	25.996	23.199	11.306	7.841	9.880	2.657	6.079	7.760	19.122	45.118	68.317	79.623	87.464	97.344	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
14/5/82-85	127.12	5.2589	0.096	2.187	1.960	10.599	26.170	23.346	11.917	8.541	11.122	4.064	2.283	4.243	14.842	41.012	64.358	76.275	84.816	95.938	100.0
14/5/100-103	127.30	5.2617	0.551	3.624	3.056	11.154	25.631	22.851	11.667	8.260	10.566	2.639	4.175	7.231	18.385	44.016	66.867	78.534	86.794	97.360	100.0
14/5/121-124	127.51	5.2649	0.620	2.243	1.920	12.130	27.010	23.237	11.550	8.100	10.528	2.661	2.863	4.783	16.913	43.923	67.160	78.710	86.810	97.338	100.0
14/5/140-143	127.70	5.2678	0.342	3.437	1.520	12.090	28.299	22.445	10.730	7.629	9.944	3.565	3.779	5.299	17.389	45.688	68.133	78.863	86.492	96.436	100.0
14/6/10-13	127.90	5.2708	0.198	2.765	1.634	11.736	27.131	22.699	11.218	7.879	10.367	4.372	2.963	4.597	16.333	43.464	66.163	77.381	85.260	95.627	100.0
14/6/30-33	128.10	5.2738	0.744	3.030	1.340	13.207	27.724	22.597	10.963	7.372	9.579	3.445	3.774	5.114	18.321	46.045	68.642	79.605	86.977	96.556	100.0
14/6/49-52	128.29	5.2767	0.204	2.812	1.737	12.434	27.356	23.028	11.274	7.828	10.115	3.212	3.016	4.753	17.187	44.543	67.571	78.845	86.673	96.788	100.0
14/6/69-72	128.49	5.2798	0.051	3.764	2.374	11.980	27.003	22.557	11.185	7.803	9.795	3.488	3.815	6.189	18.169	45.172	67.729	78.914	86.717	96.512	100.0
14/6/92-95	128.72	5.2832	0.287	3.015	1.395	12.359	27.890	22.733	10.704	8.069	10.358	3.191	3.302	4.697	17.056	44.946	67.679	78.383	86.452	96.810	100.0
14/6/112-115	128.92	5.2863	0.037	1.673	1.668	12.406	26.262	23.084	12.151	8.784	10.896	3.040	1.710	3.378	15.784	42.046	65.130	77.281	86.065	96.961	100.0
14/6/130-133	129.10	5.2890	0.072	2.212	1.728	12.363	26.746	23.434	11.708	8.293	10.294	3.150	2.284	4.012	16.375	43.121	66.555	78.263	86.556	96.850	100.0
14/7/0-3	129.30	5.2921	1.479	3.813	2.235	12.298	26.071	22.291	10.707	7.654	9.567	3.885	5.292	7.527	19.825	45.896	68.187	78.894	86.548	96.115	100.0
14/7/20-23	129.50	5.2951	0.142	2.785	2.481	11.692	26.296	23.170	11.177	8.159	10.442	3.656	2.927	5.408	17.100	43.396	66.566	77.743	85.902	96.344	100.0
14 CC/10-13	129.69	5.2980	0.143	2.567	2.729	10.899	26.203	23.555	11.254	8.288	10.621	3.742	2.710	5.439	16.338	42.541	66.096	77.350	85.638	96.259	100.0
15/1/0-3	129.90	5.3012	0.121	2.717	2.252	9.767	25.922	24.968	11.608	8.435	10.885	3.325	2.838	5.090	14.857	40.779	65.747	77.355	85.790	96.675	100.0
15/1/22-25	130.12	5.3045	0.605	2.627	1.441	11.206	27.173	23.602	11.136	8.169	11.442	2.599	3.232	4.673	15.879	43.052	66.654	77.790	85.959	97.401	100.0
15/1/39-42	130.29	5.3071	1.640	3.516	1.440	11.746	25.896	22.923	11.097	7.916	10.528	3.298	5.156	6.596	18.342	44.238	67.161	78.258	86.174	96.702	100.0
15/1/60-63	130.50	5.3103	0.588	1.761	0.787	11.111	28.298	23.950	11.128	8.094	10.860	3.424	2.349	3.136	14.247	42.545	66.495	77.623	85.717	96.577	100.0
15/1/79-82	130.69	5.3132	0.456	2.305	1.278	11.051	28.454	23.741	10.768	8.249	11.482	2.216	2.761	4.039	15.090	43.544	67.285	78.053	86.302	97.784	100.0
15/1/99-102	130.89	5.3162	0.186	1.892	0.871	12.063	29.814	23.081	10.175	8.134	11.536	2.249	2.078	2.949	15.012	44.826	67.907	78.082	86.216	97.752	100.0
15/1/120-123	131.10	5.3194	0.116	1.514	0.900	11.266	28.452	23.938	11.116	8.493	11.909	2.296	1.630	2.530	13.796	42.248	66.186	77.302	85.795	97.704	100.0
15/1/140-143	131.30	5.3224	0.097	1.811	1.224	11.226	27.419	23.252	11.442	8.611	12.179	2.737	1.908	3.132	14.358	41.777	65.029	76.471	85.082	97.261	100.0
15/2/11-14	131.51	5.3256	0.190	1.457	0.830	10.452	27.646	23.721	11.570	8.675	13.332	2.128	1.647	2.477	12.929	40.575	64.296	75.866	84.541	97.873	100.0
15/2/30-33	131.70	5.3285	0.124	1.494	0.448	9.906	28.779	24.751	10.981	8.515	12.520	2.481	1.618	2.066	11.972	40.751	65.502	76.483	84.998	97.518	100.0
15/2/51-53	131.91	5.3317	0.103	1.609	0.817	11.208	29.968	23.483	10.027	8.207	12.656	1.921	1.712	2.529	13.737	43.705	67.188	77.215	85.422	98.078	100.0
15/2/71-74	132.11	5.3347	0.170	1.822	1.575	11.539	27.794	22.781	10.859	8.466	12.183	2.811	1.992	3.567	15.106	42.900	65.681	76.540	85.006	97.189	100.0
15/2/93-96	132.33	5.3381	0.258	1.311	0.517	12.575	29.112	22.827	10.758	8.284	11.928	2.430	1.569	2.086	14.661	43.773	66.600	77.358	85.642	97.570	100.0
15/2/113-116	132.53	5.3411	0.150	1.563	0.528	12.439	29.522	22.797	10.327	8.137	12.090	2.447	1.713	2.241	14.680	44.202	66.999	77.326	85.463	97.553	100.0
15/2/134-136	132.74	5.3443	0.313	1.340	0.249	11.096	29.934	23.775	10.497	8.301	12.821	1.673	1.653	1.902	12.998	42.933	66.707	77.204	85.505	98.326	100.0
15/3/0-3	132.90	5.3467	0.192	1.338	0.852	10.861	26.618	23.154	11.914	9.017	13.817	2.238	1.530	2.382	13.243	39.861	63.015	74.929	83.946	97.763	100.0
15/3/17-20	133.07	5.3493	0.241	1.468	0.829	11.903	27.345	22.674	11.216	8.600	12.730	2.993	1.709	2.538	14.441	41.786	64.460	75.676	84.276	97.006	100.0
15/3/39-42	133.29	5.3526	0.044	1.217	0.756	13.137	27.747	22.087	11.452	8.692	12.330	2.538	1.261	2.017	15.154	42.901	64.988	76.440	85.132	97.462	100.0
15/3/56-59	133.46	5.3552	0.159	1.164	0.820	13.006	27.720	22.320	11.414	8.672	12.218	2.508	1.323	2.143	15.149	42.869	65.189	76.603	85.275	97.493	100.0
15/3/78-81	133.68	5.3586	0.130	1.286	0.553	11.539	28.015	22.967	11.253	8.690	13.433	2.134	1.416	1.969	13.508	41.523	64.490	75.743	84.433	97.866	100.0
15/3/99-102	133.89	5.3617	0.078	1.293	1.034	11.089	27.368	23.504	11.544	8.748	12.526	2.815	1.371	2.405	13.494	40.862	64.366	75.910	84.658	97.184	100.0
15/3/120-123	134.10	5.3649	0.295	2.525	1.937	11.514	26.541	22.340	10.810	8.275	11.578	4.187	2.820	4.757	16.271	42.812	65.152	75.962	84.237	95.815	100.0
15/3/140-143	134.30	5.3680	0.245	1.679	1.120	11.901	27.250	22.509	11.115	8.537	12.705	2.941	1.924	3.044	14.945	42.195	64.704	75.819	84.356	97.061	100.0
15/4/10-13	134.50	5.3710	0.140	1.523	1.025	9.888	25.856	23.573	12.463	9.422	13.355	2.754	1.663	2.688	12.576	38.432	62.005	74.468	83.890	97.245	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
15/4/30-33	134.70	5.3740	0.159	2.252	0.770	10.261	26.574	23.387	11.759	8.939	12.944	2.955	2.411	3.181	13.442	40.016	63.403	75.162	84.101	97.045	100.0
15/4/50-53	134.90	5.3771	0.191	1.861	1.606	10.067	26.677	23.547	11.409	8.982	13.567	2.093	2.052	3.658	13.725	40.402	63.949	75.358	84.340	97.907	100.0
15/4/70-73	135.10	5.3801	0.347	1.995	1.611	10.847	25.813	23.010	11.492	8.779	12.757	3.349	2.342	3.953	14.800	40.613	63.623	75.115	83.894	96.651	100.0
15/4/90-93	135.30	5.3832	0.248	1.884	1.817	11.372	25.103	22.562	11.995	9.137	12.907	2.977	2.132	3.949	15.321	40.424	62.986	74.981	84.118	97.025	100.0
15/4/110-113	135.50	5.3862	0.281	1.838	1.065	11.588	28.969	23.124	10.296	8.550	11.972	2.319	2.119	3.184	14.772	43.741	66.865	77.161	85.711	97.683	100.0
15/4/130-133	135.70	5.3892	0.254	1.971	1.521	10.148	26.346	23.839	11.608	8.911	12.586	2.817	2.225	3.746	13.894	40.240	64.079	75.687	84.598	97.184	100.0
15/5/0-3	135.90	5.3923	0.282	1.796	1.122	10.861	27.082	23.455	11.327	8.819	12.452	2.805	2.078	3.200	14.061	41.143	64.598	75.925	84.744	97.196	100.0
15/5/16-19	136.06	5.3947	0.312	2.007	1.215	11.673	27.718	22.975	10.787	8.450	12.137	2.728	2.319	3.534	15.207	42.925	65.900	76.687	85.137	97.274	100.0
15/5/42-45	136.32	5.3986	0.195	1.508	0.709	10.513	28.254	23.897	10.959	8.871	13.290	1.806	1.703	2.412	12.925	41.179	65.076	76.035	84.906	98.196	100.0
15/5/61-63	136.51	5.4015	0.055	1.344	1.703	9.928	26.714	23.937	11.679	8.995	12.737	2.907	1.399	3.102	13.030	39.744	63.681	75.360	84.355	97.092	100.0
15/5/102-105	136.92	5.4078	0.330	1.748	0.899	10.592	27.169	22.837	11.337	9.064	13.045	2.979	2.078	2.977	13.569	40.738	63.575	74.912	83.976	97.021	100.0
15/5/123-126	137.13	5.4109	0.542	2.514	1.608	10.628	25.672	21.916	11.286	8.651	12.056	5.126	3.056	4.664	15.292	40.964	62.880	74.166	82.817	94.873	100.0
15/5/142-145	137.32	5.4138	0.531	1.895	0.830	10.165	24.685	22.890	12.697	9.757	12.889	3.660	2.426	3.256	13.421	38.106	60.996	73.693	83.450	96.339	100.0
15/6/12-15	137.52	5.4169	0.149	1.955	1.439	9.188	23.759	24.607	12.968	9.437	14.291	2.207	2.104	3.543	12.731	36.490	61.097	74.065	83.502	97.793	100.0
15/6/31-34	137.71	5.4197	0.461	1.829	1.141	9.277	23.589	24.004	13.020	9.775	13.464	3.442	2.290	3.431	12.708	36.297	60.301	73.321	83.096	96.560	100.0
15/6/51-54	137.91	5.4228	0.306	1.860	1.138	8.812	24.621	23.821	12.215	9.190	15.223	2.815	2.166	3.304	12.116	36.737	60.558	72.773	81.963	97.186	100.0
15/6/65-68	138.05	5.4249	0.139	1.614	1.262	9.612	25.511	24.140	12.207	8.855	14.327	2.335	1.753	3.015	12.627	38.138	62.278	74.485	83.340	97.667	100.0
15/6/87-90	138.27	5.4282	0.177	1.449	1.130	9.508	25.895	24.780	11.939	8.579	13.384	3.160	1.626	2.756	12.264	38.159	62.939	74.878	83.457	96.841	100.0
15/6/107-110	138.47	5.4313	0.217	1.233	1.257	10.142	26.855	24.423	11.566	8.590	13.041	2.676	1.450	2.707	12.849	39.704	64.127	75.693	84.283	97.324	100.0
15/6/126-129	138.66	5.4342	0.174	1.775	1.646	10.324	26.431	24.047	11.397	8.185	13.788	2.233	1.949	3.595	13.919	40.350	64.397	75.794	83.979	97.767	100.0
15/7/0-3	138.90	5.4378	0.059	1.435	1.850	10.313	26.473	23.918	11.498	8.578	12.028	3.850	1.494	3.344	13.657	40.130	64.048	75.546	84.124	96.152	100.0
15/7/17-20	139.07	5.4404	0.093	1.877	1.246	10.023	26.870	23.720	11.146	8.545	12.094	4.386	1.970	3.216	13.239	40.109	63.829	74.975	83.520	95.614	100.0
15 CC/9-11	139.22	5.4427	0.403	1.775	1.338	9.978	25.795	24.235	11.768	8.842	13.690	2.176	2.178	3.516	13.494	39.289	63.524	75.292	84.134	97.824	100.0
16/1/0-3	139.50	5.4469	0.451	2.079	1.273	9.815	24.498	22.990	12.372	9.650	13.107	3.766	2.530	3.803	13.618	38.116	61.106	73.478	83.128	96.235	100.0
16/1/25-28	139.75	5.4507	0.493	1.944	1.033	11.271	25.277	22.177	12.351	9.397	12.747	3.312	2.437	3.470	14.741	40.018	62.195	74.546	83.943	96.690	100.0
16/1/67-70	140.17	5.4571	0.148	1.908	1.018	10.343	26.205	23.285	12.250	9.151	13.000	2.692	2.056	3.074	13.417	39.622	62.907	75.157	84.308	97.308	100.0
16/1/84-87	140.34	5.4597	0.468	2.225	1.437	11.634	26.434	22.185	11.163	8.449	12.627	3.379	2.693	4.130	15.764	42.198	64.383	75.546	83.995	96.622	100.0
16/1/104-107	140.54	5.4627	0.278	2.088	1.133	10.577	25.837	22.971	12.188	9.004	12.891	3.031	2.366	3.499	14.076	39.913	62.884	75.072	84.076	96.967	100.0
16/1/123-126	140.73	5.4656	0.216	1.604	0.854	11.272	27.317	23.111	11.448	8.539	13.467	2.170	1.820	2.674	13.946	41.263	64.374	75.822	84.361	97.828	100.0
16/1/142-145	140.92	5.4685	0.247	2.077	1.428	9.630	24.481	24.188	12.808	9.042	13.038	3.062	2.324	3.752	13.382	37.863	62.051	74.859	83.901	96.939	100.0
16/2/13-16	141.13	5.4717	0.296	1.937	1.364	10.048	24.862	23.936	12.400	8.758	12.358	4.041	2.233	3.597	13.645	38.507	62.443	74.843	83.601	95.959	100.0
16/2/36-39	141.36	5.4752	0.053	1.428	0.414	9.649	26.486	24.207	12.443	8.936	14.082	2.302	1.481	1.895	11.544	38.030	62.237	74.680	83.616	97.698	100.0
16/2/54-57	141.54	5.4779	0.196	2.056	0.777	10.662	27.177	23.117	11.720	8.619	12.702	2.974	2.252	3.029	13.691	40.868	63.985	75.705	84.324	97.026	100.0
16/2/79-82	141.79	5.4817	0.122	2.259	1.955	11.646	27.386	21.939	10.700	8.325	11.842	3.825	2.381	4.336	15.982	43.368	65.307	76.007	84.332	96.174	100.0
16/2/92-95	141.92	5.4837	0.127	1.880	0.855	11.183	27.014	23.067	11.644	8.753	12.859	2.618	2.007	2.862	14.045	41.059	64.126	75.770	84.523	97.382	100.0
16/2/112-114	142.12	5.4867	0.392	1.362	1.080	12.377	27.006	22.690	11.270	8.423	12.498	2.901	1.754	2.834	15.211	42.217	64.907	76.177	84.600	97.098	100.0
16/2/132-135	142.32	5.4897	0.207	2.425	0.993	10.494	25.972	23.296	11.828	8.579	12.205	4.002	2.632	3.625	14.119	40.091	63.387	75.215	83.794	95.999	100.0
16/3/0-3	142.50	5.4925	0.144	1.408	0.930	10.347	26.591	24.122	12.326	8.679	12.574	2.878	1.552	2.482	12.829	39.420	63.542	75.868	84.547	97.121	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
16/3/25-28	142.75	5.4963	0.122	1.107	0.444	10.712	27.451	24.252	12.180	8.635	12.568	2.529	1.229	1.673	12.385	39.836	64.088	76.268	84.903	97.471	100.0
16/3/43-46	142.93	5.4990	0.099	1.297	0.830	10.268	27.253	24.438	11.862	8.379	12.662	2.913	1.396	2.226	12.494	39.747	64.185	76.047	84.426	97.088	100.0
16/3/65-68	143.15	5.5023	0.104	1.881	1.967	10.242	26.803	23.848	11.447	8.214	12.570	2.924	1.985	3.952	14.194	40.997	64.845	76.292	84.506	97.076	100.0
16/3/82-85	143.32	5.5049	0.242	1.794	1.550	10.528	26.106	24.065	11.802	8.244	12.679	2.990	2.036	3.586	14.114	40.220	64.285	76.087	84.331	97.010	100.0
16/3/103-106	143.53	5.5081	0.203	1.160	0.658	9.056	26.709	25.576	12.345	8.301	12.024	3.968	1.363	2.021	11.077	37.786	63.362	75.707	84.008	96.032	100.0
16/3/124-127	143.74	5.5116	0.098	1.193	0.721	9.453	28.032	25.797	11.945	8.263	12.094	2.405	1.291	2.012	11.465	39.497	65.294	77.239	85.502	97.596	100.0
16/3/134-137	143.84	5.5145	0.211	1.916	1.672	10.308	28.236	23.593	10.852	8.040	12.042	3.130	2.127	3.799	14.107	42.343	65.936	76.788	84.828	96.870	100.0
16/4/7-10	144.07	5.5211	0.216	1.495	0.903	9.418	27.948	25.095	11.641	8.374	12.167	2.744	1.711	2.614	12.032	39.980	65.075	76.716	85.090	97.257	100.0
16/4/26-29	144.26	5.5266	0.417	2.121	1.175	8.803	26.017	25.396	12.449	8.551	12.294	2.777	2.538	3.713	12.516	38.533	63.929	76.378	84.929	97.223	100.0
16/4/46-49	144.46	5.5324	0.160	1.410	0.941	8.763	25.392	25.004	13.040	9.020	12.336	3.933	1.570	2.511	11.274	36.666	61.670	74.710	83.730	96.066	100.0
16/4/67-70	144.67	5.5385	0.279	2.269	1.173	10.506	26.295	23.674	12.474	8.458	11.853	3.019	2.548	3.721	14.227	40.522	64.196	76.670	85.128	96.981	100.0
16/4/93-96	144.93	5.5460	0.459	1.745	0.379	11.304	28.972	23.860	11.314	8.006	10.918	3.043	2.204	2.583	13.887	42.859	66.719	78.033	86.039	96.957	100.0
16/4/113-116	145.13	5.5518	0.223	2.416	1.433	11.324	28.058	23.301	11.026	7.801	10.928	3.490	2.639	4.072	15.396	43.454	66.755	77.781	85.582	96.510	100.0
16/4/132-135	145.32	5.5573	0.308	2.234	1.010	11.325	28.608	23.785	11.416	7.665	10.377	3.272	2.542	3.552	14.877	43.485	67.270	78.686	86.351	96.728	100.0
16/5/0-3	145.50	5.5626	0.335	1.230	0.165	10.901	28.874	25.230	11.963	8.059	10.673	2.570	1.565	1.730	12.631	41.505	66.735	78.698	86.757	97.430	100.0
16/5/14-17	145.64	5.5666	0.288	1.170	0.190	12.482	30.866	23.791	10.513	7.633	10.506	2.561	1.458	1.648	14.130	44.996	68.787	79.300	86.933	97.439	100.0
16/5/43-46	145.93	5.5750	0.230	1.910	0.859	11.910	28.705	23.634	10.921	7.954	11.316	2.562	2.140	2.999	14.909	43.614	67.248	78.169	86.123	97.439	100.0
16/5/63-66	146.13	5.5808	0.125	1.732	0.758	12.068	30.751	23.927	10.500	7.669	10.068	2.401	1.857	2.615	14.683	45.434	69.361	79.861	87.530	97.598	100.0
16/5/86-88	146.36	5.5875	0.400	2.173	2.253	14.186	28.489	22.493	10.624	7.109	9.609	2.664	2.573	4.826	19.012	47.501	69.994	80.618	87.727	97.336	100.0
16/5/102-105	146.52	5.5921	0.455	3.239	3.488	15.126	27.233	20.668	9.955	6.807	9.472	3.559	3.694	7.182	22.308	49.541	70.209	80.164	86.971	96.443	100.0
16/5/121-124	146.71	5.5976	0.230	2.218	1.411	11.774	29.047	23.052	10.687	8.117	11.057	2.405	2.448	3.859	15.633	44.680	67.732	78.419	86.536	97.593	100.0
16/5/142-145	146.92	5.6037	0.497	2.015	2.345	11.254	26.534	23.092	11.408	8.278	11.041	3.537	2.512	4.857	16.111	42.645	65.737	77.145	85.423	96.464	100.0
16/6/6-9	147.06	5.6077	0.503	2.755	2.085	10.184	25.376	23.395	12.215	8.723	12.002	2.760	3.258	5.343	15.527	40.903	64.298	76.513	85.236	97.238	100.0
16/6/26-29	147.26	5.6135	0.202	1.628	1.096	8.108	25.698	25.813	13.236	9.119	12.340	2.759	1.830	2.926	11.034	36.732	62.545	75.781	84.900	97.240	100.0
16/6/47-50	147.47	5.6196	0.120	3.294	1.725	11.729	27.717	23.155	10.650	7.633	10.608	3.369	3.414	5.139	16.868	44.585	67.740	78.390	86.023	96.631	100.0
16/6/64-66	147.64	5.6245	0.194	1.584	0.888	11.121	28.879	24.074	11.510	7.970	11.249	2.531	1.778	2.666	13.787	42.666	66.740	78.250	86.220	97.469	100.0
16/6/93-96	147.93	5.6329	0.478	1.833	0.472	12.864	30.284	22.547	10.805	7.651	10.183	2.883	2.311	2.783	15.647	45.931	68.478	79.283	86.934	97.117	100.0
16/6/115-117	148.15	5.6393	0.555	2.300	0.739	12.668	29.061	22.123	11.057	7.821	10.632	3.044	2.855	3.594	16.262	45.323	67.446	78.503	86.324	96.956	100.0
16/6/133-136	148.33	5.6445	0.317	2.990	2.474	13.525	26.977	21.293	10.648	7.173	10.229	4.376	3.307	5.781	19.306	46.283	67.576	78.224	85.397	95.626	100.0
16/7/0-3	148.50	5.6494	0.605	2.392	1.849	12.664	27.249	22.234	11.055	7.896	10.690	3.367	2.997	4.846	17.510	44.759	66.993	78.048	85.944	96.634	100.0
16/7/17-19	148.67	5.6544	0.194	1.802	1.195	11.510	28.874	23.070	10.981	8.103	11.655	2.615	1.996	3.191	14.701	43.575	66.645	77.626	85.729	97.384	100.0
16 CC/8-11	148.77	5.6573	0.632	2.766	1.618	12.431	27.064	22.390	11.361	7.826	10.524	3.388	3.398	5.016	17.447	44.511	66.901	78.262	86.088	96.612	100.0
17/1/0-3	149.10	5.6668	0.498	2.283	1.480	11.857	28.246	22.474	10.960	8.224	11.402	2.577	2.781	4.261	16.118	44.364	66.838	77.798	86.022	97.424	100.0
17/1/26-28	149.36	5.6743	0.620	2.186	1.880	12.593	26.585	22.517	11.435	7.848	10.492	3.845	2.806	4.686	17.279	43.864	66.381	77.816	85.664	96.156	100.0
17/1/42-45	149.52	5.6790	0.538	3.912	2.601	11.001	26.104	22.834	11.459	7.793	10.432	3.325	4.450	7.051	18.052	44.156	66.990	78.449	86.242	96.674	100.0
17/1/82-85	149.92	5.6906	0.192	1.779	0.783	8.950	27.874	25.081	11.971	8.814	12.109	2.448	1.971	2.754	11.704	39.578	64.659	76.630	85.444	97.553	100.0
17/1/101-104	150.11	5.6961	0.649	2.847	2.528	10.486	24.697	23.435	12.119	8.291	11.815	3.132	3.496	6.024	16.510	41.207	64.642	76.761	85.052	96.867	100.0
17/1/121-124	150.31	5.7019	0.500	4.482	2.430	10.117	23.782	23.609	12.536	8.043	10.953	3.547	4.982	7.412	17.529	41.311	64.920	77.456	85.499	96.452	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
17/1/141-144	150.51	5.7076	0.885	4.341	2.522	9.153	22.938	23.197	12.873	8.813	11.540	3.739	5.226	7.748	16.901	39.839	63.036	75.909	84.722	96.262	100.0
17/2/7-10	150.67	5.7123	0.313	1.696	0.969	12.957	29.288	22.033	10.443	8.025	11.605	2.671	2.009	2.978	15.935	45.223	67.256	77.699	85.724	97.329	100.0
17/2/27-30	150.87	5.7181	0.864	3.630	3.400	14.274	26.419	20.266	10.145	7.437	9.938	3.627	4.494	7.894	22.168	48.587	68.853	78.998	86.435	96.373	100.0
17/2/47-50	151.07	5.7239	0.685	2.840	2.321	12.242	26.711	22.138	10.892	8.121	11.442	2.607	3.525	5.846	18.088	44.799	66.937	77.829	85.950	97.392	100.0
17/2/73-76	151.33	5.7314	1.108	3.411	2.986	11.764	24.382	21.933	11.388	8.148	10.927	3.953	4.519	7.505	19.269	43.651	65.584	76.972	85.120	96.047	100.0
17/2/92-95	151.52	5.7369	0.243	3.148	2.125	11.104	25.322	22.691	11.715	8.455	11.479	3.719	3.391	5.516	16.620	41.942	64.633	76.348	84.803	96.282	100.0
17/2/115-118	151.75	5.7436	0.879	3.291	2.168	10.994	25.313	22.500	11.288	8.148	11.248	4.170	4.170	6.338	17.332	42.645	65.145	76.433	84.581	95.829	100.0
17/2/136-138	151.96	5.7496	0.673	3.053	2.788	13.286	27.115	21.322	9.942	7.503	10.472	3.845	3.726	6.514	19.800	46.915	68.237	78.179	85.682	96.154	100.0
17/3/0-3	152.10	5.7537	0.423	1.907	0.965	8.601	26.894	25.632	11.941	8.584	12.504	2.549	2.330	3.295	11.896	38.790	64.422	76.363	84.947	97.451	100.0
17/3/15-18	152.25	5.7580	0.635	3.431	2.001	10.065	25.060	23.975	12.202	8.189	10.904	3.538	4.066	6.067	16.132	41.192	65.167	77.369	85.558	96.462	100.0
17/3/37-40	152.47	5.7644	0.357	4.119	2.352	11.216	25.473	22.658	11.844	7.943	10.257	3.781	4.476	6.828	18.044	43.517	66.175	78.019	85.962	96.219	100.0
17/3/65-67	152.75	5.7725	0.430	2.616	1.469	10.943	28.219	23.188	11.162	8.122	11.002	2.851	3.046	4.515	15.458	43.677	66.865	78.027	86.149	97.151	100.0
17/3/81-84	152.91	5.7772	0.345	2.768	2.824	11.749	25.828	22.053	11.593	8.615	10.781	3.443	3.113	5.937	17.686	43.514	65.567	77.160	85.775	96.556	100.0
17/3/102-105	153.12	5.7832	0.225	1.816	0.340	9.589	28.494	23.890	11.767	9.338	12.115	2.426	2.041	2.381	11.970	40.464	64.354	76.121	85.459	97.574	100.0
17/3/116-119	153.26	5.7873	0.476	4.123	2.721	12.397	25.808	20.440	10.936	8.454	10.728	3.917	4.599	7.320	19.717	45.525	65.965	76.901	85.355	96.083	100.0
17/3/135-138	153.45	5.7928	0.389	4.057	2.999	11.439	24.551	20.922	12.182	8.719	10.756	3.985	4.446	7.445	18.884	43.435	64.357	76.539	85.258	96.014	100.0
17/4/6-9	153.66	5.7989	0.587	4.543	2.822	10.414	24.163	21.468	12.177	8.499	10.749	4.577	5.130	7.952	18.366	42.529	63.997	76.174	84.673	95.422	100.0
17/4/37-39	153.97	5.8079	0.772	2.319	2.450	10.249	23.896	23.302	12.663	8.764	11.966	3.620	3.091	5.541	15.790	39.686	62.988	75.651	84.415	96.381	100.0
17/4/53-56	154.13	5.8125	0.287	2.711	2.331	9.991	24.994	23.699	12.388	8.415	11.112	4.071	2.998	5.329	15.320	40.314	64.013	76.401	84.816	95.928	100.0
17/4/72-75	154.32	5.8180	0.330	2.673	2.555	9.483	25.649	23.329	11.796	8.261	11.166	4.758	3.003	5.558	15.041	40.690	64.019	75.815	84.076	95.242	100.0
17/4/94-97	154.54	5.8244	0.439	3.811	2.606	10.228	26.182	22.617	11.562	8.247	10.824	3.485	4.250	6.856	17.084	43.266	65.883	77.445	85.692	96.516	100.0
17/4/117-119	154.77	5.8310	0.447	2.240	1.486	8.975	25.366	24.059	12.747	9.028	11.829	3.823	2.687	4.173	13.148	38.514	62.573	75.320	84.348	96.177	100.0
17/4/135-138	154.95	5.8362	0.282	3.177	2.395	9.304	25.343	23.380	12.167	8.629	11.225	4.099	3.459	5.854	15.158	40.501	63.881	76.048	84.677	95.902	100.0
17/5/0-3	155.10	5.8406	0.217	1.513	0.228	8.705	27.470	25.465	12.584	8.818	12.224	2.776	1.730	1.958	10.663	38.133	63.598	76.182	85.000	97.224	100.0
17/5/14-17	155.24	5.8446	0.363	1.765	2.682	11.054	26.102	23.350	11.783	8.279	11.054	3.569	2.128	4.810	15.864	41.966	65.316	77.099	85.378	96.432	100.0
17/5/38-40	155.48	5.8516	0.423	2.878	2.674	10.744	26.072	22.918	11.838	8.114	10.542	3.797	3.301	5.975	16.719	42.791	65.709	77.547	85.661	96.203	100.0
17/5/57-60	155.67	5.8571	0.265	2.631	2.350	10.215	25.697	22.805	11.961	8.932	12.039	3.105	2.896	5.246	15.461	41.158	63.963	75.924	84.856	96.895	100.0
17/5/84-87	155.94	5.8649	0.425	1.641	1.322	10.566	28.070	23.225	11.468	8.984	11.727	2.573	2.066	3.388	13.954	42.024	65.249	76.717	85.701	97.428	100.0
17/5/103-106	156.13	5.8704	0.093	2.472	3.040	9.852	25.934	22.249	12.076	9.220	11.488	3.576	2.565	5.605	15.457	41.391	63.640	75.716	84.936	96.424	100.0
17/5/117-120	156.27	5.8745	0.310	2.887	1.911	10.482	25.952	21.662	12.354	9.388	11.425	3.629	3.197	5.108	15.590	41.542	63.204	75.558	84.946	96.371	100.0
17/5/137-140	156.47	5.8803	1.003	2.444	1.941	9.801	23.841	21.781	13.264	9.432	11.595	4.897	3.447	5.388	15.189	39.030	60.811	74.075	83.507	95.102	100.0
17/6/11-14	156.71	5.8872	0.694	2.712	3.776	11.312	25.672	21.740	11.411	8.000	10.376	4.307	3.406	7.182	18.494	44.166	65.906	77.317	85.317	95.693	100.0
17/6/35-38	156.95	5.8942	0.240	2.243	2.285	12.313	27.494	21.943	10.856	8.198	10.642	3.785	2.483	4.768	17.081	44.575	66.518	77.374	85.572	96.214	100.0
17/6/52-55	157.12	5.8991	0.254	3.141	2.720	12.375	26.788	21.351	10.806	7.907	10.351	4.306	3.395	6.115	18.490	45.278	66.629	77.435	85.342	95.693	100.0
17/6/77-79	157.37	5.9063	0.040	2.711	4.361	12.344	25.303	20.911	11.743	8.386	10.411	3.790	2.751	7.112	19.456	44.759	65.670	77.413	85.799	96.210	100.0
17/6/92-95	157.52	5.9107	0.290	2.418	3.931	13.754	25.386	20.839	11.099	7.818	10.175	4.290	2.708	6.639	20.393	45.779	66.618	77.717	85.535	95.710	100.0
17/6/116-119	157.76	5.9176	0.356	1.958	1.394	9.568	26.492	23.349	12.024	9.115	12.796	2.946	2.314	3.708	13.276	39.768	63.117	75.141	84.256	97.052	100.0
17/6/133-136	157.93	5.9225	0.234	2.038	3.351	10.786	25.508	22.089	11.418	8.423	11.335	4.819	2.272	5.623	16.409	41.917	64.006	75.424	83.847	95.182	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
17/7/0-3	158.10	5.9275	1.231	1.636	2.417	11.109	26.010	22.063	11.328	8.586	11.444	4.177	2.867	5.284	16.393	42.403	64.466	75.794	84.380	95.824	100.0
17/7/17-20	158.27	5.9324	1.576	2.705	2.793	11.379	25.086	21.343	11.166	8.220	11.048	4.683	4.281	7.074	18.453	43.539	64.882	76.048	84.268	95.316	100.0
17 CC/6-9	158.52	5.9396	0.108	2.480	3.244	10.426	25.271	21.551	12.022	9.284	11.829	3.785	2.588	5.832	16.258	41.529	63.080	75.102	84.386	96.215	100.0
18/1/0-3	158.70	5.9448	0.157	1.605	0.542	8.591	26.635	23.777	12.980	9.894	12.345	3.473	1.762	2.304	10.895	37.530	61.307	74.287	84.181	96.526	100.0
18/1/25-28	158.95	5.9521	0.621	1.509	2.693	11.961	25.555	20.206	12.424	9.420	11.436	4.175	2.130	4.823	16.784	42.339	62.545	74.969	84.389	95.825	100.0
18/1/43-46	159.13	5.9573	0.151	1.329	0.803	11.821	27.480	21.122	12.381	9.550	11.667	3.697	1.480	2.283	14.104	41.584	62.706	75.087	84.637	96.304	100.0
18/1/65-68	159.35	5.9637	0.757	1.923	3.339	15.227	24.923	18.945	11.169	8.269	10.382	5.066	2.680	6.019	21.246	46.169	65.114	76.283	84.552	94.934	100.0
18/1/79-82	159.49	5.9677	1.785	2.875	3.416	13.958	25.043	18.819	10.467	8.031	10.473	5.131	4.660	8.076	22.034	47.077	65.896	76.363	84.394	94.867	100.0
18/1/102-105	159.72	5.9744	0.512	2.259	1.612	10.426	26.799	21.490	11.750	9.181	12.630	3.341	2.771	4.383	14.809	41.608	63.098	74.848	84.029	96.659	100.0
18/1/116-119	159.86	5.9784	0.192	2.706	1.520	10.158	25.308	21.734	12.090	9.179	12.493	4.620	2.898	4.418	14.576	39.884	61.618	73.708	82.887	95.380	100.0
18/1/141-144	160.11	5.9857	0.472	4.184	3.630	12.397	25.249	19.563	11.055	7.818	10.422	5.210	4.656	8.286	20.683	45.932	65.495	76.550	84.368	94.790	100.0
18/2/13-16	160.33	5.9921	0.610	3.407	1.763	10.934	24.785	20.812	12.719	9.168	12.244	3.558	4.017	5.780	16.714	41.499	62.311	75.030	84.198	96.442	100.0
18/2/34-37	160.54	5.9981	0.471	4.822	2.741	11.073	24.384	20.058	12.486	8.685	11.490	3.789	5.293	8.034	19.107	43.491	63.549	76.035	84.720	96.210	100.0
18/2/53-56	160.73	6.0036	0.168	1.683	0.995	9.996	26.960	22.622	12.901	8.895	12.754	3.027	1.851	2.846	12.842	39.802	62.424	75.325	84.220	96.974	100.0
18/2/79-82	160.99	6.0112	0.215	2.347	1.131	9.164	24.044	22.070	13.944	9.671	13.047	4.367	2.562	3.693	12.857	36.901	58.971	72.915	82.586	95.633	100.0
18/2/96-99	161.16	6.0161	0.850	3.937	4.183	12.732	22.408	19.180	12.337	8.261	11.153	4.957	4.787	8.970	21.702	44.110	63.290	75.627	83.888	95.041	100.0
18/2/112-114	161.32	6.0207	0.035	2.274	2.171	11.058	25.340	21.045	12.826	9.104	12.091	4.055	2.309	4.480	15.538	40.878	61.923	74.749	83.853	95.944	100.0
18/2/133-136	161.53	6.0268	0.219	2.060	1.837	10.847	25.386	21.950	13.286	9.187	11.789	3.440	2.279	4.116	14.963	40.349	62.299	75.585	84.772	96.561	100.0
18/3/0-3	161.70	6.0317	0.484	2.788	3.578	11.486	22.926	20.316	12.563	8.425	11.492	5.941	3.272	6.850	18.336	41.262	61.578	74.141	82.566	94.058	100.0
18/3/14-17	161.84	6.0358	0.212	1.726	0.728	10.942	27.530	23.296	13.097	8.495	11.078	2.895	1.938	2.666	13.608	41.138	64.434	77.531	86.026	97.104	100.0
18/3/42-45	162.12	6.0439	0.762	2.448	1.446	12.849	27.448	21.270	12.567	8.091	9.866	3.254	3.210	4.656	17.505	44.953	66.223	78.790	86.881	96.747	100.0
18/3/56-59	162.26	6.0479	0.283	2.178	1.081	11.312	27.451	22.270	13.070	8.511	10.886	2.958	2.461	3.542	14.854	42.305	64.575	77.645	86.156	97.042	100.0
18/3/85-88	162.55	6.0563	0.376	2.066	1.340	9.974	27.764	23.967	12.212	8.421	11.328	2.550	2.442	3.782	13.756	41.520	65.487	77.699	86.120	97.448	100.0
18/3/117-120	162.87	6.0656	0.098	0.792	0.089	9.870	29.452	23.899	13.475	9.165	10.497	2.662	0.890	0.979	10.849	40.301	64.200	77.675	86.840	97.337	100.0
18/3/135-137	163.05	6.0708	0.423	2.312	0.617	9.293	27.999	23.882	13.362	8.928	10.705	2.478	2.735	3.352	12.645	40.644	64.526	77.888	86.816	97.521	100.0
18/4/13-16	163.33	6.0789	0.413	1.532	0.283	10.583	30.618	23.753	11.867	8.252	9.922	2.778	1.945	2.228	12.811	43.429	67.182	79.049	87.301	97.223	100.0
18/4/36-39	163.56	6.0856	0.408	2.348	0.970	10.276	29.025	22.943	12.265	8.697	10.637	2.433	2.756	3.726	14.002	43.027	65.970	78.235	86.932	97.569	100.0
18/4/53-56	163.73	6.0905	0.281	2.115	0.582	10.451	30.155	22.755	11.731	8.761	10.741	2.427	2.396	2.978	13.429	43.584	66.339	78.070	86.831	97.572	100.0
18/4/73-76	163.93	6.0963	0.285	2.091	0.570	10.190	29.077	22.716	12.540	8.861	10.804	2.866	2.376	2.946	13.136	42.213	64.929	77.469	86.330	97.134	100.0
18/4/93-96	164.13	6.1021	0.827	2.629	0.820	10.814	29.731	22.406	11.828	8.377	10.234	2.334	3.456	4.276	15.090	44.821	67.227	79.055	87.432	97.666	100.0
18/4/111-113	164.31	6.1073	0.446	2.098	0.521	12.254	32.054	22.027	10.910	7.914	9.232	2.544	2.544	3.065	15.319	47.373	69.400	80.310	88.224	97.456	100.0
18/4/132-135	164.52	6.1134	0.615	1.919	0.414	11.378	30.779	22.316	11.647	8.438	9.767	2.726	2.534	2.948	14.326	45.105	67.421	79.069	87.507	97.274	100.0
18/5/0-3	164.70	6.1186	0.418	1.831	0.326	11.856	31.401	21.644	11.105	8.689	10.186	2.544	2.249	2.574	14.431	45.832	67.476	78.581	87.270	97.456	100.0
18/5/26-29	164.96	6.1261	0.358	2.080	0.518	11.423	30.616	21.738	11.254	8.822	10.837	2.355	2.438	2.956	14.379	44.995	66.733	77.987	86.809	97.645	100.0
18/5/43-46	165.13	6.1311	0.166	1.247	0.294	11.258	28.697	22.070	13.031	9.351	10.797	3.089	1.413	1.707	12.965	41.662	63.732	76.763	86.114	96.911	100.0
18/5/65-67	165.35	6.1374	0.126	1.193	0.220	10.977	30.353	23.169	12.121	8.960	10.373	2.509	1.319	1.539	12.516	42.869	66.038	78.159	87.119	97.492	100.0
18/5/80-83	165.50	6.1418	0.166	1.166	0.277	10.428	28.983	23.622	12.573	9.153	10.682	2.950	1.332	1.609	12.037	41.020	64.642	77.215	86.368	97.050	100.0
18/5/104-106	165.74	6.1487	0.452	2.296	1.879	11.649	29.311	22.290	11.221	8.068	9.755	3.079	2.748	4.627	16.276	45.587	67.877	79.098	87.166	96.921	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
18/5/125-127	165.95	6.1548	0.188	1.296	0.551	12.730	30.000	22.059	11.444	8.606	10.021	3.104	1.484	2.035	14.765	44.765	66.824	78.268	86.874	96.895	100.0
18/5/141-144	166.11	6.1594	0.331	1.923	1.368	12.151	30.200	21.843	10.784	8.197	10.006	3.198	2.254	3.622	15.773	45.973	67.816	78.600	86.797	96.803	100.0
18/6/6-9	166.26	6.1638	0.122	1.047	0.129	11.500	32.913	22.979	10.772	8.500	9.711	2.327	1.169	1.298	12.798	45.711	68.690	79.462	87.962	97.673	100.0
18/6/26-29	166.46	6.1696	0.205	1.453	0.224	11.810	31.573	22.049	11.117	8.742	10.011	2.816	1.658	1.882	13.692	45.265	67.314	78.431	87.173	97.184	100.0
18/6/46-49	166.66	6.1754	0.094	1.216	0.321	12.643	34.096	21.650	10.048	8.391	9.324	2.216	1.310	1.631	14.274	48.370	70.020	80.068	88.459	97.783	100.0
18/6/66-68	166.86	6.1812	0.155	1.156	0.148	12.030	34.730	22.023	10.147	8.329	9.118	2.166	1.311	1.459	13.489	48.219	70.242	80.389	88.718	97.836	100.0
18/6/86-89	167.06	6.1870	0.145	1.555	0.261	11.685	32.739	21.734	10.938	8.895	9.701	2.346	1.700	1.961	13.646	46.385	68.119	79.057	87.952	97.653	100.0
18/6/104-106	167.24	6.1922	0.216	1.542	0.212	12.212	32.518	21.150	11.150	8.747	9.610	2.644	1.758	1.970	14.182	46.700	67.850	79.000	87.747	97.357	100.0
18/6/124-127	167.44	6.1980	0.169	1.436	0.313	12.977	33.232	21.308	10.600	8.342	9.148	2.475	1.605	1.918	14.895	48.127	69.435	80.035	88.377	97.525	100.0
18 CC/7-10	167.57	6.2017	0.543	2.429	0.445	11.730	31.698	21.762	10.901	8.588	9.733	2.172	2.972	3.417	15.147	46.845	68.607	79.508	88.096	97.829	100.0
19/1/0-3	168.30	6.2229	0.646	2.132	0.465	12.105	33.158	21.693	9.516	8.126	9.750	2.410	2.778	3.243	15.347	48.506	70.198	79.715	87.841	97.591	100.0
19/1/22-24	168.52	6.2292	0.999	2.616	1.256	14.168	31.227	20.664	9.867	7.586	9.128	2.489	3.615	4.871	19.039	50.266	70.930	80.797	88.383	97.511	100.0
19/1/41-44	168.71	6.2347	0.274	2.055	0.870	12.277	29.701	21.508	11.700	8.561	9.921	3.132	2.329	3.199	15.476	45.177	66.685	78.385	86.946	96.867	100.0
19/1/62-65	168.92	6.2408	0.574	2.154	0.859	14.216	31.679	20.499	10.269	8.042	9.228	2.480	2.728	3.587	17.803	49.482	69.981	80.250	88.292	97.520	100.0
19/1/83-85	169.13	6.2469	0.746	2.061	0.787	13.495	30.237	20.735	10.936	8.453	9.828	2.722	2.807	3.594	17.089	47.326	68.061	78.997	87.450	97.278	100.0
19/1/104-107	169.34	6.2530	0.356	2.245	1.028	12.148	29.107	21.018	11.795	9.158	10.322	2.824	2.601	3.629	15.777	44.884	65.902	77.697	86.855	97.177	100.0
19/1/121-124	169.51	6.2579	0.502	2.515	0.965	12.041	29.047	21.008	11.759	9.269	10.582	2.313	3.017	3.982	16.023	45.070	66.078	77.837	87.106	97.688	100.0
19/1/142-145	169.72	6.2640	0.520	2.193	0.544	10.900	28.545	21.482	12.510	9.899	10.529	2.879	2.713	3.257	14.157	42.702	64.184	76.694	86.593	97.122	100.0
19/2/5-8	169.85	6.2678	0.284	2.085	0.732	11.614	30.507	21.859	11.561	8.964	9.560	2.833	2.369	3.101	14.715	45.222	67.081	78.642	87.606	97.166	100.0
19/2/26-28	170.06	6.2738	0.788	2.364	0.858	12.264	29.898	20.876	11.467	9.032	9.792	2.662	3.152	4.010	16.274	46.172	67.048	78.515	87.547	97.339	100.0
19/2/52-55	170.32	6.2814	0.269	2.043	0.982	13.703	29.848	20.161	11.636	8.797	9.553	3.007	2.312	3.294	16.997	46.845	67.006	78.642	87.439	96.992	100.0
19/2/72-74	170.52	6.2872	0.517	2.155	1.111	14.633	31.250	20.553	10.785	8.000	8.667	2.330	2.672	3.783	18.416	49.666	70.219	81.004	89.004	97.671	100.0
19/2/93-96	170.73	6.2933	0.510	1.914	0.556	13.274	32.153	21.440	10.406	7.965	9.226	2.558	2.424	2.980	16.254	48.407	69.847	80.253	88.218	97.444	100.0
19/2/114-117	170.94	6.2993	0.514	2.214	0.828	13.427	32.048	21.377	10.324	7.955	8.928	2.386	2.728	3.556	16.983	49.031	70.408	80.732	88.687	97.615	100.0
19/2/135-138	171.15	6.3054	0.783	2.337	0.494	11.958	31.651	21.716	10.631	8.228	9.560	2.641	3.120	3.614	15.572	47.223	68.939	79.570	87.798	97.358	100.0
19/3/0-3	171.30	6.3098	0.560	2.429	0.506	10.841	30.497	22.339	11.428	8.871	10.261	2.269	2.989	3.495	14.336	44.833	67.172	78.600	87.471	97.732	100.0
19/3/27-29	171.57	6.3176	0.273	2.175	0.504	12.056	33.335	21.955	9.674	7.922	9.271	2.837	2.448	2.952	15.008	48.343	70.298	79.972	87.894	97.165	100.0
19/3/42-45	171.72	6.3219	0.763	2.732	2.273	13.618	31.057	20.692	9.740	7.764	8.973	2.389	3.495	5.768	19.386	50.443	71.135	80.875	88.639	97.612	100.0
19/3/62-64	171.92	6.3277	0.752	2.539	1.469	12.801	29.403	20.837	10.969	8.602	9.644	2.984	3.291	4.760	17.561	46.964	67.801	78.770	87.372	97.016	100.0
19/3/83-86	172.13	6.3338	0.436	2.129	1.468	13.469	30.234	21.162	10.873	8.351	9.106	2.772	2.565	4.033	17.502	47.736	68.898	79.771	88.122	97.228	100.0
19/3/102-105	172.32	6.3393	0.487	2.314	1.338	12.774	30.870	21.708	10.280	8.004	10.005	2.220	2.801	4.139	16.913	47.783	69.491	79.771	87.775	97.780	100.0
19/3/117-120	172.47	6.3436	1.010	2.953	2.185	12.695	29.611	21.237	10.220	7.855	9.332	2.903	3.963	6.148	18.843	48.454	69.691	79.911	87.766	97.098	100.0
19/3/136-138	172.66	6.3491	0.576	1.856	0.776	12.536	32.402	22.247	9.901	8.044	9.400	2.261	2.432	3.208	15.744	48.146	70.393	80.294	88.338	97.738	100.0
19/4/6-9	172.86	6.3549	0.798	2.547	1.635	14.011	31.786	21.019	9.754	7.554	8.532	2.364	3.345	4.980	18.991	50.777	71.796	81.550	89.104	97.636	100.0
19/4/27-29	173.07	6.3610	0.769	2.534	1.877	13.833	30.093	20.194	10.437	8.212	9.442	2.609	3.303	5.180	19.013	49.106	69.300	79.737	87.949	97.391	100.0
19/4/47-50	173.27	6.3668	0.610	2.227	1.564	13.728	31.055	21.066	10.314	7.980	9.007	2.449	2.837	4.401	18.129	49.184	70.250	80.564	88.544	97.551	100.0
19/4/72-74	173.52	6.3741	0.553	2.480	2.098	14.969	31.758	20.575	9.207	7.310	8.657	2.394	3.033	5.131	20.100	51.858	72.433	81.640	88.950	97.607	100.0
19/4/92-95	173.72	6.3798	0.355	2.296	1.654	13.776	30.164	20.631	10.648	8.190	9.367	2.919	2.651	4.305	18.081	48.245	68.876	79.524	87.714	97.081	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
19/4/113-115	173.93	6.3859	0.405	1.832	0.788	12.849	30.356	21.437	11.481	8.760	9.263	2.829	2.237	3.025	15.874	46.230	67.667	79.148	87.908	97.171	100.0
19/4/134-137	174.14	6.3920	0.708	2.083	1.135	12.265	29.584	21.418	11.493	9.110	9.622	2.583	2.791	3.926	16.191	45.775	67.193	78.686	87.796	97.418	100.0
19/5/0-3	174.30	6.3966	0.420	2.118	0.627	11.042	29.818	22.278	11.620	9.460	10.375	2.241	2.538	3.165	14.207	44.025	66.303	77.923	87.383	97.758	100.0
19/5/24-27	174.54	6.4036	0.413	1.629	0.320	11.719	31.901	22.590	10.553	8.775	9.787	2.313	2.042	2.362	14.081	45.982	68.572	79.125	87.900	97.687	100.0
19/5/42-45	174.72	6.4088	0.409	1.563	0.651	13.801	33.755	21.919	9.031	7.770	8.956	2.146	1.972	2.623	16.424	50.179	72.098	81.129	88.899	97.855	100.0
19/5/56-59	174.86	6.4129	0.420	1.651	0.393	12.139	33.378	23.155	9.974	8.009	8.806	2.075	2.071	2.464	14.603	47.981	71.136	81.110	89.119	97.925	100.0
19/5/96-99	175.26	6.4244	0.439	1.881	0.946	12.507	33.458	22.913	9.494	7.771	8.571	2.019	2.320	3.266	15.773	49.231	72.144	81.638	89.409	97.980	100.0
19/5/117-120	175.47	6.4305	0.427	1.903	0.517	10.920	32.747	23.530	10.460	8.310	8.847	2.339	2.330	2.847	13.767	46.514	70.044	80.504	88.814	97.661	100.0
19/5/141-144	175.71	6.4375	0.430	1.761	0.268	10.700	32.402	23.575	11.030	8.603	9.060	2.171	2.191	2.459	13.159	45.561	69.136	80.166	88.769	97.829	100.0
19/6/6-9	175.86	6.4418	0.511	1.614	0.538	12.700	33.149	22.374	10.064	8.085	8.831	2.134	2.125	2.663	15.363	48.512	70.886	80.950	89.035	97.866	100.0
19/6/26-29	176.06	6.4476	0.696	1.902	0.818	13.516	32.863	21.942	9.695	7.650	8.598	2.320	2.598	3.416	16.932	49.795	71.737	81.432	89.082	97.680	100.0
19/6/52-55	176.32	6.4551	0.777	2.091	0.426	11.428	32.003	22.801	10.829	8.129	9.032	2.485	2.868	3.294	14.722	46.725	69.526	80.355	88.484	97.516	100.0
19/6/67-69	176.47	6.4595	0.403	1.591	0.395	12.079	32.726	22.869	10.504	7.796	9.091	2.547	1.994	2.389	14.468	47.194	70.063	80.567	88.363	97.454	100.0
19/6/84-87	176.64	6.4644	0.378	1.536	0.400	12.141	33.413	23.087	10.126	7.655	9.018	2.245	1.914	2.314	14.455	47.868	70.955	81.081	88.736	97.754	100.0
19/6/112-114	176.92	6.4725	0.729	2.050	1.076	12.218	30.852	22.390	10.843	8.049	9.230	2.563	2.779	3.855	16.073	46.925	69.315	80.158	88.207	97.437	100.0
19/6/134-137	177.14	6.4789	0.257	2.002	0.578	10.407	31.063	23.499	11.655	8.641	9.751	2.147	2.259	2.837	13.244	44.307	67.806	79.461	88.102	97.853	100.0
19/7/0-3	177.30	6.4835	0.453	1.932	0.423	11.469	33.127	22.459	10.093	8.007	9.511	2.527	2.385	2.808	14.277	47.403	69.863	79.956	87.962	97.473	100.0
19/7/22-25	177.52	6.4899	0.363	1.640	0.241	9.644	32.403	23.764	11.221	8.508	9.621	2.595	2.003	2.244	11.888	44.291	68.055	79.276	87.784	97.405	100.0
19 CC/0-3	177.82	6.4986	0.456	2.046	0.389	10.686	32.329	22.845	10.872	8.152	9.545	2.679	2.502	2.891	13.577	45.906	68.751	79.623	87.775	97.320	100.0
20/1/0-3	177.90	6.5009	0.643	2.166	0.358	10.056	31.724	23.940	11.409	7.956	9.213	2.534	2.809	3.167	13.223	44.947	68.887	80.296	88.252	97.465	100.0
20/1/15-18	178.05	6.5052	0.434	1.809	0.341	11.093	33.578	23.859	10.001	7.421	9.210	2.253	2.243	2.584	13.677	47.255	71.114	81.115	88.536	97.746	100.0
20/1/37-40	178.27	6.5116	0.387	1.901	0.665	9.324	31.286	25.374	11.355	7.734	9.627	2.345	2.288	2.953	12.277	43.563	68.937	80.292	88.026	97.653	100.0
20/1/58-60	178.48	6.5177	0.364	1.665	0.431	9.520	31.878	25.275	11.101	7.910	9.564	2.292	2.029	2.460	11.980	43.858	69.133	80.234	88.144	97.708	100.0
20/1/78-80	178.68	6.5235	0.429	2.002	0.477	8.598	30.510	25.618	11.845	8.104	10.357	2.060	2.431	2.908	11.506	42.016	67.634	79.479	87.583	97.940	100.0
20/1/97-99	178.87	6.5290	0.351	1.723	0.403	10.250	32.796	24.834	10.370	7.257	9.404	2.611	2.074	2.477	12.727	45.523	70.357	80.727	87.984	97.388	100.0
20/1/118-120	179.08	6.5351	0.349	1.680	0.414	9.229	32.023	25.558	10.998	7.754	9.640	2.354	2.029	2.443	11.672	43.695	69.253	80.251	88.005	97.645	100.0
20/1/137-139	179.27	6.5406	0.306	1.614	0.449	9.137	31.701	25.531	11.189	8.036	9.697	2.339	1.920	2.369	11.506	43.207	68.738	79.927	87.963	97.660	100.0
20/2/5-7	179.45	6.5458	0.319	1.471	0.246	10.315	33.352	24.862	10.149	7.600	9.400	2.285	1.790	2.036	12.351	45.703	70.565	80.714	88.314	97.714	100.0
20/2/27-29	179.67	6.5522	0.304	1.526	0.321	9.863	32.838	25.165	10.445	7.722	9.473	2.342	1.830	2.151	12.014	44.852	70.017	80.462	88.184	97.657	100.0
20/2/46-48	179.86	6.5577	0.327	1.518	0.205	9.594	33.471	25.335	10.295	7.845	9.378	2.031	1.845	2.050	11.644	45.115	70.450	80.745	88.590	97.968	100.0
20/2/77-79	180.17	6.5666	0.591	1.980	0.360	9.328	32.939	24.916	10.447	8.046	9.216	2.177	2.571	2.931	12.259	45.198	70.114	80.561	88.607	97.823	100.0
20/2/93-95	180.33	6.5713	0.413	2.024	0.376	10.136	33.826	23.827	10.021	7.937	9.233	2.207	2.437	2.813	12.949	46.775	70.602	80.623	88.560	97.793	100.0
20/2/106-108	180.46	6.5750	0.358	1.684	0.219	11.345	34.565	22.980	9.929	8.011	8.764	2.144	2.042	2.261	13.606	48.171	71.151	81.080	89.091	97.855	100.0
20/2/133-135	180.73	6.5829	0.442	1.834	0.330	9.851	31.523	23.902	11.487	8.821	9.553	2.257	2.276	2.606	12.457	43.980	67.882	79.369	88.190	97.743	100.0
20/3/1-3	180.91	6.5881	0.463	1.849	0.321	9.599	31.023	23.876	11.592	8.981	9.898	2.397	2.312	2.633	12.232	43.255	67.131	78.723	87.704	97.602	100.0
20/3/24-26	181.14	6.5947	0.408	2.072	0.509	8.653	30.339	24.226	12.342	9.067	9.713	2.670	2.480	2.989	11.642	41.981	66.207	78.549	87.616	97.329	100.0
20/3/42-44	181.32	6.6000	0.394	1.873	0.272	8.713	31.688	24.308	11.848	8.983	9.625	2.297	2.267	2.539	11.252	42.940	67.248	79.096	88.079	97.704	100.0
20/3/67-69	181.57	6.6072	0.425	1.812	0.274	11.040	33.648	23.259	10.679	7.844	8.643	2.377	2.237	2.511	13.551	47.199	70.458	81.137	88.981	97.624	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
20/3/82-84	181.72	6.6115	0.349	1.658	0.236	10.223	32.729	23.502	10.972	8.433	9.575	2.323	2.007	2.243	12.466	45.195	68.697	79.669	88.102	97.677	100.0
20/3/96-98	181.86	6.6156	0.299	1.559	0.237	9.802	32.050	23.948	11.588	8.510	9.639	2.369	1.858	2.095	11.897	43.947	67.895	79.483	87.993	97.632	100.0
20/3/116-118	182.06	6.6214	0.230	1.814	0.569	9.522	29.915	24.005	12.500	8.879	10.297	2.271	2.044	2.613	12.135	42.050	66.055	78.555	87.434	97.731	100.0
20/3/133-135	182.23	6.6263	0.720	2.727	1.118	9.579	29.712	23.379	11.997	8.687	9.919	2.162	3.447	4.565	14.144	43.856	67.235	79.232	87.919	97.838	100.0
20/4/7-9	182.47	6.6333	0.517	2.346	0.539	9.024	30.299	23.350	12.036	9.158	10.010	2.721	2.863	3.402	12.426	42.725	66.075	78.111	87.269	97.279	100.0
20/4/28-30	182.68	6.6393	0.446	2.024	0.407	9.535	31.785	23.649	11.240	8.786	9.778	2.351	2.470	2.877	12.412	44.197	67.846	79.086	87.872	97.650	100.0
20/4/48-50	182.88	6.6451	0.433	1.857	0.333	9.333	31.997	23.783	11.321	9.004	9.656	2.282	2.290	2.623	11.956	43.953	67.736	79.057	88.061	97.717	100.0
20/4/68-70	183.08	6.6509	0.424	1.912	0.395	8.292	31.254	24.321	11.790	9.209	9.787	2.616	2.336	2.731	11.023	42.277	66.598	78.388	87.597	97.384	100.0
20/4/86-88	183.26	6.6561	0.475	2.206	0.442	8.464	31.300	24.070	11.829	9.000	9.611	2.602	2.681	3.123	11.587	42.887	66.957	78.786	87.786	97.397	100.0
20/4/105-107	183.45	6.6616	0.502	2.257	0.487	10.147	32.974	23.173	10.752	8.217	9.060	2.431	2.759	3.246	13.393	46.367	69.540	80.292	88.509	97.569	100.0
20/4/132-135	183.72	6.6695	0.434	1.990	0.367	9.288	32.010	23.841	11.428	8.619	9.660	2.363	2.424	2.791	12.079	44.089	67.930	79.358	87.977	97.637	100.0
20/5/1-3	183.91	6.6750	0.487	1.970	0.363	11.047	33.159	23.144	10.210	8.037	9.464	2.120	2.457	2.820	13.867	47.026	70.170	80.379	88.416	97.880	100.0
20/5/25-27	184.15	6.6819	0.506	2.067	0.471	8.944	31.192	24.200	11.874	8.538	9.547	2.662	2.573	3.044	11.988	43.180	67.380	79.254	87.792	97.339	100.0
20/5/42-44	184.32	6.6868	0.519	2.020	0.389	11.400	33.987	22.785	9.769	7.731	9.174	2.227	2.539	2.928	14.328	48.315	71.100	80.869	88.600	97.774	100.0
20/5/61-63	184.51	6.6923	0.896	2.575	0.406	10.298	32.889	22.992	10.220	7.985	9.425	2.315	3.471	3.877	14.175	47.064	70.056	80.276	88.261	97.686	100.0
20/5/82-84	184.72	6.6984	0.510	2.052	0.357	11.047	33.625	23.060	9.784	7.732	9.482	2.352	2.562	2.919	13.966	47.591	70.651	80.435	88.167	97.649	100.0
20/5/101-103	184.91	6.7039	0.406	1.797	0.413	11.197	34.074	23.419	9.560	7.665	9.232	2.238	2.203	2.616	13.813	47.887	71.306	80.866	88.531	97.763	100.0
20/5/117-119	185.07	6.7086	0.471	2.155	0.466	11.974	34.292	22.289	9.004	7.866	9.653	1.832	2.626	3.092	15.066	49.358	71.647	80.651	88.517	98.170	100.0
20/5/137-139	185.27	6.7144	0.505	2.375	0.658	10.413	32.381	23.083	10.316	8.525	9.879	1.866	2.880	3.538	13.951	46.332	69.415	79.731	88.256	98.135	100.0
20/6/7-9	185.47	6.7201	0.445	2.047	0.405	11.624	33.901	22.103	9.786	8.143	9.320	2.226	2.492	2.897	14.521	48.422	70.525	80.311	88.454	97.774	100.0
20/6/34-36	185.74	6.7280	0.589	1.974	0.317	11.794	33.129	22.044	10.226	8.304	9.376	2.246	2.563	2.880	14.674	47.803	69.847	80.073	88.377	97.753	100.0
20/6/52-54	185.92	6.7332	0.468	1.952	0.468	11.934	32.666	22.224	10.347	8.309	9.385	2.248	2.420	2.888	14.822	47.488	69.712	80.059	88.368	97.753	100.0
20/6/68-70	186.08	6.7378	0.709	1.979	0.432	12.367	33.227	22.059	9.818	7.910	9.053	2.446	2.688	3.120	15.487	48.714	70.773	80.591	88.501	97.554	100.0
20/6/92-94	186.32	6.7448	0.525	1.893	0.363	12.078	32.942	22.029	10.170	8.366	9.378	2.257	2.418	2.781	14.859	47.801	69.830	80.000	88.366	97.744	100.0
20/6/111-113	186.51	6.7503	0.438	1.608	0.207	10.400	32.507	23.230	11.037	8.682	9.576	2.315	2.046	2.253	12.653	45.160	68.390	79.427	88.109	97.685	100.0
20/6/132-134	186.72	6.7563	0.329	1.733	0.345	9.906	31.493	23.340	11.571	8.965	9.718	2.600	2.062	2.407	12.313	43.806	67.146	78.717	87.682	97.400	100.0
20/7/0-2	186.90	6.7616	0.248	1.849	0.540	9.306	30.371	23.491	12.008	9.581	10.599	2.007	2.097	2.637	11.943	42.314	65.805	77.813	87.394	97.993	100.0
20/7/17-19	187.07	6.7665	0.217	1.906	0.574	10.200	31.510	22.895	10.908	9.386	10.470	1.933	2.123	2.697	12.897	44.407	67.302	78.210	87.596	98.066	100.0
20 CC/7-9	187.22	6.7708	0.215	1.877	0.946	9.398	29.986	23.445	11.934	9.589	10.416	2.195	2.092	3.038	12.436	42.422	65.867	77.801	87.390	97.806	100.0
21/1/1-3	187.51	6.7792	0.224	1.777	0.456	9.011	30.133	23.402	12.064	9.949	10.946	2.039	2.001	2.457	11.468	41.601	65.002	77.066	87.015	97.961	100.0
21/1/26-28	187.76	6.7865	0.370	1.829	0.379	7.983	29.653	24.095	12.229	10.123	11.239	2.100	2.199	2.578	10.561	40.214	64.309	76.538	86.661	97.900	100.0
21/1/43-45	187.93	6.7914	0.351	1.668	0.264	9.954	32.295	23.070	10.726	9.203	10.120	2.349	2.019	2.283	12.237	44.532	67.602	78.328	87.531	97.651	100.0
21/1/58-60	188.08	6.7957	0.213	1.667	0.336	8.251	30.819	24.249	11.556	9.845	11.027	2.036	1.880	2.216	10.467	41.286	65.535	77.091	86.936	97.963	100.0
21/182-84	188.32	6.8027	0.344	1.419	0.185	9.620	32.573	23.584	10.630	9.295	10.231	2.119	1.763	1.948	11.568	44.141	67.725	78.355	87.650	97.881	100.0
21/1/102-104	188.52	6.8085	0.339	1.562	0.218	10.590	33.493	22.909	9.934	9.043	9.877	2.034	1.901	2.119	12.709	46.202	69.111	79.045	88.088	97.965	100.0
21/1/117-119	188.67	6.8128	0.339	1.529	0.220	8.868	31.529	23.831	11.475	9.560	10.239	2.410	1.868	2.088	10.956	42.485	66.316	77.791	87.351	97.590	100.0
21/1142-144	188.92	6.8201	0.351	1.688	0.307	8.658	30.517	23.786	12.374	9.501	10.090	2.728	2.039	2.346	11.004	41.521	65.307	77.681	87.182	97.272	100.0
21/2/8-10	189.08	6.8247	0.422	1.719	0.220	10.395	32.865	22.576	10.461	9.082	9.925	2.334	2.141	2.361	12.756	45.621	68.197	78.658	87.740	97.665	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
21/2/33-35	189.33	6.8319	0.322	1.515	0.196	10.149	32.642	23.128	10.963	9.009	9.774	2.301	1.837	2.033	12.182	44.824	67.952	78.915	87.924	97.698	100.0
21/2/46-48	189.46	6.8357	0.313	1.504	0.209	10.391	32.385	22.897	11.037	9.057	9.875	2.331	1.817	2.027	12.418	44.803	67.700	78.737	87.794	97.669	100.0
21/2/75-77	189.75	6.8441	0.393	1.508	0.175	10.331	33.109	22.886	10.392	9.031	10.054	2.122	1.901	2.076	12.407	45.516	68.402	78.794	87.825	97.879	100.0
21/2/93-96	189.93	6.8493	0.233	1.364	0.228	9.990	32.916	23.486	10.410	8.769	10.177	2.426	1.597	1.825	11.815	44.731	68.217	78.627	87.396	97.573	100.0
21/2/117-119	190.17	6.8563	0.359	1.673	0.239	10.035	32.782	23.309	10.465	8.692	10.048	2.398	2.032	2.271	12.306	45.088	68.397	78.862	87.554	97.602	100.0
21/2/142-144	190.42	6.8635	0.420	1.998	0.387	9.523	31.674	23.320	11.356	8.951	9.967	2.405	2.418	2.805	12.328	44.002	67.322	78.678	87.629	97.596	100.0
21/3/1-3	190.51	6.8661	0.368	1.711	0.273	9.936	31.902	23.177	11.518	8.796	9.700	2.619	2.079	2.352	12.288	44.190	67.367	78.885	87.681	97.381	100.0
21/3/16-18	190.66	6.8705	0.348	1.800	0.384	9.407	31.296	23.186	11.708	9.219	10.192	2.461	2.148	2.532	11.939	43.235	66.421	78.129	87.348	97.540	100.0
21/3/37-39	190.87	6.8765	0.260	2.063	0.736	9.758	30.943	22.863	11.653	9.032	10.394	2.298	2.323	3.059	12.817	43.760	66.623	78.276	87.308	97.702	100.0
21/3/62-64	191.12	6.8838	0.391	1.825	0.312	9.523	31.057	23.232	11.713	8.947	10.191	2.809	2.216	2.528	12.051	43.108	66.340	78.053	87.000	97.191	100.0
21/3/82-84	191.32	6.8896	0.420	1.878	0.417	9.455	30.658	23.414	12.017	8.945	10.034	2.763	2.298	2.715	12.170	42.828	66.242	78.259	87.204	97.238	100.0
21/3/102-104	191.52	6.8954	0.398	1.696	0.225	10.322	33.523	23.091	10.073	8.502	9.835	2.334	2.095	2.320	12.642	46.165	69.256	79.329	87.832	97.667	100.0
21/3/121-123	191.71	6.9009	0.452	2.148	0.486	8.786	30.870	23.696	11.651	9.240	10.417	2.255	2.600	3.086	11.872	42.742	66.438	78.089	87.329	97.746	100.0
21/3/136-139	191.86	6.9052	0.312	1.548	0.229	10.053	33.477	23.382	10.320	8.650	9.729	2.300	1.860	2.089	12.142	45.619	69.001	79.321	87.971	97.700	100.0
21/4/7-9	192.07	6.9113	0.388	1.749	0.243	10.367	33.107	22.876	10.140	8.787	9.979	2.362	2.137	2.380	12.747	45.854	68.730	78.870	87.657	97.636	100.0
21/4/36-38	192.36	6.9197	0.380	1.782	0.269	8.502	32.011	24.232	11.295	8.899	10.172	2.459	2.162	2.431	10.933	42.944	67.176	78.471	87.370	97.542	100.0
21/4/52-54	192.52	6.9243	0.358	1.448	0.138	11.826	35.744	21.995	8.651	8.230	9.765	1.844	1.806	1.944	13.770	49.514	71.509	80.160	88.390	98.155	100.0
21/4/73-75	192.73	6.9304	0.376	1.567	0.141	10.440	35.276	23.272	9.306	8.169	9.478	1.975	1.943	2.084	12.524	47.800	71.072	80.378	88.547	98.025	100.0
21/4/96-98	192.96	6.9371	0.256	1.911	0.356	10.493	33.842	23.054	9.419	8.470	10.466	1.735	2.167	2.523	13.016	46.858	69.912	79.331	87.801	98.267	100.0
21/4/112-114	193.12	6.9417	0.249	1.963	0.572	9.126	31.303	24.085	10.966	8.847	10.820	2.069	2.212	2.784	11.910	43.213	67.298	78.264	87.111	97.931	100.0
21/4/133-135	193.33	6.9478	0.380	1.785	0.304	8.968	31.899	24.376	11.039	8.696	10.124	2.430	2.165	2.469	11.437	43.336	67.712	78.751	87.447	97.571	100.0
21/5/0-2	193.50	6.9527	0.351	2.092	0.607	9.313	31.326	23.998	10.952	8.590	10.634	2.137	2.443	3.050	12.363	43.689	67.687	78.639	87.229	97.863	100.0
21/5/22-24	193.72	6.9591	0.424	1.892	0.306	10.045	32.345	23.171	10.496	8.847	10.505	1.970	2.316	2.622	12.667	45.012	68.183	78.679	87.526	98.031	100.0
21/5/42-44	193.92	6.9649	0.405	2.021	0.728	8.896	29.465	23.683	11.901	9.390	11.070	2.441	2.426	3.154	12.050	41.515	65.198	77.099	86.489	97.559	100.0
21/5/62-64	194.12	6.9707	0.481	1.706	0.282	11.261	32.937	22.689	9.976	8.585	9.777	2.305	2.187	2.469	13.730	46.667	69.356	79.332	87.917	97.694	100.0
21/5/84-86	194.34	6.9770	0.549	2.625	0.946	9.643	29.825	23.358	11.488	8.887	10.387	2.291	3.174	4.120	13.763	43.588	66.946	78.434	87.321	97.708	100.0
21/5/102-104	194.52	6.9822	1.019	2.747	0.915	9.772	29.968	23.471	11.341	8.527	9.624	2.617	3.766	4.681	14.453	44.421	67.892	79.233	87.760	97.384	100.0
21/5/122-124	194.72	6.9880	0.505	2.243	0.386	11.795	33.694	22.271	9.563	7.929	9.361	2.254	2.748	3.134	14.929	48.623	70.894	80.457	88.386	97.747	100.0
21/5/140-142	194.90	6.9932	0.591	2.524	0.660	10.739	32.248	23.006	10.174	8.004	9.892	2.163	3.115	3.775	14.514	46.762	69.768	79.942	87.946	97.838	100.0
21/6/7-9	195.07	6.9982	0.517	2.289	0.878	11.273	32.601	23.164	9.764	7.587	9.772	2.155	2.806	3.684	14.957	47.558	70.722	80.486	88.073	97.845	100.0
21/6/33-35	195.33	7.0057	0.506	2.620	1.660	11.137	31.297	22.610	10.017	7.882	10.240	2.030	3.126	4.786	15.923	47.220	69.830	79.847	87.729	97.969	100.0
21/6/49-51	195.49	7.0103	0.451	2.384	1.070	9.545	30.903	23.923	11.392	8.302	9.571	2.458	2.836	3.906	13.451	44.355	68.277	79.669	87.971	97.542	100.0
21/6/66-68	195.66	7.0153	0.514	2.567	1.164	10.168	31.014	23.120	11.021	8.349	9.490	2.593	3.081	4.245	14.413	45.427	68.547	79.568	87.917	97.407	100.0
21/6/87-89	195.87	7.0213	0.568	2.643	1.531	10.521	30.683	22.615	10.834	8.187	9.700	2.718	3.211	4.742	15.263	45.946	68.561	79.395	87.582	97.282	100.0
21/6/107-109	196.07	7.0271	0.617	2.809	1.112	11.494	32.432	22.223	9.874	7.704	9.196	2.539	3.426	4.538	16.032	48.464	70.687	80.561	88.265	97.461	100.0
21/6/134-136	196.34	7.0350	0.523	2.626	1.200	10.765	31.099	22.577	10.518	8.138	9.843	2.712	3.149	4.349	15.114	46.213	68.790	79.308	87.446	97.289	100.0
21/7/0-2	196.50	7.0396	0.934	3.711	2.790	11.491	29.079	21.024	10.525	8.293	9.314	2.840	4.645	7.435	18.926	48.005	69.029	79.554	87.847	97.161	100.0
21/7/22-24	196.72	7.0460	0.541	2.698	1.725	11.019	30.705	22.135	10.675	8.360	9.554	2.588	3.239	4.964	15.983	46.688	68.823	79.498	87.858	97.412	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
21 CC/6-8	197.00	7.0541	1.008	3.650	2.077	10.395	29.074	22.282	11.241	8.207	9.456	2.609	4.658	6.735	17.130	46.204	68.486	79.727	87.934	97.390	100.0
22/1/1-3	197.11	7.0573	0.422	2.278	0.712	10.894	31.860	23.070	10.398	8.223	10.186	1.956	2.700	3.412	14.306	46.166	69.236	79.634	87.857	98.043	100.0
22/1/16-18	197.26	7.0616	0.475	2.126	0.755	10.150	30.579	23.576	11.222	8.384	10.429	2.305	2.601	3.356	13.506	44.085	67.661	78.883	87.267	97.696	100.0
22/1/38-40	197.48	7.0680	0.501	2.191	0.950	11.096	31.651	23.120	10.199	8.008	10.012	2.272	2.692	3.642	14.738	46.389	69.509	79.708	87.715	97.728	100.0
22/1/58-60	197.68	7.0738	0.725	2.266	0.835	10.962	32.015	23.063	9.811	8.293	10.141	1.891	2.991	3.826	14.788	46.803	69.866	79.677	87.970	98.111	100.0
22/1/84-86	197.94	7.0813	0.473	2.390	1.467	11.026	31.423	22.730	10.111	8.154	9.625	2.600	2.863	4.330	15.356	46.779	69.509	79.620	87.774	97.399	100.0
22/1/104-106	198.14	7.0871	0.581	2.400	1.146	10.214	31.310	23.351	10.494	8.112	10.156	2.236	2.981	4.127	14.341	45.651	69.002	79.496	87.608	97.764	100.0
22/1/122-124	198.32	7.0923	0.494	2.072	0.820	9.954	31.844	23.872	10.367	8.261	10.351	1.963	2.566	3.386	13.340	45.184	69.056	79.423	87.684	98.035	100.0
22/1/142-144	198.52	7.0981	0.637	2.206	0.877	9.394	30.335	23.553	11.190	8.807	10.668	2.334	2.843	3.720	13.114	43.449	67.002	78.192	86.999	97.667	100.0
22/2/13-15	198.73	7.1042	0.710	2.621	1.465	10.237	29.656	22.538	11.535	8.793	9.773	2.673	3.331	4.796	15.033	44.689	67.227	78.762	87.555	97.328	100.0
22/2/32-34	198.92	7.1097	0.992	2.688	1.056	12.760	31.702	20.962	9.810	8.035	9.398	2.597	3.680	4.736	17.496	49.198	70.160	79.970	88.005	97.403	100.0
22/2/54-56	199.14	7.1160	0.894	2.348	1.046	14.965	33.421	19.678	8.681	7.523	8.989	2.455	3.242	4.288	19.253	52.674	72.352	81.033	88.556	97.545	100.0
22/2/74-77	199.34	7.1218	0.743	2.416	1.414	12.983	31.823	21.441	9.920	7.734	9.042	2.485	3.159	4.573	17.556	49.379	70.820	80.740	88.474	97.516	100.0
22/2/93-95	199.53	7.1273	0.468	2.035	0.574	11.547	33.112	22.678	9.836	8.022	9.327	2.402	2.503	3.077	14.625	47.736	70.414	80.250	88.272	97.599	100.0
22/2/112-114	199.72	7.1328	0.708	2.078	0.617	13.368	33.007	21.142	9.447	8.188	9.267	2.178	2.786	3.403	16.771	49.778	70.920	80.367	88.555	97.822	100.0
22/2/133-135	199.93	7.1389	0.565	2.532	1.016	12.936	32.213	20.783	10.110	8.361	9.071	2.413	3.097	4.113	17.049	49.262	70.045	80.155	88.516	97.587	100.0
22/3/1-3	200.11	7.1441	0.842	2.422	1.272	13.532	31.860	20.410	9.941	8.198	9.079	2.443	3.264	4.536	18.068	49.928	70.338	80.279	88.477	97.556	100.0
22/3/15-17	200.25	7.1482	0.710	2.124	0.815	13.342	32.517	21.158	9.973	8.073	8.925	2.364	2.834	3.649	16.991	49.508	70.666	80.639	88.712	97.637	100.0
22/3/42-44	200.52	7.1560	0.780	2.613	0.857	9.930	30.892	23.146	11.224	8.713	9.392	2.453	3.393	4.250	14.180	45.072	68.218	79.442	88.155	97.547	100.0
22/3/56-58	200.66	7.1601	0.993	2.492	1.310	13.889	32.191	20.747	9.554	7.927	8.627	2.270	3.485	4.795	18.684	50.875	71.622	81.176	89.103	97.730	100.0
22/3/82-84	200.92	7.1676	0.861	2.453	0.895	13.456	33.051	20.784	9.447	7.918	8.797	2.337	3.314	4.209	17.665	50.716	71.500	80.947	88.865	97.662	100.0
22/3/95-97	201.05	7.1714	0.802	2.292	0.403	11.282	33.181	22.370	9.966	8.104	9.181	2.419	3.094	3.497	14.779	47.960	70.330	80.296	88.400	97.581	100.0
22/3/117-119	201.27	7.1777	0.490	1.975	0.380	12.567	33.939	22.053	9.462	7.965	9.052	2.117	2.465	2.845	15.412	49.351	71.404	80.866	88.831	97.883	100.0
22/3/132-134	201.42	7.1821	0.464	2.068	0.568	11.173	32.818	22.846	10.123	8.203	9.345	2.391	2.532	3.100	14.273	47.092	69.937	80.061	88.263	97.609	100.0
22/4/7-9	201.67	7.1893	0.513	2.383	0.652	9.133	32.316	24.047	10.386	8.563	10.092	1.916	2.896	3.548	12.681	44.997	69.044	79.430	87.993	98.085	100.0
22/4/33-35	201.93	7.1968	0.695	2.321	0.818	10.351	32.997	23.569	9.898	8.060	8.937	2.352	3.016	3.834	14.185	47.182	70.751	80.649	88.709	97.646	100.0
22/4/73-75	202.33	7.2084	0.720	2.368	1.061	13.438	34.452	21.323	8.335	7.534	8.753	2.017	3.088	4.149	17.587	52.039	73.362	81.697	89.231	97.984	100.0
22/4/92-95	202.52	7.2139	0.579	2.563	1.459	13.943	33.373	20.283	8.456	7.886	9.230	2.228	3.142	4.601	18.544	51.917	72.200	80.656	88.542	97.772	100.0
22/4/113-115	202.73	7.2200	0.672	2.122	1.357	17.433	34.799	18.648	7.500	7.195	8.344	1.929	2.794	4.151	21.584	56.383	75.031	82.531	89.726	98.070	100.0
22/4/133-135	202.93	7.2258	0.672	2.050	2.576	19.426	34.165	17.582	6.906	6.686	8.017	1.919	2.722	5.298	24.724	58.889	76.471	83.377	90.063	98.080	100.0
22 CC/7-10	203.17	7.2328	0.508	2.743	1.231	6.196	27.786	25.793	12.564	9.569	11.120	2.489	3.251	4.482	10.678	38.464	64.257	76.821	86.390	97.510	100.0
23/1/1-3	206.71	7.3502	0.359	1.597	0.456	11.792	32.458	22.803	10.552	8.593	9.266	2.125	1.956	2.412	14.204	46.662	69.465	80.017	88.610	97.876	100.0
23/1/15-17	206.85	7.3549	0.446	1.772	0.538	14.136	33.421	21.201	9.183	7.930	9.177	2.194	2.218	2.756	16.892	50.313	71.514	80.697	88.627	97.804	100.0
23/1/43-45	207.13	7.3643	0.676	2.133	0.628	13.348	33.062	21.694	9.368	7.820	8.961	2.310	2.810	3.438	16.786	49.848	71.541	80.910	88.730	97.691	100.0
23/1/58-60	207.28	7.3693	0.694	2.116	1.121	12.642	31.368	21.848	10.268	8.232	9.230	2.483	2.810	3.931	16.573	47.941	69.789	80.057	88.289	97.519	100.0
23/1/78-80	207.48	7.3760	0.700	2.238	0.760	12.103	31.707	22.269	10.353	8.117	9.252	2.500	2.938	3.698	15.801	47.508	69.777	80.130	88.247	97.499	100.0
23/1/103-105	207.73	7.3844	0.742	2.182	0.748	12.605	32.411	22.038	9.721	7.818	9.188	2.547	2.924	3.672	16.277	48.688	70.726	80.447	88.265	97.453	100.0
23/1/118-120	207.88	7.3894	0.590	1.774	0.382	13.077	33.562	21.993	9.473	7.795	9.124	2.231	2.364	2.746	15.823	49.385	71.378	80.851	88.646	97.770	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
23/1/142-144	208.12	7.3974	0.497	1.462	0.326	14.420	35.247	21.821	8.658	7.212	8.363	1.993	1.959	2.285	16.705	51.952	73.773	82.431	89.643	98.006	100.0
23/2/6-8	208.26	7.4021	0.449	1.732	0.406	12.828	33.760	22.765	9.459	7.537	8.917	2.148	2.181	2.587	15.415	49.175	71.940	81.399	88.936	97.853	100.0
23/2/32-34	208.52	7.4108	0.359	1.435	0.359	13.570	34.788	22.447	9.138	7.270	8.542	2.092	1.794	2.153	15.723	50.511	72.958	82.096	89.366	97.908	100.0
23/2/53-55	208.73	7.4179	0.637	1.888	0.373	13.774	34.485	21.894	8.865	7.309	8.670	2.104	2.525	2.898	16.672	51.157	73.051	81.916	89.225	97.895	100.0
23/2/86-88	209.06	7.4289	0.568	2.003	0.677	13.708	34.121	22.157	9.107	7.154	8.469	2.036	2.571	3.248	16.956	51.077	73.234	82.341	89.495	97.964	100.0
23/2/107-109	209.27	7.4360	0.373	1.495	0.320	13.952	34.356	22.254	9.249	7.330	8.586	2.085	1.868	2.188	16.140	50.496	72.750	81.999	89.329	97.915	100.0
23/2/134-136	209.54	7.4450	0.443	1.517	0.326	13.978	33.693	21.839	9.409	7.654	8.943	2.197	1.960	2.286	16.264	49.957	71.796	81.205	88.859	97.802	100.0
23/3/0-2	209.70	7.4504	0.451	1.783	0.447	14.259	33.525	21.609	9.351	7.632	8.803	2.139	2.234	2.681	16.940	50.465	72.074	81.425	89.057	97.860	100.0
23/3/15-17	209.85	7.4554	0.475	1.688	0.619	15.162	34.256	21.304	8.699	7.256	8.493	2.049	2.163	2.782	17.944	52.200	73.504	82.203	89.459	97.952	100.0
23/3/42-44	210.12	7.4644	0.433	1.887	0.802	13.751	33.264	22.023	9.002	7.408	9.174	2.256	2.320	3.122	16.873	50.137	72.160	81.162	88.570	97.744	100.0
23/3/63-65	210.33	7.4715	0.858	3.287	3.100	14.320	28.976	20.270	9.271	7.660	9.774	2.484	4.145	7.245	21.565	50.541	70.811	80.082	87.741	97.516	100.0
23/3/83-85	210.53	7.4782	0.349	1.325	0.273	12.424	32.607	23.929	10.004	7.738	9.165	2.187	1.674	1.947	14.371	46.978	70.907	80.911	88.649	97.814	100.0
23/3/102-104	210.72	7.4845	0.239	1.607	0.676	14.739	32.527	22.358	9.006	7.431	9.599	1.818	1.846	2.522	17.261	49.788	72.146	81.152	88.583	98.182	100.0
23/3/117-119	210.87	7.4896	0.240	1.756	0.488	12.550	31.486	23.824	10.292	7.868	9.672	1.824	1.996	2.484	15.034	46.520	70.344	80.636	88.504	98.176	100.0
23/3/136-138	211.06	7.4959	0.411	1.538	0.507	14.088	32.605	22.920	9.395	7.470	8.941	2.122	1.949	2.456	16.544	49.149	72.069	81.464	88.934	97.875	100.0
23/4/7-9	211.27	7.5030	0.619	1.938	1.042	14.186	31.156	22.280	9.696	7.518	9.155	2.410	2.556	3.598	17.784	48.941	71.221	80.917	88.435	97.590	100.0
23/4/32-34	211.52	7.5113	0.552	1.671	0.474	14.392	33.714	21.801	9.290	7.490	8.564	2.052	2.223	2.697	17.089	50.803	72.604	81.894	89.384	97.948	100.0
23/4/52-54	211.72	7.5180	0.419	1.595	0.422	14.138	33.725	21.952	9.338	7.515	8.788	2.107	2.014	2.436	16.574	50.299	72.251	81.589	89.104	97.892	100.0
23/4/73-75	211.93	7.5251	0.521	1.874	0.493	13.725	33.574	22.110	9.285	7.592	8.749	2.078	2.395	2.888	16.613	50.187	72.297	81.582	89.174	97.923	100.0
23/4/93-95	212.13	7.5318	0.590	2.496	0.997	12.596	31.721	22.246	9.916	7.802	9.168	2.467	3.086	4.083	16.679	48.400	70.646	80.562	88.364	97.532	100.0
23/4/112-114	212.32	7.5381	0.480	2.281	1.093	13.688	33.004	21.555	9.323	7.530	8.716	2.330	2.761	3.854	17.542	50.546	72.101	81.424	88.954	97.670	100.0
23/4/133-135	212.53	7.5452	0.480	1.989	0.625	15.603	34.377	20.101	8.738	7.446	8.410	2.232	2.469	3.094	18.697	53.074	73.175	81.913	89.359	97.769	100.0
23/5/1-3	212.71	7.5512	0.538	2.369	1.163	14.563	31.970	20.278	10.103	8.160	8.572	2.284	2.907	4.070	18.633	50.603	70.881	80.984	89.144	97.716	100.0
23/5/24-26	212.94	7.5589	0.554	2.227	0.587	15.119	33.889	20.188	9.180	7.506	8.454	2.297	2.781	3.368	18.487	52.376	72.564	81.744	89.250	97.704	100.0
23/5/42-44	213.12	7.5649	0.551	2.436	0.898	14.649	33.573	20.656	9.272	7.280	8.394	2.292	2.987	3.885	18.534	52.107	72.763	82.035	89.315	97.709	100.0
23/5/83-85	213.53	7.5787	0.543	2.276	0.956	14.485	33.203	20.961	9.313	7.242	8.626	2.395	2.820	3.776	18.261	51.464	72.425	81.737	88.979	97.605	100.0
23/5/102-104	213.72	7.5850	0.237	1.834	0.787	15.856	33.492	20.246	9.268	7.208	8.645	2.426	2.071	2.858	18.714	52.206	72.452	81.720	88.928	97.573	100.0
23/5/122-124	213.92	7.5917	0.490	1.951	0.660	15.538	33.654	20.649	9.292	7.131	8.335	2.300	2.441	3.101	18.639	52.293	72.942	82.234	89.365	97.700	100.0
23/5/142-144	214.12	7.5984	0.447	1.815	0.742	13.816	32.286	22.008	9.916	7.419	9.003	2.548	2.262	3.004	16.820	49.106	71.114	81.030	88.449	97.452	100.0
23/6/7-9	214.27	7.6034	0.517	2.205	0.949	13.479	33.306	22.335	9.093	7.026	8.697	2.393	2.722	3.671	17.150	50.456	72.791	81.884	88.910	97.607	100.0
23/6/31-33	214.51	7.6115	0.481	1.870	0.544	15.305	33.887	21.189	8.952	6.901	8.512	2.359	2.351	2.895	18.200	52.087	73.276	82.228	89.129	97.641	100.0
23/6/52-54	214.72	7.6185	0.559	1.931	0.646	15.533	33.402	20.676	8.983	7.200	8.865	2.204	2.490	3.136	18.669	52.071	72.747	81.730	88.930	97.795	100.0
23/6/85-87	215.05	7.6296	0.457	1.688	0.432	15.167	33.900	20.969	9.190	7.189	8.824	2.183	2.145	2.577	17.744	51.644	72.613	81.803	88.992	97.816	100.0
23/6/111-113	215.31	7.6383	0.445	1.635	0.348	15.926	35.306	20.580	8.441	6.881	8.392	2.046	2.080	2.428	18.354	53.660	74.240	82.681	89.562	97.954	100.0
23/6/133-135	215.53	7.6456	0.551	2.032	0.653	16.839	35.000	19.474	8.260	6.759	8.176	2.256	2.583	3.236	20.075	55.075	74.549	82.809	89.568	97.744	100.0
23/7/1-3	215.71	7.6517	0.489	1.861	0.199	15.083	34.804	20.461	9.382	7.405	8.285	2.032	2.350	2.549	17.632	52.435	72.897	82.279	89.683	97.968	100.0
23/7/23-25	215.93	7.6590	0.800	1.930	0.445	15.914	34.228	20.141	8.640	7.240	8.590	2.073	2.730	3.175	19.089	53.317	73.458	82.098	89.338	97.928	100.0
23 CC/7-10	216.22	7.6688	0.908	2.434	0.676	15.598	33.868	20.205	9.035	6.915	8.112	2.249	3.342	4.018	19.616	53.484	73.689	82.724	89.639	97.751	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
24/1/1-3	216.31	7.6718	0.557	1.994	0.245	13.309	32.509	21.651	11.220	7.845	8.361	2.309	2.551	2.796	16.105	48.614	70.265	81.485	89.330	97.691	100.0
24/1/27-29	216.57	7.6805	0.578	1.735	0.272	14.318	33.733	21.491	10.084	7.344	8.183	2.262	2.313	2.585	16.903	50.636	72.127	82.211	89.555	97.738	100.0
24/1/43-45	216.73	7.6858	0.471	2.014	0.557	14.800	32.916	20.624	10.171	7.622	8.484	2.340	2.485	3.042	17.842	50.758	71.382	81.553	89.175	97.659	100.0
24/1/64-66	216.94	7.6929	0.675	3.317	0.932	16.300	33.971	18.963	8.666	6.814	7.897	2.466	3.992	4.924	21.224	55.195	74.158	82.824	89.638	97.535	100.0
24/1/82-84	217.12	7.6989	0.638	2.642	0.797	16.933	34.478	18.749	8.742	6.600	7.885	2.535	3.280	4.077	21.010	55.488	74.237	82.979	89.579	97.464	100.0
24/1/104-106	217.34	7.7063	0.348	2.258	0.654	18.173	36.095	18.532	7.980	6.448	7.622	1.890	2.606	3.260	21.433	57.528	76.060	84.040	90.488	98.110	100.0
24/1/123-125	217.53	7.7126	0.566	1.955	0.718	20.736	36.781	17.132	7.101	5.942	7.243	1.826	2.521	3.239	23.975	60.756	77.888	84.989	90.931	98.174	100.0
24/1/142-144	217.72	7.7190	0.588	2.027	0.399	19.105	36.284	17.768	8.258	6.465	7.270	1.837	2.615	3.013	22.118	58.402	76.170	84.428	90.893	98.163	100.0
24/2/12-14	217.92	7.7257	0.599	2.054	0.164	17.608	36.772	18.373	8.474	6.588	7.479	1.888	2.653	2.817	20.425	57.197	75.570	84.044	90.632	98.111	100.0
24/2/28-30	218.08	7.7311	0.519	1.898	0.219	17.858	36.636	18.592	8.559	6.463	7.395	1.861	2.417	2.636	20.494	57.130	75.722	84.281	90.744	98.139	100.0
24/2/46-48	218.26	7.7371	0.490	1.913	0.209	17.468	36.215	18.829	8.990	6.542	7.462	1.881	2.403	2.612	20.080	56.295	75.124	84.114	90.656	98.118	100.0
24/2/72-74	218.52	7.7458	0.431	1.475	0.342	18.200	35.737	18.852	8.930	6.360	7.693	1.979	1.906	2.248	20.448	56.185	75.037	83.967	90.327	98.020	100.0
24/2/87-89	218.67	7.7508	0.461	1.607	0.285	16.864	34.951	19.772	9.661	6.561	7.822	2.016	2.068	2.353	19.217	54.168	73.940	83.601	90.162	97.984	100.0
24/2/107-109	218.87	7.7575	0.554	1.797	0.320	16.397	34.412	20.112	9.505	6.540	8.207	2.157	2.351	2.671	19.068	53.480	73.592	83.097	89.637	97.844	100.0
24/2/135-137	219.15	7.7669	0.615	2.113	0.180	15.629	34.704	20.580	9.328	6.485	8.048	2.316	2.728	2.908	18.537	53.241	73.821	83.149	89.634	97.682	100.0
24/3/1-3	219.31	7.7723	0.569	2.045	0.279	17.565	36.335	19.252	8.240	6.071	7.677	1.967	2.614	2.893	20.458	56.793	76.045	84.285	90.356	98.033	100.0
24/3/23-25	219.53	7.7796	0.435	1.428	0.265	18.926	38.091	18.426	7.669	6.021	7.268	1.472	1.863	2.128	21.054	59.145	77.571	85.240	91.261	98.529	100.0
24/3/42-44	219.72	7.7860	0.441	1.483	0.181	18.195	38.577	18.685	7.791	5.947	7.219	1.482	1.924	2.105	20.300	58.877	77.562	85.353	91.299	98.518	100.0
24/3/56-58	219.86	7.7907	0.354	1.389	0.227	18.200	38.124	18.775	7.856	6.033	7.365	1.677	1.743	1.970	20.170	58.294	77.069	84.925	90.958	98.323	100.0
24/3/82-84	220.12	7.7994	0.533	2.020	0.562	17.970	36.889	18.920	7.901	5.847	7.442	1.917	2.553	3.115	21.085	57.974	76.894	84.795	90.642	98.084	100.0
24/3/102-104	220.32	7.8061	0.541	2.140	0.965	19.575	36.553	18.120	7.377	5.752	7.151	1.826	2.681	3.646	23.221	59.774	77.894	85.271	91.023	98.174	100.0
24/3/116-118	220.46	7.8108	0.590	2.256	0.293	16.415	36.603	19.811	8.156	6.269	7.693	1.915	2.846	3.139	19.554	56.157	75.968	84.124	90.393	98.086	100.0
24/3/133-135	220.63	7.8165	0.594	2.510	0.354	15.030	35.653	20.552	8.886	6.533	7.710	2.177	3.104	3.458	18.488	54.141	74.693	83.579	90.112	97.822	100.0
24/4/7-9	220.87	7.8245	0.622	2.310	0.382	16.353	36.151	19.776	8.441	6.265	7.558	2.143	2.932	3.314	19.667	55.818	75.594	84.035	90.300	97.858	100.0
24/4/32-34	221.12	7.8329	0.442	1.801	0.359	17.131	36.777	19.401	8.306	6.358	7.533	1.891	2.243	2.602	19.733	56.510	75.911	84.217	90.575	98.108	100.0
24/4/47-49	221.27	7.8379	0.502	1.846	0.341	17.955	37.732	19.075	7.538	5.936	7.223	1.852	2.348	2.689	20.644	58.376	77.451	84.989	90.925	98.148	100.0
24/4/72-74	221.52	7.8463	0.582	2.358	1.303	17.588	34.905	18.823	8.099	6.349	7.769	2.225	2.940	4.243	21.831	56.736	75.559	83.658	90.007	97.776	100.0
24/4/86-88	221.66	7.8510	0.445	1.620	0.250	16.924	36.758	19.606	8.262	6.543	7.828	1.763	2.065	2.315	19.239	55.997	75.603	83.865	90.408	98.236	100.0
24/4/112-114	221.92	7.8597	0.484	1.857	0.317	16.310	36.983	19.873	7.942	6.545	7.773	1.916	2.341	2.658	18.968	55.951	75.824	83.766	90.311	98.084	100.0
24/4/133-135	222.13	7.8667	0.499	1.952	0.286	15.437	36.507	20.512	8.524	6.733	7.685	1.865	2.451	2.737	18.174	54.681	75.193	83.717	90.450	98.135	100.0
24/5/1-3	222.31	7.8728	0.490	1.796	0.178	14.514	36.233	20.920	8.814	7.165	8.117	1.773	2.286	2.464	16.978	53.211	74.131	82.945	90.110	98.227	100.0
24/5/15-17	222.45	7.8774	0.444	1.765	0.323	14.434	35.552	20.757	8.926	7.369	8.401	2.028	2.209	2.532	16.966	52.518	73.275	82.201	89.570	97.971	100.0
24/5/43-45	222.73	7.8868	0.475	1.880	0.413	15.172	34.928	20.338	9.072	7.207	8.434	2.082	2.355	2.768	17.940	52.868	73.206	82.278	89.485	97.919	100.0
24/5/63-65	222.93	7.8935	0.301	1.455	0.161	16.916	37.437	19.336	8.122	6.690	8.000	1.582	1.756	1.917	18.833	56.270	75.606	83.728	90.418	98.418	100.0
24/5/84-86	223.14	7.9006	0.326	1.268	0.236	17.479	37.681	19.238	8.054	6.544	7.676	1.498	1.594	1.830	19.309	56.990	76.228	84.282	90.826	98.502	100.0
24/5/103-105	223.33	7.9069	0.464	1.456	0.165	16.592	36.745	19.550	8.529	6.832	7.937	1.730	1.920	2.085	18.677	55.422	74.972	83.501	90.333	98.270	100.0
24/5/118-120	223.48	7.9119	0.543	1.838	0.170	15.711	36.231	19.966	8.621	7.010	8.129	1.782	2.381	2.551	18.262	54.493	74.459	83.080	90.090	98.219	100.0
24/5/142-144	223.72	7.9200	0.462	1.710	0.197	16.660	37.059	19.791	8.107	6.554	7.767	1.691	2.173	2.370	19.030	56.088	75.880	83.987	90.541	98.308	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
24/6/7-9	223.87	7.9250	0.521	1.863	0.187	15.198	36.001	20.603	8.906	6.791	7.959	1.971	2.384	2.571	17.769	53.770	74.373	83.279	90.070	98.029	100.0
24/6/27-29	224.07	7.9317	0.548	2.173	0.371	16.011	37.203	19.928	8.074	6.513	7.395	1.784	2.721	3.092	19.103	56.306	76.234	84.308	90.821	98.216	100.0
24/6/47-49	224.27	7.9384	0.645	2.221	0.389	16.049	37.347	19.701	8.004	6.460	7.370	1.814	2.866	3.255	19.304	56.651	76.352	84.356	90.816	98.186	100.0
24/6/67-69	224.47	7.9451	0.526	2.022	0.251	14.521	37.159	20.416	8.413	6.780	7.930	1.983	2.548	2.799	17.320	54.479	74.895	83.308	90.088	98.018	100.0
24/6/86-88	224.66	7.9515	0.508	2.054	0.548	16.561	36.784	19.586	8.074	6.454	7.558	1.873	2.562	3.110	19.671	56.455	76.041	84.115	90.569	98.127	100.0
24/6/107-109	224.87	7.9585	0.474	1.767	0.193	16.597	37.738	19.476	8.159	6.552	7.433	1.611	2.241	2.434	19.031	56.769	76.245	84.404	90.956	98.389	100.0
24/6/132-134	225.12	7.9669	0.587	2.320	0.721	16.587	35.537	19.378	8.340	6.663	7.731	2.136	2.907	3.628	20.215	55.752	75.130	83.470	90.133	97.864	100.0
24 CC/9-11	225.36	7.9749	1.063	2.798	0.862	15.189	34.259	19.891	9.002	6.944	7.824	2.168	3.861	4.723	19.912	54.171	74.062	83.064	90.008	97.832	100.0
25/1/1-3	225.91	7.9933	0.724	2.941	1.128	13.330	33.600	20.627	10.082	7.773	7.738	2.056	3.665	4.793	18.123	51.723	72.350	82.432	90.205	97.943	100.0
25/1/23-25	226.13	8.0007	0.876	2.935	2.400	16.643	33.114	19.236	8.754	6.603	7.390	2.049	3.811	6.211	22.854	55.968	75.204	83.958	90.561	97.951	100.0
25/1/42-44	226.32	8.0071	0.860	3.051	1.781	16.239	33.919	19.525	8.630	6.484	7.423	2.088	3.911	5.692	21.932	55.850	75.375	84.005	90.489	97.912	100.0
25/1/63-65	226.53	8.0141	0.927	3.146	1.821	14.268	32.011	20.316	10.122	7.053	7.843	2.493	4.073	5.894	20.162	52.173	72.489	82.611	89.664	97.507	100.0
25/1/85-87	226.75	8.0215	1.070	3.109	1.986	14.475	32.437	20.224	9.611	6.878	7.728	2.483	4.179	6.165	20.640	53.077	73.301	82.912	89.790	97.518	100.0
25/1/103-105	226.93	8.0275	1.032	2.870	1.390	14.017	32.641	20.802	9.720	7.183	8.064	2.283	3.902	5.292	19.309	51.950	72.752	82.472	89.655	97.719	100.0
25/1/125-123	227.13	8.0342	0.576	2.363	0.798	13.972	32.811	21.388	10.261	7.313	8.200	2.318	2.939	3.737	17.709	50.520	71.908	82.169	89.482	97.682	100.0
25/1/144-146	227.34	8.0412	1.097	2.862	1.959	15.320	31.183	19.768	9.542	7.008	8.495	2.766	3.959	5.918	21.238	52.421	72.189	81.731	88.739	97.234	100.0
25/2/5-7	227.45	8.0449	0.969	2.799	1.523	14.265	31.630	20.311	10.113	7.327	8.348	2.714	3.768	5.291	19.556	51.186	71.497	81.610	88.937	97.285	100.0
25/2/-32-34	227.72	8.0540	0.897	2.735	2.028	15.205	31.778	19.921	9.750	7.239	8.143	2.303	3.632	5.660	20.865	52.643	72.564	82.314	89.553	97.696	100.0
25/2/53-55	227.93	8.0610	0.589	2.654	1.758	15.558	32.318	19.981	9.469	7.122	8.234	2.317	3.243	5.001	20.559	52.877	72.858	82.327	89.449	97.683	100.0
25/2/72-74	228.12	8.0674	1.018	2.780	1.547	15.194	32.336	20.494	9.653	6.860	7.888	2.231	3.798	5.345	20.539	52.875	73.369	83.022	89.882	97.770	100.0
25/2/95-97	228.35	8.0751	1.204	2.986	1.587	15.409	32.533	20.060	9.364	6.690	7.687	2.478	4.190	5.777	21.186	53.719	73.779	83.143	89.833	97.520	100.0
25/2/112-114	228.52	8.0808	1.078	2.950	1.350	16.211	33.650	19.687	8.931	6.508	7.491	2.143	4.028	5.379	21.590	55.240	74.927	83.859	90.367	97.858	100.0
25/2/134-136	228.74	8.0881	1.099	3.163	1.522	14.601	32.405	20.219	9.927	7.045	7.777	2.243	4.262	5.784	20.385	52.790	73.009	82.936	89.981	97.758	100.0
25/3/0-2	228.90	8.0935	1.194	3.203	1.614	13.825	31.680	20.555	10.214	7.226	7.925	2.563	4.397	6.011	19.836	51.516	72.071	82.285	89.511	97.436	100.0
25/3/23-25	229.13	8.1012	1.105	3.155	1.757	13.656	31.498	20.857	10.121	7.087	8.102	2.663	4.260	6.017	19.673	51.171	72.028	82.149	89.236	97.338	100.0
25/3/43-45	229.33	8.1079	1.099	2.884	1.480	14.568	32.249	20.400	9.771	7.013	7.944	2.592	3.983	5.463	20.031	52.280	72.680	82.451	89.464	97.408	100.0
25/3/63-65	229.53	8.1146	1.022	3.111	1.922	14.765	32.565	20.507	9.337	6.631	7.652	2.487	4.133	6.055	20.820	53.385	73.892	83.229	89.860	97.512	100.0
25/3/95-97	229.85	8.1253	0.973	2.957	1.420	14.970	33.133	20.201	9.568	6.821	7.707	2.250	3.930	5.350	20.320	53.453	73.654	83.222	90.043	97.750	100.0
25/3/118-120	230.08	8.1330	1.059	2.749	1.928	16.190	32.070	19.460	9.441	6.741	7.984	2.378	3.808	5.736	21.926	53.996	73.456	82.897	89.638	97.622	100.0
25/3/137-139	230.27	8.1394	1.062	3.421	1.862	15.637	31.658	19.839	9.561	6.743	7.681	2.535	4.483	6.345	21.982	53.640	73.479	83.040	89.783	97.464	100.0
25/4/7-9	230.47	8.1461	1.111	2.680	1.511	15.658	32.220	19.844	9.535	6.887	8.137	2.417	3.791	5.302	20.960	53.180	73.024	82.559	89.446	97.583	100.0
25/4/32-34	230.72	8.1545	0.460	2.096	0.646	14.938	33.746	20.694	9.694	7.028	8.266	2.431	2.556	3.202	18.140	51.886	72.580	82.274	89.302	97.568	100.0
25/4/53-55	230.93	8.1615	0.624	2.088	0.963	15.044	32.798	20.389	9.959	7.223	8.419	2.493	2.712	3.676	18.720	51.518	71.906	81.865	89.088	97.507	100.0
25/4/74-76	231.14	8.1685	0.537	2.186	0.982	15.602	33.724	20.408	9.504	6.879	7.919	2.260	2.723	3.705	19.307	53.031	73.439	82.943	89.822	97.741	100.0
25/4/93-95	231.33	8.1749	0.693	1.900	1.495	19.639	33.936	18.216	8.097	6.087	7.681	2.255	2.593	4.088	23.727	57.663	75.879	83.976	90.063	97.744	100.0
25/4/112-114	231.52	8.1813	0.531	1.760	0.825	15.894	32.590	20.230	9.976	7.233	8.470	2.490	2.291	3.116	19.010	51.600	71.830	81.806	89.039	97.509	100.0
25/4/133-135	231.73	8.1883	0.533	2.214	1.591	15.695	31.725	20.056	9.879	7.030	8.672	2.605	2.747	4.338	20.033	51.758	71.814	81.693	88.723	97.395	100.0
25/5/1-3	231.91	8.1943	0.591	1.668	0.680	15.217	32.374	20.850	10.339	7.289	8.505	2.486	2.259	2.939	18.156	50.530	71.380	81.719	89.008	97.513	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
25/5/16-18	232.06	8.1994	0.634	2.071	1.165	15.963	32.265	20.199	9.667	6.980	8.521	2.535	2.705	3.870	19.833	52.098	72.297	81.964	88.944	97.465	100.0
25/5/38-40	232.28	8.2067	0.938	2.590	1.977	15.832	31.667	20.371	9.570	6.815	7.965	2.275	3.528	5.505	21.337	53.004	73.375	82.945	89.760	97.725	100.0
25/5/62-64	232.52	8.2148	0.715	2.522	1.386	15.451	33.412	20.452	8.830	6.661	8.181	2.388	3.237	4.623	20.074	53.486	73.938	82.768	89.429	97.610	100.0
25/5/82-84	232.72	8.2215	0.971	2.696	1.590	14.803	32.439	20.623	9.454	6.898	8.135	2.393	3.667	5.257	20.060	52.499	73.122	82.576	89.474	97.609	100.0
25/5/102-104	232.92	8.2282	0.850	2.375	1.312	16.369	34.032	19.933	8.416	6.481	7.918	2.312	3.225	4.537	20.906	54.938	74.871	83.287	89.769	97.687	100.0
25/5/117-119	233.07	8.2332	0.849	2.574	2.116	17.543	32.344	19.127	8.569	6.544	7.965	2.369	3.423	5.539	23.082	55.426	74.553	83.122	89.666	97.631	100.0
25/5137-139	233.27	8.2399	0.587	2.372	0.905	16.185	34.354	20.260	8.794	6.648	7.711	2.183	2.959	3.864	20.049	54.403	74.663	83.457	90.105	97.816	100.0
25/6/7-9	233.47	8.2466	0.902	2.470	0.878	14.544	34.117	21.089	9.224	6.778	7.773	2.226	3.372	4.250	18.794	52.911	74.000	83.224	90.002	97.775	100.0
25/6/27-29	233.67	8.2533	0.931	2.551	1.100	15.895	34.898	19.996	8.560	6.434	7.441	2.195	3.482	4.582	20.477	55.375	75.371	83.931	90.365	97.806	100.0
25/6/48-50	233.88	8.2603	0.553	2.313	1.459	14.519	33.479	20.983	9.676	7.163	7.678	2.177	2.866	4.325	18.844	52.323	73.306	82.982	90.145	97.823	100.0
25/6/75-77	234.15	8.2694	1.252	3.212	1.795	15.120	33.433	20.034	8.775	6.524	7.445	2.411	4.464	6.259	21.379	54.812	74.846	83.621	90.145	97.590	100.0
25/6/93-95	234.33	8.2754	1.089	2.866	1.699	14.577	33.619	21.032	8.807	6.496	7.639	2.176	3.955	5.654	20.231	53.850	74.882	83.689	90.185	97.824	100.0
25/6/112-114	234.52	8.2818	1.011	2.677	1.442	14.419	33.671	21.409	9.082	6.580	7.557	2.153	3.688	5.130	19.549	53.220	74.629	83.711	90.291	97.848	100.0
25/6/133-135	234.73	8.2888	0.679	2.352	0.983	14.307	33.710	21.673	9.219	6.833	7.947	2.297	3.031	4.014	18.321	52.031	73.704	82.923	89.756	97.703	100.0
25/7/1-3	234.91	8.2948	1.129	2.849	1.431	14.818	33.459	21.177	8.670	6.362	7.659	2.446	3.978	5.409	20.227	53.686	74.863	83.533	89.895	97.554	100.0
25/7/17-19	235.07	8.3002	1.127	3.097	2.071	14.006	31.254	21.427	9.719	6.760	8.073	2.466	4.224	6.295	20.301	51.554	72.981	82.700	89.460	97.533	100.0
25 CC/10-22	235.26	8.3065	0.866	2.728	2.138	14.219	31.686	21.598	9.695	6.625	7.823	2.622	3.594	5.732	19.951	51.637	73.235	82.930	89.555	97.378	100.0
26/1/1-3	235.51	8.3149	0.972	2.798	2.306	16.650	32.262	20.237	9.280	6.164	7.058	2.273	3.770	6.076	22.726	54.988	75.225	84.505	90.669	97.727	100.0
26/1/23-25	235.73	8.3223	0.834	2.060	1.926	16.978	31.812	19.833	9.540	6.666	7.969	2.380	2.894	4.820	21.798	53.610	73.443	82.983	89.649	97.618	100.0
26/1/41-43	235.91	8.3283	0.569	1.791	1.484	15.622	31.227	20.786	10.481	7.183	8.359	2.498	2.360	3.844	19.466	50.693	71.479	81.960	89.143	97.502	100.0
26/1/58-60	236.08	8.3340	0.845	2.126	2.213	17.422	32.027	19.921	9.068	6.256	7.774	2.348	2.971	5.184	22.606	54.633	74.554	83.622	89.878	97.652	100.0
26/1/82-84	236.32	8.3420	0.843	2.007	1.509	16.255	31.563	20.394	10.107	7.000	7.982	2.339	2.850	4.359	20.614	52.177	72.571	82.678	89.678	97.660	100.0
26/1/102-104	236.52	8.3487	0.827	2.093	2.168	16.661	31.002	19.733	9.776	6.912	8.111	2.717	2.920	5.088	21.749	52.751	72.484	82.260	89.172	97.283	100.0
26/1/117-119	236.67	8.3538	0.607	2.390	2.196	16.919	31.394	19.899	9.554	6.837	7.907	2.298	2.997	5.193	22.112	53.506	73.405	82.959	89.796	97.703	100.0
26/1/142-144	236.92	8.3621	0.941	2.656	2.301	15.969	31.224	20.078	9.898	7.076	7.662	2.195	3.597	5.898	21.867	53.091	73.169	83.067	90.143	97.805	100.0
26/2/13-15	237.13	8.3692	0.908	2.961	2.575	15.492	30.374	19.997	10.234	7.338	7.693	2.429	3.869	6.444	21.936	52.310	72.307	82.541	89.879	97.572	100.0
26/2/32-34	237.32	8.3755	0.644	2.641	2.497	15.982	31.434	20.154	9.667	6.923	7.737	2.321	3.285	5.782	21.764	53.199	73.353	83.020	89.942	97.679	100.0
26/2/56-58	237.56	8.3836	0.879	2.452	2.335	16.388	31.014	19.912	9.867	7.039	7.866	2.248	3.331	5.666	22.054	53.068	72.980	82.847	89.886	97.752	100.0
26/2/93-95	237.93	8.3960	0.937	2.689	1.758	15.031	32.437	20.832	9.725	6.631	7.515	2.444	3.626	5.384	20.415	52.852	73.684	83.409	90.040	97.555	100.0
26/2/112-114	238.12	8.4023	1.272	3.578	2.291	14.178	31.147	20.425	9.999	6.946	7.454	2.710	4.850	7.141	21.319	52.466	72.891	82.890	89.836	97.290	100.0
26/2/133-135	238.33	8.4094	1.253	3.783	2.430	15.160	32.277	20.306	9.025	6.241	7.177	2.348	5.036	7.466	22.626	54.903	75.209	84.234	90.475	97.652	100.0
26/3/1-3	238.51	8.4154	1.076	3.195	1.850	14.138	32.226	20.706	9.991	6.871	7.508	2.438	4.271	6.121	20.259	52.485	73.191	83.182	90.053	97.561	100.0
26/3/22-24	238.72	8.4224	0.635	2.789	1.757	15.986	33.746	20.004	9.094	6.451	7.389	2.148	3.424	5.181	21.167	54.913	74.917	84.011	90.462	97.851	100.0
26/3/43-45	238.93	8.4295	0.638	2.851	1.873	15.725	32.854	19.710	9.404	6.758	7.660	2.526	3.489	5.362	21.087	53.941	73.651	83.055	89.813	97.473	100.0
26/3/56-58	239.06	8.4338	0.551	2.506	1.104	15.466	34.755	20.494	9.115	6.476	7.222	2.310	3.057	4.161	19.627	54.382	74.876	83.991	90.467	97.689	100.0
26/3/82-84	239.32	8.4425	1.120	3.101	2.075	17.415	32.424	18.736	8.924	6.501	7.330	2.373	4.221	6.296	23.711	56.135	74.871	83.795	90.296	97.626	100.0
26/3/102-104	239.52	8.4492	1.116	3.159	2.061	17.029	32.329	18.538	8.829	6.813	7.633	2.494	4.275	6.336	23.365	55.694	74.232	83.061	89.874	97.507	100.0
26/3/117-119	239.67	8.4543	1.054	3.156	2.135	17.123	32.553	18.408	8.928	6.858	7.398	2.386	4.211	6.345	23.469	56.022	74.430	83.358	90.216	97.614	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
26/3/133-135	239.83	8.4596	0.767	3.292	1.552	16.242	33.276	19.417	9.141	6.832	7.214	2.267	4.059	5.611	21.853	55.129	74.546	83.687	90.519	97.733	100.0
26/4/7-9	240.07	8.4677	1.364	3.859	2.086	17.543	32.300	17.992	8.529	6.736	7.312	2.279	5.223	7.309	24.852	57.152	75.144	83.673	90.409	97.721	100.0
26/4/32-34	240.32	8.4760	1.295	3.273	2.556	20.348	33.622	16.667	7.441	5.900	6.739	2.158	4.568	7.124	27.472	61.094	77.761	85.202	91.102	97.841	100.0
26/4/52-54	240.52	8.4827	0.626	2.064	1.552	20.756	34.427	17.718	8.105	6.035	6.789	1.928	2.690	4.242	24.998	59.425	77.143	85.248	91.283	98.072	100.0
26/4/72-74	240.72	8.4894	0.612	2.255	1.020	19.209	34.126	18.800	8.704	6.183	7.076	2.015	2.867	3.887	23.096	57.222	76.022	84.726	90.909	97.985	100.0
26/4/92-94	240.92	8.4961	1.030	2.866	1.641	19.905	33.686	17.790	8.202	5.842	6.823	2.216	3.896	5.537	25.442	59.128	76.918	85.120	90.962	97.785	100.0
26/4/112-114	241.12	8.5028	0.919	2.684	1.737	19.081	34.014	18.217	8.383	6.088	6.715	2.163	3.603	5.340	24.421	58.435	76.652	85.035	91.123	97.838	100.0
26/4/132-134	241.32	8.5095	0.798	2.554	1.910	18.101	33.305	18.719	8.631	6.476	7.192	2.314	3.352	5.262	23.363	56.668	75.387	84.018	90.494	97.686	100.0
26/5/0-2	241.50	8.5156	1.179	3.154	2.033	18.413	33.811	18.300	8.260	6.132	6.636	2.081	4.333	6.366	24.779	58.590	76.890	85.150	91.282	97.918	100.0
26/5/15-17	241.65	8.5206	1.219	3.574	2.167	17.434	32.940	18.391	8.526	6.367	7.050	2.331	4.793	6.960	24.394	57.334	75.725	84.251	90.618	97.668	100.0
26/5/42-44	241.92	8.5296	1.357	3.361	1.581	17.547	32.970	18.548	8.836	6.375	7.081	2.343	4.718	6.298	23.845	56.816	75.364	84.200	90.575	97.656	100.0
26/5/63-65	242.13	8.5367	1.090	2.855	1.362	17.571	33.501	18.694	9.005	6.424	7.126	2.370	3.945	5.307	22.878	56.379	75.073	84.078	90.502	97.628	100.0
26/5/82-84	242.32	8.5430	0.717	2.922	1.566	18.798	34.058	18.127	8.684	6.317	6.841	1.971	3.639	5.205	24.003	58.061	76.188	84.872	91.189	98.030	100.0
26/5/102-104	242.52	8.5497	1.018	2.620	1.272	17.538	33.126	19.050	9.086	6.569	7.322	2.398	3.638	4.910	22.448	55.574	74.624	83.710	90.279	97.601	100.0
26/5/117-119	242.67	8.5548	0.540	2.162	0.984	17.012	32.640	18.960	9.849	7.377	8.104	2.371	2.702	3.686	20.698	53.338	72.298	82.147	89.524	97.628	100.0
26/5/142-144	242.92	8.5631	0.706	2.069	1.387	18.507	32.037	18.033	9.495	7.099	8.005	2.662	2.775	4.162	22.669	54.706	72.739	82.234	89.333	97.338	100.0
26/6/7-9	243.07	8.5682	0.508	2.423	0.882	15.979	31.558	18.729	10.107	7.954	9.181	2.679	2.931	3.813	19.792	51.350	70.079	80.186	88.140	97.321	100.0
26/6/26-28	243.26	8.5745	1.131	3.392	2.879	20.678	31.238	16.067	8.216	6.016	7.520	2.864	4.523	7.402	28.080	59.318	75.385	83.601	89.617	97.137	100.0
26/6/47-49	243.47	8.5816	0.771	2.084	1.234	16.593	27.919	18.507	12.042	8.319	9.372	3.160	2.855	4.089	20.682	48.601	67.108	79.150	87.469	96.841	100.0
26/6/63-65	243.63	8.5869	0.534	1.628	0.753	14.482	27.047	20.303	12.949	8.585	10.240	3.479	2.162	2.915	17.397	44.444	64.747	77.696	86.281	96.521	100.0
26 CC/13-15	243.86	8.5946	0.794	2.338	2.138	17.060	26.925	17.305	11.788	9.002	9.564	3.084	3.132	5.270	22.330	49.255	66.560	78.348	87.350	96.914	100.0
27/1/1-3	245.11	8.6365	0.856	2.348	1.531	16.562	27.379	17.818	11.693	9.073	9.950	2.789	3.205	4.736	21.297	48.676	66.494	78.187	87.260	97.210	100.0
27/1/25-27	245.35	8.6445	0.952	2.079	2.034	15.929	27.729	19.040	11.413	7.870	9.394	3.560	3.031	5.065	20.994	48.723	67.763	79.176	87.046	96.440	100.0
27/1/43-45	245.53	8.6506	0.999	2.946	1.375	15.031	28.661	19.415	11.030	7.835	9.522	3.185	3.945	5.320	20.351	49.012	68.427	79.457	87.292	96.814	100.0
27/1/65-67	245.75	8.6579	0.747	2.208	1.844	13.316	24.919	20.754	13.557	8.632	10.443	3.581	2.955	4.799	18.115	43.034	63.788	77.345	85.977	96.420	100.0
27/1/81-83	245.91	8.6633	0.353	1.825	0.998	14.000	26.573	21.026	12.664	8.213	11.196	3.151	2.178	3.176	17.176	43.749	64.775	77.439	85.652	96.848	100.0
27/1/96-98	246.06	8.6683	0.590	1.870	1.357	13.451	24.434	21.129	14.256	8.725	10.844	3.343	2.460	3.817	17.268	41.702	62.831	77.087	85.812	96.656	100.0
27/1/117-119	246.27	8.6753	0.387	1.955	2.405	14.008	24.783	21.062	13.173	8.119	11.272	2.837	2.342	4.747	18.755	43.538	64.600	77.773	85.892	97.164	100.0
27/1/142-144	246.52	8.6837	0.469	2.440	1.841	12.935	25.048	21.046	13.416	8.542	11.410	2.854	2.909	4.750	17.685	42.733	63.779	77.195	85.737	97.147	100.0
27/2/5-7	246.65	8.6881	0.889	2.288	1.689	13.503	25.662	20.497	13.352	8.668	10.531	2.920	3.177	4.866	18.369	44.031	64.528	77.880	86.548	97.079	100.0
27/2/27-29	246.87	8.6954	0.640	2.148	1.841	13.159	24.340	20.494	14.256	8.999	10.509	3.612	2.788	4.629	17.788	42.128	62.622	76.878	85.877	96.386	100.0
27/2/53-55	247.13	8.7041	0.903	2.350	2.539	15.835	26.586	18.169	12.333	8.694	9.141	3.449	3.253	5.792	21.627	48.213	66.382	78.715	87.409	96.550	100.0
27/2/73-76	247.33	8.7108	1.215	3.723	2.864	17.030	28.931	17.616	10.105	7.601	8.222	2.692	4.938	7.802	24.832	53.763	71.379	81.484	89.085	97.307	100.0
27/2/93-95	247.53	8.7175	1.426	3.978	3.017	16.348	29.320	17.716	9.510	7.388	8.232	3.066	5.404	8.421	24.769	54.089	71.805	81.315	88.703	96.935	100.0
27/2/107-109	247.67	8.7222	1.133	3.534	2.297	16.157	30.314	18.832	9.513	7.136	8.147	2.937	4.667	6.964	23.121	53.435	72.267	81.780	88.916	97.063	100.0
27/2/132-134	247.92	8.7306	0.944	3.038	2.209	15.790	29.076	18.657	10.781	7.993	8.663	2.849	3.982	6.191	21.981	51.057	69.714	80.495	88.488	97.151	100.0
27/3/1-3	248.11	8.7370	1.257	3.789	2.422	16.331	29.691	18.149	10.059	7.569	8.101	2.631	5.046	7.468	23.799	53.490	71.639	81.698	89.267	97.368	100.0
27/3/16-18	248.26	8.7420	1.195	3.333	2.514	16.253	30.657	18.280	9.729	7.344	8.050	2.644	4.528	7.042	23.295	53.952	72.232	81.961	89.305	97.355	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
27/3/37-39	248.47	8.7490	1.321	3.734	2.605	16.960	30.171	17.667	9.762	7.367	7.845	2.569	5.055	7.660	24.620	54.791	72.458	82.220	89.587	97.432	100.0
27/3/56-58	248.66	8.7554	1.379	4.395	3.165	16.500	29.600	17.354	9.445	7.203	7.966	2.993	5.774	8.939	25.439	55.039	72.393	81.838	89.041	97.007	100.0
27/3/83-85	248.93	8.7644	1.285	3.613	2.371	15.517	29.126	18.196	10.462	7.792	8.449	3.189	4.898	7.269	22.786	51.912	70.108	80.570	88.362	96.811	100.0
27/3/104-106	249.14	8.7715	1.239	4.039	2.122	14.833	27.787	18.372	11.560	8.478	8.698	2.872	5.278	7.400	22.233	50.020	68.392	79.952	88.430	97.128	100.0
27/3/117-119	249.27	8.7758	1.255	3.665	1.669	13.659	28.459	19.454	11.735	8.277	8.897	2.931	4.920	6.589	20.248	48.707	68.161	79.896	88.173	97.070	100.0
27/7/142-144	249.52	8.7842	1.201	3.625	2.536	14.020	28.018	18.754	11.489	8.599	9.011	2.747	4.826	7.362	21.382	49.400	68.154	79.644	88.242	97.253	100.0
27/4/7-9	249.67	8.7892	1.243	3.282	2.752	13.624	27.017	18.769	12.145	8.767	9.037	3.364	4.525	7.277	20.901	47.918	66.687	78.832	87.599	96.636	100.0
27/4/32-34	249.92	8.7976	0.415	2.452	1.559	12.644	26.497	20.284	13.834	9.371	9.730	3.214	2.867	4.426	17.070	43.567	63.851	77.685	87.056	96.786	100.0
27/4/52-54	250.12	8.8043	0.506	2.697	1.661	13.850	26.991	19.399	13.046	9.040	9.609	3.201	3.203	4.864	18.714	45.705	65.104	78.150	87.190	96.799	100.0
27/4/67-69	250.27	8.8093	1.057	3.277	2.865	14.567	27.708	18.779	11.549	8.328	8.944	2.926	4.334	7.199	21.766	49.474	68.253	79.802	88.130	97.074	100.0
27/4/86-88	250.46	8.8157	1.023	2.788	1.641	12.427	26.042	20.670	13.191	9.080	9.903	3.235	3.811	5.452	17.879	43.921	64.591	77.782	86.862	96.765	100.0
27/4/112-114	250.72	8.8244	0.492	2.325	1.477	13.847	28.903	20.202	11.028	9.006	10.382	2.338	2.817	4.294	18.141	47.044	67.246	78.274	87.280	97.662	100.0
27/4/132-134	250.92	8.8311	0.560	2.493	1.880	13.507	29.375	20.528	10.561	8.775	9.684	2.638	3.053	4.933	18.440	47.815	68.343	78.904	87.679	97.363	100.0
27/5/0-2	251.10	8.8371	0.689	2.693	1.359	11.716	30.751	22.039	10.432	8.303	9.448	2.570	3.382	4.741	16.457	47.208	69.247	79.679	87.982	97.430	100.0
27/5/23-26	251.33	8.8448	0.998	2.665	1.294	12.075	30.901	21.540	9.967	8.461	9.514	2.585	3.663	4.957	17.032	47.933	69.473	79.440	87.901	97.415	100.0
27/5/38-40	251.48	8.8499	1.026	2.934	1.974	12.814	30.038	20.920	9.899	8.228	9.539	2.629	3.960	5.934	18.748	48.786	69.706	79.605	87.833	97.372	100.0
27/5/57-59	251.67	8.8562	0.694	2.571	1.362	11.366	29.992	22.178	10.998	8.567	9.676	2.595	3.265	4.627	15.992	45.985	68.163	79.161	87.728	97.405	100.0
27/5/83-85	251.93	8.8649	0.494	2.555	2.164	12.790	28.803	21.063	10.844	8.576	9.694	3.015	3.049	5.213	18.003	46.806	67.869	78.713	87.289	96.983	100.0
27/5/103-105	252.13	8.8716	0.946	2.860	1.775	12.197	29.471	21.632	10.700	8.342	9.452	2.625	3.806	5.581	17.778	47.249	68.881	79.581	87.923	97.375	100.0
27/5/118-120	252.28	8.8767	0.476	2.535	1.688	11.844	29.016	21.164	11.242	8.957	9.946	3.132	3.011	4.699	16.543	45.559	66.723	77.965	86.922	96.868	100.0
27/5/143-145	252.53	8.8850	0.576	2.292	0.996	12.887	30.066	21.014	11.264	8.827	9.443	2.635	2.868	3.864	16.751	46.817	67.831	79.095	87.922	97.365	100.0
27/6/7-9	252.67	8.8897	0.649	2.781	0.934	12.828	30.662	21.058	10.789	8.059	9.239	3.001	3.430	4.364	17.192	47.854	68.912	79.701	87.760	96.999	100.0
27/6/32-34	252.92	8.8981	0.441	2.742	2.136	13.821	29.960	19.890	10.295	8.166	9.483	3.067	3.183	5.319	19.140	49.100	68.990	79.285	87.451	96.934	100.0
27/6/53-55	253.13	8.9051	0.581	2.490	0.771	14.224	31.723	20.195	10.009	8.073	9.301	2.631	3.071	3.842	18.066	49.789	69.984	79.993	88.066	97.367	100.0
27/6/73-75	253.33	8.9118	0.555	2.128	1.571	15.563	30.732	19.217	10.279	8.268	9.123	2.565	2.683	4.254	19.817	50.549	69.766	80.045	88.313	97.436	100.0
27/6/87-89	253.47	8.9165	0.701	2.468	0.687	14.177	31.775	20.549	10.343	7.963	8.878	2.460	3.169	3.856	18.033	49.808	70.357	80.700	88.663	97.541	100.0
27/6/107-109	253.67	8.9232	0.601	2.453	0.842	14.684	31.897	20.081	9.872	7.862	9.103	2.606	3.054	3.896	18.580	50.477	70.558	80.430	88.292	97.395	100.0
27/6/132-134	253.92	8.9316	0.591	1.907	0.969	15.856	31.341	19.366	10.174	8.095	9.111	2.591	2.498	3.467	19.323	50.664	70.030	80.204	88.299	97.410	100.0
27/7/0-2	254.10	8.9376	0.959	2.499	0.984	16.409	32.861	19.580	9.423	6.951	8.026	2.308	3.458	4.442	20.851	53.712	73.292	82.715	89.666	97.692	100.0
27/7/17-19	254.27	8.9433	0.897	2.569	1.245	16.156	33.356	19.866	8.943	6.754	7.773	2.442	3.466	4.711	20.867	54.223	74.089	83.032	89.786	97.559	100.0
27 CC/10-12	254.49	8.9533	0.855	2.329	0.644	16.329	33.819	19.601	9.199	6.868	8.015	2.341	3.184	3.828	20.157	53.976	73.577	82.776	89.644	97.659	100.0
28/1/4-6	254.74	8.9675	0.630	1.979	0.788	15.647	33.140	20.094	10.012	7.517	7.958	2.234	2.609	3.397	19.044	52.184	72.278	82.290	89.807	97.765	100.0
28/1/23-25	254.93	8.9783	0.559	2.004	0.636	16.744	35.870	20.100	8.356	6.366	7.303	2.063	2.563	3.199	19.943	55.813	75.913	84.269	90.635	97.938	100.0
28/1/42-44	255.12	8.9891	0.495	2.089	0.291	14.249	34.926	21.409	9.528	7.167	7.867	1.979	2.584	2.875	17.124	52.050	73.459	82.987	90.154	98.021	100.0
28/1/58-60	255.28	8.9982	0.530	2.104	0.317	14.571	34.832	21.172	9.433	7.061	7.779	2.202	2.634	2.951	17.522	52.354	73.526	82.959	90.020	97.799	100.0
28/1/83-85	255.53	9.0124	0.797	2.436	0.572	15.148	33.953	20.605	9.631	7.087	7.627	2.144	3.233	3.805	18.953	52.906	73.511	83.142	90.229	97.856	100.0
28/1/103-105	255.73	9.0237	0.816	2.192	0.575	15.590	33.439	20.343	9.749	7.174	7.870	2.252	3.008	3.583	19.173	52.612	72.955	82.704	89.878	97.748	100.0
28/1/121-123	255.91	9.0340	0.747	2.313	0.547	16.588	34.052	20.060	9.319	6.698	7.527	2.150	3.060	3.607	20.195	54.246	74.306	83.625	90.323	97.851	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
28/1/141-143	256.11	9.0453	0.611	2.205	0.528	16.112	33.505	20.306	9.829	7.028	7.701	2.176	2.816	3.344	19.456	52.961	73.267	83.096	90.124	97.825	100.0
28/2/7-9	256.27	9.0544	0.593	2.291	0.716	16.829	33.180	19.832	9.710	6.935	7.709	2.204	2.884	3.600	20.429	53.609	73.441	83.151	90.086	97.795	100.0
28/2/33-35	256.53	9.0692	0.649	2.335	0.861	17.340	33.790	19.720	9.362	6.655	7.254	2.035	2.984	3.845	21.185	54.975	74.695	84.057	90.712	97.966	100.0
28/2/54-56	256.74	9.0811	0.622	2.291	0.950	18.407	33.640	19.256	9.099	6.307	7.124	2.304	2.913	3.863	22.270	55.910	75.166	84.265	90.572	97.696	100.0
28/2/83-85	257.03	9.0976	0.786	2.593	1.057	18.702	33.080	18.637	9.070	6.388	7.308	2.379	3.379	4.436	23.138	56.218	74.855	83.925	90.313	97.621	100.0
28/2/98-100	257.18	9.1062	0.612	2.668	0.875	17.957	33.134	19.233	9.456	6.470	7.251	2.345	3.280	4.155	22.112	55.246	74.479	83.935	90.405	97.656	100.0
28/2/113-115	257.33	9.1147	0.541	2.636	0.951	18.380	33.614	19.066	9.047	6.364	7.295	2.106	3.177	4.128	22.508	56.122	75.188	84.235	90.599	97.894	100.0
28/2/133-135	257.53	9.1261	0.640	2.933	0.892	17.087	33.424	19.525	9.313	6.421	7.364	2.400	3.573	4.465	21.552	54.976	74.501	83.814	90.235	97.599	100.0
28/3/1-3	257.71	9.1363	0.916	2.677	0.786	16.382	33.560	19.948	9.353	6.379	7.494	2.504	3.593	4.379	20.761	54.321	74.269	83.622	90.001	97.495	100.0
28/3/25-27	257.95	9.1499	0.634	2.386	0.676	17.540	34.501	19.579	9.106	6.139	7.114	2.326	3.020	3.696	21.236	55.737	75.316	84.422	90.561	97.675	100.0
28/3/42-44	258.12	9.1596	0.613	3.184	0.964	18.062	33.973	19.151	8.941	6.065	6.825	2.221	3.797	4.761	22.823	56.796	75.947	84.888	90.953	97.778	100.0
28/3/55-57	258.25	9.1670	0.801	2.480	0.635	18.646	34.363	19.119	9.231	6.082	6.553	2.090	3.281	3.916	22.562	56.925	76.044	85.275	91.357	97.910	100.0
28/3/84-86	258.54	9.1835	0.555	2.242	0.631	17.863	33.728	19.316	9.832	6.548	7.161	2.124	2.797	3.428	21.291	55.019	74.336	84.168	90.716	97.876	100.0
28/3/118-120	258.88	9.2028	0.837	2.362	1.195	19.385	32.967	18.193	8.803	6.528	7.377	2.354	3.199	4.394	23.779	56.746	74.939	83.742	90.270	97.647	100.0
28/3/137-139	259.07	9.2136	0.696	2.433	1.180	19.001	33.034	18.417	8.963	6.721	7.449	2.108	3.129	4.309	23.310	56.344	74.761	83.724	90.445	97.894	100.0
28/4/6-8	259.26	9.2244	0.699	2.341	0.818	18.819	34.119	18.582	9.072	6.504	7.054	1.993	3.040	3.858	22.677	56.796	75.378	84.450	90.954	98.008	100.0
28/4/33-35	259.53	9.2397	0.554	2.467	1.125	18.920	32.929	18.409	9.271	6.694	7.303	2.329	3.021	4.146	23.066	55.995	74.404	83.675	90.369	97.672	100.0
28/4/47-49	259.67	9.2477	0.556	2.880	0.878	18.151	33.483	18.707	9.342	6.465	7.192	2.346	3.436	4.314	22.465	55.948	74.655	83.997	90.462	97.654	100.0
28/4/66-68	259.86	9.2585	0.666	2.565	0.677	16.948	33.131	19.212	9.984	6.957	7.477	2.384	3.231	3.908	20.856	53.987	73.199	83.183	90.140	97.617	100.0
28/4/93-95	260.13	9.2738	0.570	2.616	1.101	17.713	33.332	19.493	9.189	6.599	7.139	2.248	3.186	4.287	22.000	55.332	74.825	84.014	90.613	97.752	100.0
28/4/108-110	260.28	9.2824	0.623	2.095	0.956	17.674	33.386	19.329	9.387	6.893	7.536	2.122	2.718	3.674	21.348	54.734	74.063	83.450	90.343	97.879	100.0
28/4/134-136	260.54	9.2971	0.612	2.440	1.216	17.233	32.539	19.471	9.650	6.819	7.580	2.439	3.052	4.268	21.501	54.040	73.511	83.161	89.980	97.560	100.0
28/5/1-3	260.71	9.3068	0.385	1.489	1.188	20.198	35.181	18.949	8.460	5.781	6.618	1.752	1.874	3.062	23.260	58.441	77.390	85.850	91.631	98.249	100.0
28/5/16-18	260.86	9.3153	0.560	2.117	1.143	17.752	33.215	19.360	9.482	6.626	7.558	2.186	2.677	3.820	21.572	54.787	74.147	83.629	90.255	97.813	100.0
28/5/42-44	261.12	9.3301	0.627	2.482	1.272	17.932	32.623	19.114	9.653	6.621	7.497	2.179	3.109	4.381	22.313	54.936	74.050	83.703	90.324	97.821	100.0
28/5/61-63	261.31	9.3409	1.190	2.988	1.717	19.096	32.681	17.759	8.750	6.050	7.325	2.443	4.178	5.895	24.991	57.672	75.431	84.181	90.231	97.556	100.0
28/5/85-87	261.55	9.3546	0.560	2.221	1.402	18.454	32.030	18.488	9.749	6.939	7.911	2.246	2.781	4.183	22.637	54.667	73.155	82.904	89.843	97.754	100.0
28/5/102-104	261.72	9.3642	0.646	3.027	1.871	19.435	32.989	17.867	8.806	5.969	7.055	2.337	3.673	5.544	24.979	57.968	75.835	84.641	90.610	97.665	100.0
28/5/121-123	261.91	9.3750	1.290	3.021	1.748	19.921	32.802	17.585	8.505	5.832	6.997	2.298	4.311	6.059	25.980	58.782	76.367	84.872	90.704	97.701	100.0
28/5/141-143	262.11	9.3864	1.196	3.152	1.931	19.045	32.402	17.760	8.615	6.034	7.383	2.481	4.348	6.279	25.324	57.726	75.486	84.101	90.135	97.518	100.0
28/6/8-10	262.28	9.3960	0.817	2.876	1.209	18.079	33.461	19.190	8.954	5.918	7.142	2.354	3.693	4.902	22.981	56.442	75.632	84.586	90.504	97.646	100.0
28 CC/8-10	262.45	9.4057	0.898	2.394	1.063	17.441	33.134	19.247	9.480	6.505	7.614	2.225	3.292	4.355	21.796	54.930	74.177	83.657	90.162	97.776	100.0
29/1/0-2	264.30	9.5109	0.998	2.948	1.278	16.260	32.402	19.101	10.029	7.029	7.744	2.210	3.946	5.224	21.484	53.886	72.987	83.016	90.045	97.789	100.0
29/1/34-36	264.64	9.5302	0.644	2.482	0.764	17.510	34.432	19.282	9.223	6.324	7.247	2.091	3.126	3.890	21.400	55.832	75.114	84.337	90.661	97.908	100.0
29/1/58-60	264.88	9.5438	0.669	2.314	1.204	17.777	34.172	19.299	8.565	6.043	7.683	2.273	2.983	4.187	21.964	56.136	75.435	84.000	90.043	97.726	100.0
29/1/80-82	265.10	9.5563	1.152	3.042	1.202	15.456	34.373	20.486	8.512	5.998	7.580	2.198	4.194	5.396	20.852	55.225	75.711	84.223	90.221	97.801	100.0
29/1/96-98	265.26	9.5654	0.843	3.105	1.310	15.798	34.587	20.375	8.435	5.906	7.473	2.168	3.948	5.258	21.056	55.643	76.018	84.452	90.359	97.832	100.0
29/1/117-119	265.47	9.5774	0.788	3.416	1.678	15.975	34.007	20.272	8.625	5.901	7.052	2.287	4.204	5.882	21.857	55.864	76.136	84.761	90.662	97.714	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
29/1/142-144	265.72	9.5916	1.089	2.773	0.997	15.711	33.989	20.115	9.051	6.307	7.486	2.483	3.862	4.859	20.570	54.559	74.674	83.725	90.032	97.518	100.0
29/2/12-14	265.92	9.6029	0.651	2.692	1.034	15.408	34.464	20.534	9.133	6.442	7.479	2.164	3.343	4.377	19.785	54.249	74.783	83.916	90.358	97.837	100.0
29/2/32-34	266.12	9.6143	0.951	2.833	1.069	14.777	34.356	20.987	9.131	6.452	7.373	2.070	3.784	4.853	19.630	53.986	74.973	84.104	90.556	97.929	100.0
29/2/46-48	266.26	9.6223	0.776	2.341	0.700	14.881	33.579	20.742	9.870	6.941	7.879	2.292	3.117	3.817	18.698	52.277	73.019	82.889	89.830	97.709	100.0
29/2/64-66	266.44	9.6325	0.662	2.659	1.659	16.499	33.818	19.798	9.106	6.419	7.278	2.102	3.321	4.980	21.479	55.297	75.095	84.201	90.620	97.898	100.0
29/2/85-87	266.65	9.6444	0.704	2.411	0.876	16.947	34.578	19.693	9.195	6.340	7.172	2.084	3.115	3.991	20.938	55.516	75.209	84.404	90.744	97.916	100.0
29/2/107-109	266.87	9.6569	0.594	2.169	0.842	16.322	34.444	19.956	9.522	6.490	7.273	2.390	2.763	3.605	19.927	54.371	74.327	83.849	90.339	97.612	100.0
29/2/133-135	267.13	9.6717	0.655	2.707	2.473	17.766	32.953	18.657	8.957	6.335	7.330	2.166	3.362	5.835	23.601	56.554	75.211	84.168	90.503	97.833	100.0
29/3/1- 3	267.31	9.6820	0.587	2.377	1.569	16.813	33.387	19.002	9.697	7.014	7.455	2.099	2.964	4.533	21.346	54.733	73.735	83.432	90.446	97.901	100.0
29/3/23-25	267.53	9.6945	0.434	2.193	0.725	16.159	35.614	20.222	9.053	6.256	7.228	2.117	2.626	3.351	19.510	55.124	75.346	84.399	90.655	97.883	100.0
29/3/42-44	267.72	9.7053	0.485	2.108	2.542	22.389	36.072	17.263	6.989	4.678	5.715	1.759	2.593	5.135	27.524	63.596	80.859	87.848	92.526	98.241	100.0
29/3/57-59	267.87	9.7138	0.541	2.080	0.465	15.668	35.088	20.427	9.522	6.575	7.458	2.175	2.621	3.086	18.754	53.842	74.269	83.791	90.366	97.824	100.0
29/3/84-86	268.14	9.7291	0.597	2.234	0.516	16.462	35.953	20.264	8.864	6.114	7.001	1.995	2.831	3.347	19.809	55.762	76.026	84.890	91.004	98.005	100.0
29/3/104-106	268.34	9.7405	0.462	2.064	0.260	15.265	36.499	21.048	9.059	6.359	7.175	1.809	2.526	2.786	18.051	54.550	75.598	84.657	91.016	98.191	100.0
29/3/117-119	268.47	9.7479	0.489	1.864	0.293	16.005	36.609	20.827	8.908	6.242	7.015	1.748	2.353	2.646	18.651	55.260	76.087	84.995	91.237	98.252	100.0
29/3/138-140	268.68	9.7598	0.414	1.731	0.203	14.472	35.211	21.394	9.861	6.981	7.748	1.985	2.145	2.348	16.820	52.031	73.425	83.286	90.267	98.015	100.0
29/4/6- 8	268.86	9.7701	0.755	2.619	0.551	15.289	35.049	20.607	9.176	6.448	7.361	2.144	3.374	3.925	19.214	54.263	74.870	84.046	90.494	97.855	100.0
29/4/48-50	269.28	9.7885	0.494	2.430	1.444	14.985	34.638	20.996	9.112	6.466	7.308	2.128	2.924	4.368	19.353	53.991	74.987	84.099	90.565	97.873	100.0
29/4/72-74	269.52	9.7959	0.523	2.170	0.475	12.941	34.737	22.403	10.038	7.019	7.539	2.154	2.693	3.168	16.109	50.846	73.249	83.287	90.306	97.845	100.0
29/4/95-97	269.75	9.8030	0.601	2.450	0.471	14.099	35.200	20.873	9.658	6.861	7.606	2.182	3.051	3.522	17.621	52.821	73.694	83.352	90.213	97.819	100.0
29/4/107-109	269.87	9.8067	0.480	1.957	0.271	13.768	35.287	21.482	10.116	6.997	7.494	2.149	2.437	2.708	16.476	51.763	73.245	83.361	90.358	97.852	100.0
29/4/135-137	270.15	9.8153	0.464	1.829	0.291	13.939	35.695	22.093	9.863	6.734	7.274	1.819	2.293	2.584	16.523	52.218	74.311	84.174	90.908	98.182	100.0
29/5/1- 3	270.31	9.8203	0.601	2.237	0.382	13.297	35.331	22.189	9.700	6.766	7.392	2.105	2.838	3.220	16.517	51.848	74.037	83.737	90.503	97.895	100.0
29/5/15-17	270.45	9.8246	0.853	2.809	1.616	14.789	34.782	20.959	8.973	6.201	7.007	2.011	3.662	5.278	20.067	54.849	75.808	84.781	90.982	97.989	100.0
29/5/42-44	270.72	9.8329	0.516	2.438	1.877	15.217	34.113	20.785	9.100	6.356	7.420	2.178	2.954	4.832	20.048	54.161	74.946	84.046	90.402	97.822	100.0
29/5/61-63	270.91	9.8384	0.920	4.937	5.507	17.764	30.817	18.205	7.468	5.310	6.807	2.265	5.857	11.364	29.128	59.945	78.150	85.618	90.928	97.735	100.0
29/5/85-87	271.15	9.8447	2.275	7.150	5.721	15.183	27.490	17.838	8.674	6.207	6.904	2.556	9.425	15.146	30.329	57.819	75.657	84.331	90.538	97.442	100.0
29/5/104-106	271.34	9.8498	1.068	5.883	7.600	17.716	27.246	17.427	8.517	5.810	6.342	2.391	6.951	14.551	32.267	59.513	76.940	85.457	91.267	97.609	100.0
29/5/118-120	271.48	9.8535	2.335	7.668	6.810	17.258	28.208	16.507	7.374	5.141	6.264	2.434	10.003	16.813	34.071	62.279	78.786	86.160	91.301	97.565	100.0
29/5/142-144	271.72	9.8598	0.484	1.766	0.196	13.945	32.613	21.061	11.717	7.515	8.244	2.460	2.250	2.446	16.391	49.004	70.065	81.782	89.297	97.541	100.0
29/6/14-16	271.94	9.8657	1.188	3.226	1.086	15.926	33.646	19.277	9.581	6.303	7.322	2.446	4.414	5.500	21.426	55.072	74.349	83.930	90.233	97.555	100.0
29 CC/17-19	272.19	9.8723	0.428	1.933	0.370	15.710	34.269	20.032	10.663	6.984	7.430	2.181	2.361	2.731	18.441	52.710	72.742	83.405	90.389	97.819	100.0
30/1/1- 3	273.91	9.9179	0.510	2.000	0.201	13.075	32.745	20.729	12.145	8.526	7.887	2.183	2.510	2.711	15.786	48.531	69.260	81.405	89.931	97.818	100.0
30/1/14-16	274.04	9.9213	0.444	1.954	0.330	14.228	34.971	21.050	10.239	6.925	7.637	2.222	2.398	2.728	16.956	51.927	72.977	83.216	90.141	97.778	100.0
30/1/42-44	274.32	9.9287	0.321	1.675	0.124	12.512	36.293	22.444	10.195	7.041	7.657	1.738	1.996	2.120	14.632	50.925	73.369	83.564	90.605	98.262	100.0
30/1/58-60	274.48	9.9330	0.418	1.803	0.262	14.439	36.698	21.187	9.168	6.605	7.494	1.926	2.221	2.483	16.922	53.620	74.807	83.975	90.580	98.074	100.0
30/1/82-84	274.72	9.9393	0.523	2.047	0.204	12.135	35.511	22.308	10.159	7.258	7.824	2.031	2.570	2.774	14.909	50.420	72.728	82.887	90.145	97.969	100.0
30/1/103-105	274.93	9.9449	0.942	2.419	0.735	13.969	34.710	21.326	8.949	6.700	7.969	2.281	3.361	4.096	18.065	52.775	74.101	83.050	89.750	97.719	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
30/1/122-124	275.12	9.9499	0.388	1.729	0.211	12.253	35.793	22.666	9.698	7.106	8.108	2.048	2.117	2.328	14.581	50.374	73.040	82.738	89.844	97.952	100.0
30/1/141-143	275.31	9.9550	0.538	1.994	0.217	13.315	36.017	21.719	9.116	6.861	8.155	2.068	2.532	2.749	16.064	52.081	73.800	82.916	89.777	97.932	100.0
30/2/5- 7	275.45	9.9587	0.428	1.882	0.586	14.384	34.761	21.168	9.575	6.789	8.081	2.347	2.310	2.896	17.280	52.041	73.209	82.784	89.573	97.654	100.0
30/2/32-34	275.72	9.9658	0.492	1.971	0.545	15.396	34.767	20.145	9.588	6.947	7.892	2.258	2.463	3.008	18.404	53.171	73.316	82.904	89.851	97.743	100.0
30/2/53-55	275.93	9.9714	0.742	2.295	0.395	16.179	35.930	19.711	9.066	6.085	7.367	2.232	3.037	3.432	19.611	55.541	75.252	84.318	90.403	97.770	100.0
30/2/92-94	276.32	9.9817	0.441	1.983	0.434	15.539	35.864	20.645	9.171	6.301	7.450	2.172	2.424	2.858	18.397	54.261	74.906	84.077	90.378	97.828	100.0
30/2/112-114	276.52	9.9870	0.446	1.717	0.320	15.523	35.738	21.137	9.229	6.268	7.455	2.166	2.163	2.483	18.006	53.744	74.881	84.110	90.378	97.833	100.0
30/2/133-135	276.73	9.9926	0.484	1.975	0.242	14.380	35.630	21.421	9.747	6.606	7.561	1.955	2.459	2.701	17.081	52.711	74.132	83.879	90.485	98.046	100.0
30/3/1- 3	276.91	9.9974	0.523	1.922	0.151	15.553	36.616	20.334	9.175	6.493	7.336	1.896	2.445	2.596	18.149	54.765	75.099	84.274	90.767	98.103	100.0
30/3/15-17	277.05	10.0011	0.435	1.638	0.154	16.360	35.945	19.536	9.321	6.820	7.921	1.871	2.073	2.227	18.587	54.532	74.068	83.389	90.209	98.130	100.0
30/3/43-45	277.33	10.0085	0.673	2.061	0.538	16.339	35.668	19.704	8.584	6.411	7.777	2.244	2.734	3.272	19.611	55.279	74.983	83.567	89.978	97.755	100.0
30/3/65-67	277.55	10.0143	0.446	1.804	0.178	15.605	36.934	20.543	9.381	6.158	7.101	1.849	2.250	2.428	18.033	54.967	75.510	84.891	91.049	98.150	100.0
30/3/84-86	277.74	10.0194	0.592	2.086	0.214	15.569	36.260	20.771	9.301	5.827	7.216	2.164	2.678	2.892	18.461	54.721	75.492	84.793	90.620	97.836	100.0
30/3/103-105	277.93	10.0244	0.564	1.839	0.159	15.672	35.882	20.217	9.178	6.499	7.873	2.116	2.403	2.562	18.234	54.116	74.333	83.511	90.010	97.883	100.0
30/3/117-119	278.07	10.0281	0.543	1.985	0.351	15.819	34.905	20.161	9.434	6.599	7.887	2.316	2.528	2.879	18.698	53.603	73.764	83.198	89.797	97.684	100.0
30/3/138-140	278.28	10.0337	0.558	2.056	0.477	15.956	34.896	20.262	9.396	6.319	7.753	2.326	2.614	3.092	19.048	53.944	74.206	83.602	89.921	97.674	100.0
30/4/9- 11	278.49	10.0392	0.507	1.749	0.288	17.809	36.837	19.282	8.241	5.977	7.407	1.903	2.256	2.544	20.353	57.190	76.472	84.713	90.690	98.097	100.0
30/4/32-34	278.72	10.0453	0.440	1.635	0.157	16.346	34.885	19.888	9.865	6.754	7.952	2.076	2.075	2.232	18.578	53.463	73.351	83.216	89.970	97.922	100.0
30/4/48-50	278.88	10.0496	0.554	2.123	0.189	14.839	34.900	20.663	9.732	6.634	7.960	2.407	2.677	2.866	17.705	52.605	73.268	83.000	89.634	97.594	100.0
30/4/73-75	279.13	10.0562	0.386	1.499	0.127	15.089	35.232	21.257	9.735	6.677	8.075	1.923	1.885	2.012	17.101	52.333	73.590	83.325	90.002	98.077	100.0
30/4/93-95	279.33	10.0615	0.473	1.686	0.143	13.950	35.165	21.670	9.640	6.700	8.338	2.236	2.159	2.302	16.252	51.417	73.087	82.727	89.427	97.765	100.0
30/4/113-115	279.53	10.0668	0.712	2.187	0.265	14.959	35.450	20.850	9.268	6.338	7.707	2.265	2.899	3.164	18.123	53.573	74.423	83.691	90.029	97.736	100.0
30/4/135-137	279.75	10.0726	0.441	1.896	0.199	12.145	34.861	23.054	10.215	6.817	8.197	2.173	2.337	2.536	14.681	49.542	72.596	82.811	89.628	97.825	100.0
30/5/6- 8	279.96	10.0782	0.419	1.862	0.225	12.543	35.343	22.817	9.755	6.706	8.171	2.159	2.281	2.506	15.049	50.392	73.209	82.964	89.670	97.841	100.0
30/5/15-17	280.05	10.0806	0.442	1.901	0.251	12.192	34.189	22.935	10.395	6.921	8.284	2.490	2.343	2.594	14.786	48.975	71.910	82.305	89.226	97.510	100.0
30/5/35-37	280.25	10.0859	0.532	1.806	0.311	14.394	34.063	21.692	9.524	6.906	8.530	2.242	2.338	2.649	17.043	51.106	72.798	82.322	89.228	97.758	100.0
30/5/84-86	280.74	10.0989	0.445	1.622	0.148	13.116	34.868	22.782	9.739	6.667	8.388	2.224	2.067	2.215	15.331	50.199	72.981	82.720	89.387	97.775	100.0
30/5/102-104	280.92	10.1036	0.436	1.962	0.227	13.708	36.952	22.349	8.750	6.265	7.496	1.855	2.398	2.625	16.333	53.285	75.634	84.384	90.649	98.145	100.0
31/1/1- 3	283.51	10.1723	0.480	2.186	0.377	11.325	32.325	22.123	11.882	8.335	8.535	2.431	2.666	3.043	14.368	46.693	68.816	80.698	89.033	97.568	100.0
31/1/17-19	283.67	10.1765	0.561	2.217	0.314	13.581	36.027	21.901	9.097	6.625	7.688	1.989	2.778	3.092	16.673	52.700	74.601	83.698	90.323	98.011	100.0
31/1/44-46	283.94	10.1837	0.500	2.392	0.474	12.759	35.591	22.383	9.393	6.639	7.646	2.222	2.892	3.366	16.125	51.716	74.099	83.493	90.131	97.777	100.0
31/1/58-60	284.08	10.1874	0.438	2.165	0.296	12.455	37.050	22.528	9.150	6.731	7.348	1.837	2.603	2.899	15.354	52.404	74.932	84.082	90.813	98.161	100.0
31/1/83-85	284.33	10.1940	0.551	2.473	0.635	13.782	36.632	21.817	8.528	6.179	7.278	2.124	3.024	3.659	17.441	54.073	75.890	84.418	90.597	97.875	100.0
31/1/105-107	284.55	10.1998	0.388	2.113	0.411	12.717	35.878	22.742	9.498	6.532	7.518	2.204	2.501	2.912	15.629	51.507	74.249	83.747	90.279	97.797	100.0
31/1/118-120	284.68	10.2033	0.513	2.379	0.499	12.570	35.000	22.732	9.665	6.681	7.721	2.240	2.892	3.391	15.961	50.961	73.693	83.358	90.039	97.760	100.0
31/1/138-140	284.88	10.2086	0.547	2.195	0.307	12.777	35.519	22.623	9.441	6.753	7.822	2.015	2.742	3.049	15.826	51.345	73.968	83.409	90.162	97.984	100.0
31/2/9- 11	285.09	10.2141	0.568	1.996	0.251	13.779	36.645	21.999	8.780	6.451	7.592	1.940	2.564	2.815	16.594	53.239	75.238	84.018	90.469	98.061	100.0
31/2/29-31	285.29	10.2194	0.502	2.124	0.248	13.182	35.922	22.529	9.342	6.490	7.507	2.154	2.626	2.874	16.056	51.978	74.507	83.849	90.339	97.846	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
31/2/48-50	285.48	10.2245	0.514	2.330	0.566	14.175	35.394	21.635	8.950	6.463	7.726	2.246	2.844	3.410	17.585	52.979	74.614	83.564	90.027	97.753	100.0
31/2/73-75	285.73	10.2311	0.658	2.456	0.376	16.015	36.177	20.147	8.376	6.185	7.452	2.159	3.114	3.490	19.505	55.682	75.829	84.205	90.390	97.842	100.0
31/2/88-90	285.88	10.2351	0.614	2.277	0.440	16.841	36.079	19.402	8.246	6.346	7.672	2.082	2.891	3.331	20.172	56.251	75.653	83.900	90.245	97.917	100.0
31/2/110-112	286.10	10.2409	0.662	2.424	0.500	15.202	35.402	20.656	8.924	6.353	7.640	2.236	3.086	3.586	18.788	54.190	74.846	83.770	90.123	97.763	100.0
31/2/134-136	286.34	10.2473	0.609	2.406	0.431	13.557	34.962	22.146	9.490	6.453	7.678	2.266	3.015	3.446	17.003	51.965	74.111	83.601	90.054	97.732	100.0
31/3/1- 3	286.51	10.2518	0.536	2.119	0.374	14.648	36.184	21.903	8.704	6.118	7.307	2.107	2.655	3.029	17.677	53.861	75.764	84.468	90.586	97.893	100.0
31/3/23-25	286.73	10.2576	0.849	2.273	0.688	13.791	34.578	22.050	9.035	6.419	7.957	2.361	3.122	3.810	17.601	52.179	74.229	83.264	89.683	97.640	100.0
31/3/38-40	286.88	10.2616	0.559	2.271	0.618	14.444	35.095	21.558	8.890	6.321	7.871	2.373	2.830	3.448	17.892	52.987	74.545	83.435	89.756	97.627	100.0
31/3/57-59	287.04	10.2658	0.579	2.048	0.575	14.653	34.980	21.569	8.691	6.401	8.085	2.418	2.627	3.202	17.855	52.835	74.404	83.095	89.496	97.581	100.0
31/3/82-84	287.32	10.2732	0.812	2.164	0.755	14.854	33.803	21.634	9.226	6.467	7.930	2.356	2.976	3.731	18.585	52.388	74.022	83.248	89.715	97.645	100.0
31/3/102-104	287.52	10.2785	0.477	1.924	0.497	13.688	34.521	22.405	9.581	6.621	7.912	2.374	2.401	2.898	16.586	51.107	73.512	83.093	89.714	97.626	100.0
31/3/117-119	287.67	10.2825	0.442	1.714	0.367	14.225	36.168	22.225	8.775	6.333	7.691	2.060	2.156	2.523	16.748	52.916	75.141	83.916	90.249	97.940	100.0
31/3/141-143	287.91	10.2889	0.480	1.871	0.355	16.507	36.333	20.421	8.490	6.156	7.409	1.977	2.351	2.706	19.213	55.546	75.967	84.457	90.613	98.022	100.0
31/4/8- 10	288.08	10.2934	0.442	1.703	0.531	17.041	35.828	20.394	8.614	6.191	7.353	1.903	2.145	2.676	19.717	55.545	75.939	84.553	90.744	98.097	100.0
31/4/30-32	288.30	10.2992	0.478	1.772	0.570	17.263	35.636	20.266	8.405	6.065	7.520	2.025	2.250	2.820	20.083	55.719	75.985	84.390	90.455	97.975	100.0
31/4/55-57	288.55	10.3058	0.731	1.886	0.553	17.004	34.178	20.100	9.250	6.362	7.640	2.295	2.617	3.170	20.175	54.353	74.453	83.703	90.065	97.705	100.0
31/4/70-72	288.70	10.3098	0.488	1.636	0.724	19.948	35.841	18.710	7.911	5.807	7.081	1.853	2.124	2.848	22.796	58.637	77.347	85.258	91.065	98.146	100.0
31/4/89-91	288.89	10.3148	0.388	1.398	0.622	19.394	36.013	18.815	8.204	6.123	7.351	1.691	1.786	2.408	21.802	57.815	76.630	84.834	90.957	98.308	100.0
31/4/110-112	289.10	10.3204	0.510	1.756	0.800	19.609	35.329	18.791	8.164	5.746	7.151	2.144	2.266	3.066	22.675	58.004	76.795	84.959	90.705	97.856	100.0
31/4/134-136	289.34	10.3267	0.487	1.455	0.714	19.524	35.084	18.751	8.685	6.146	7.393	1.760	1.942	2.656	22.180	57.264	76.015	84.700	90.846	98.239	100.0
31/5/0-2	289.50	10.3310	0.563	1.948	0.438	17.813	34.760	19.197	9.310	6.359	7.582	2.030	2.511	2.949	20.762	55.522	74.719	84.029	90.388	97.970	100.0
31/5/23-25	289.73	10.3371	0.458	1.703	0.326	15.949	35.559	20.467	8.915	6.480	8.024	2.119	2.161	2.487	18.436	53.995	74.462	83.377	89.857	97.881	100.0
31/5/43-45	289.93	10.3424	0.432	1.755	0.328	15.909	34.221	20.646	9.806	6.616	8.135	2.151	2.187	2.515	18.424	52.645	73.291	83.097	89.713	97.848	100.0
31/5/62-64	290.12	10.3474	0.506	1.977	0.564	16.571	33.999	20.191	9.564	6.327	7.903	2.398	2.483	3.047	19.618	53.617	73.808	83.372	89.699	97.602	100.0
31/5/83-85	290.33	10.3530	0.507	1.791	0.359	16.287	33.839	20.008	10.053	6.908	7.961	2.288	2.298	2.657	18.944	52.783	72.791	82.844	89.752	97.713	100.0
31/5/101-103	290.51	10.3577	0.450	1.741	0.555	16.012	34.947	20.594	8.898	6.356	8.045	2.402	2.191	2.746	18.758	53.705	74.299	83.197	89.553	97.598	100.0
31/5/120-122	290.70	10.3628	0.314	1.596	0.253	13.537	35.835	21.764	9.427	6.962	8.217	2.095	1.910	2.163	15.700	51.535	73.299	82.726	89.688	97.905	100.0
31 CC/0-2	290.74	10.3638	0.442	1.696	0.580	16.173	35.499	21.642	8.787	5.835	7.241	2.105	2.138	2.718	18.891	54.390	76.032	84.819	90.654	97.895	100.0
32/1/1- 3	293.11	10.4266	0.370	1.704	0.240	12.426	32.725	21.609	11.591	8.145	8.704	2.486	2.074	2.314	14.740	47.465	69.074	80.665	88.810	97.514	100.0
32/1/23-25	293.33	10.4325	0.406	1.439	0.986	17.727	34.831	20.335	8.294	6.220	7.762	2.001	1.845	2.831	20.558	55.389	75.724	84.018	90.238	98.000	100.0
32/1/41-43	293.51	10.4372	0.403	1.335	0.805	17.091	34.118	20.940	8.995	6.417	7.883	2.013	1.738	2.543	19.634	53.752	74.692	83.687	90.104	97.987	100.0
32/1/61-63	293.71	10.4425	0.474	1.433	1.043	18.047	33.310	20.049	9.057	6.232	7.949	2.407	1.907	2.950	20.997	54.307	74.356	83.413	89.645	97.594	100.0
32/1/83-85	293.93	10.4484	0.583	1.736	0.854	17.425	33.899	20.760	9.241	5.879	7.408	2.216	2.319	3.173	20.598	54.497	75.257	84.498	90.377	97.785	100.0
32/1/102-104	294.12	10.4534	0.507	1.582	0.649	16.744	34.614	21.125	8.745	6.007	7.790	2.237	2.089	2.738	19.482	54.096	75.221	83.967	89.973	97.763	100.0
32/1/121-123	294.31	10.4584	0.477	1.505	0.523	15.588	34.353	21.308	9.206	6.719	8.178	2.143	1.982	2.505	18.093	52.446	73.754	82.960	89.679	97.857	100.0
32/1/141-143	294.51	10.4637	0.410	1.548	0.515	14.048	33.792	22.641	9.911	6.718	8.256	2.160	1.958	2.473	16.521	50.313	72.954	82.865	89.583	97.839	100.0
32/2/11- 13	294.71	10.4690	0.408	1.432	0.426	15.301	35.461	22.493	8.888	6.017	7.610	1.964	1.840	2.266	17.567	53.028	75.521	84.409	90.426	98.036	100.0
32/2/30-32	294.90	10.4741	0.315	0.963	0.317	14.846	36.021	22.421	8.897	6.556	8.006	1.658	1.278	1.595	16.441	52.462	74.883	83.780	90.336	98.342	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
32/2/52-54	295.12	10.4799	0.348	1.289	0.234	13.131	34.799	22.956	10.030	6.929	8.169	2.116	1.637	1.871	15.002	49.801	72.757	82.787	89.716	97.885	100.0
32/2/73-75	295.33	10.4855	0.444	1.792	0.485	13.759	34.241	22.409	9.999	6.732	7.841	2.298	2.236	2.721	16.480	50.721	73.130	83.129	89.861	97.702	100.0
32/2/93-95	295.53	10.4908	0.430	1.505	0.352	14.706	34.794	21.529	9.709	6.866	8.009	2.099	1.935	2.287	16.993	51.787	73.316	83.025	89.891	97.900	100.0
32/2/113-115	295.73	10.4961	0.508	1.639	0.522	16.525	33.397	20.504	9.942	6.560	7.985	2.419	2.147	2.669	19.194	52.591	73.095	83.037	89.597	97.582	100.0
32/2/133-135	295.93	10.5014	0.527	2.083	0.346	14.356	35.722	21.720	9.118	6.190	7.654	2.284	2.610	2.956	17.312	53.034	74.754	83.872	90.062	97.716	100.0
32/3/1- 3	296.11	10.5061	0.401	1.277	0.187	15.699	37.519	20.926	8.277	6.513	7.520	1.680	1.678	1.865	17.564	55.083	76.009	84.286	90.799	98.319	100.0
32/3/40-42	296.50	10.5165	0.609	2.421	0.513	14.994	34.788	21.275	9.166	6.209	7.710	2.316	3.030	3.543	18.537	53.325	74.600	83.766	89.975	97.685	100.0
32/3/62-64	296.72	10.5223	0.478	1.950	0.335	12.930	33.921	23.041	10.032	6.619	8.223	2.470	2.428	2.763	15.693	49.614	72.655	82.687	89.306	97.529	100.0
32/3/83-85	296.93	10.5279	0.542	2.169	0.538	12.937	33.882	22.654	10.316	6.814	7.833	2.316	2.711	3.249	16.186	50.068	72.722	83.038	89.852	97.685	100.0
32/3/102-104	297.12	10.5329	0.612	2.126	0.448	15.996	36.377	20.014	8.439	6.212	7.588	2.187	2.738	3.186	19.182	55.559	75.574	84.013	90.225	97.813	100.0
32/3/123-125	297.33	10.5385	0.807	2.299	0.905	17.076	35.694	19.143	8.231	6.192	7.472	2.181	3.106	4.011	21.087	56.781	75.924	84.155	90.347	97.819	100.0
32/3/140-142	297.50	10.5430	0.605	2.213	0.667	15.694	35.192	20.008	8.803	6.431	7.973	2.413	2.818	3.485	19.179	54.371	74.379	83.182	89.613	97.586	100.0
32/4/10- 12	297.70	10.5483	0.435	1.699	0.465	16.269	37.626	20.205	7.994	6.175	7.286	1.847	2.134	2.599	18.868	56.494	76.699	84.693	90.868	98.154	100.0
32/4/30-32	297.90	10.5536	0.518	1.962	0.596	15.798	36.763	20.629	8.296	6.089	7.271	2.076	2.480	3.076	18.874	55.637	76.266	84.562	90.651	97.922	100.0
32/4/48-50	298.08	10.5583	0.441	1.721	0.492	15.164	35.541	20.576	9.325	6.869	7.826	2.046	2.162	2.654	17.818	53.359	73.935	83.260	90.129	97.955	100.0
32/4/68-70	298.28	10.5636	0.535	2.378	0.987	16.731	35.275	19.396	8.280	6.325	7.795	2.298	2.913	3.900	20.631	55.906	75.302	83.582	89.907	97.702	100.0
32/4/92-94	298.52	10.5700	0.700	1.936	0.867	17.462	35.240	19.169	8.591	6.236	7.533	2.267	2.636	3.503	20.965	56.205	75.374	83.965	90.201	97.734	100.0
32/4/110-112	298.70	10.5748	0.729	2.308	0.707	16.775	34.667	19.753	9.193	6.164	7.424	2.280	3.037	3.744	20.519	55.186	74.939	84.132	90.296	97.720	100.0
32/4/133-135	298.93	10.5809	0.477	1.837	0.922	16.555	33.924	20.292	9.343	6.370	7.874	2.406	2.314	3.236	19.791	53.715	74.007	83.350	89.720	97.594	100.0
32/5/1- 3	299.11	10.5856	0.578	1.938	0.630	16.729	34.595	20.106	8.978	6.302	7.799	2.345	2.516	3.146	19.875	54.470	74.576	83.554	89.856	97.655	100.0
32/5/28-30	299.38	10.5928	0.521	1.828	0.670	17.017	35.779	20.203	8.144	6.026	7.795	2.017	2.349	3.019	20.036	55.815	76.018	84.162	90.188	97.983	100.0
32/5/40-42	299.50	10.5960	0.702	2.127	0.595	14.639	33.321	21.296	9.513	6.777	8.515	2.514	2.830	3.425	18.064	51.385	72.681	82.194	88.971	97.486	100.0
32 CC/2- 4	299.67	10.6005	0.351	1.586	0.374	13.886	33.523	21.502	10.370	7.568	8.586	2.257	1.937	2.311	16.197	49.720	71.222	81.592	89.160	97.746	100.0
33/1/1- 3	302.71	10.6810	0.442	1.678	0.328	13.053	32.730	22.022	11.081	7.706	8.485	2.473	2.120	2.448	15.501	48.231	70.253	81.334	89.040	97.525	100.0
33/1/27-29	302.97	10.6879	0.428	1.785	0.532	15.816	35.840	20.788	8.822	6.043	7.627	2.319	2.213	2.745	18.561	54.401	75.189	84.011	90.054	97.681	100.0
33/1/40-42	303.10	10.6914	0.551	1.585	0.333	15.661	35.492	20.646	9.253	6.369	7.740	2.371	2.136	2.469	18.130	53.622	74.268	83.521	89.890	97.630	100.0
33/1/59-61	303.29	10.6964	0.409	1.623	0.498	15.945	35.858	20.508	8.864	6.327	7.850	2.118	2.032	2.530	18.475	54.333	74.841	83.705	90.032	97.882	100.0
33/1/83-85	303.53	10.7028	0.488	1.796	0.334	15.164	35.800	20.958	8.994	6.396	7.928	2.143	2.284	2.618	17.782	53.582	74.540	83.534	89.930	97.858	100.0
33/1/107-109	303.77	10.7091	0.413	1.434	0.128	14.695	35.893	21.379	9.383	6.692	8.053	1.930	1.847	1.975	16.670	52.563	73.942	83.325	90.017	98.070	100.0
33/1/121-123	303.91	10.7128	0.548	1.841	0.164	14.817	35.060	21.086	9.687	6.777	7.910	2.111	2.389	2.553	17.370	52.430	73.516	83.203	89.980	97.890	100.0
33/1/143-145	304.13	10.7187	0.565	1.754	0.491	16.375	36.015	20.201	8.411	6.266	7.670	2.253	2.319	2.810	19.185	55.200	75.401	83.812	90.078	97.748	100.0
33/2/9- 11	304.29	10.7229	0.401	1.689	0.183	14.280	35.773	21.810	9.597	6.611	7.653	2.002	2.090	2.273	16.553	52.326	74.136	83.733	90.344	97.997	100.0
33/2/27-29	304.47	10.7277	0.436	1.688	0.343	15.300	36.174	21.139	8.586	6.417	7.830	2.086	2.124	2.467	17.767	53.941	75.080	83.666	90.083	97.913	100.0
33/2/46-48	304.66	10.7327	0.504	1.955	0.659	15.353	35.208	21.330	8.959	6.168	7.612	2.251	2.459	3.118	18.471	53.679	75.009	83.968	90.136	97.748	100.0
33/2/82-84	305.02	10.7422	0.481	1.820	0.411	14.759	34.192	21.493	9.806	6.765	8.105	2.169	2.301	2.712	17.471	51.663	73.156	82.962	89.727	97.832	100.0
33/2/95-97	305.15	10.7457	0.677	1.985	0.532	14.272	33.243	21.954	9.977	6.732	8.174	2.453	2.662	3.194	17.466	50.709	72.663	82.640	89.372	97.546	100.0
33/2/114-116	305.34	10.7507	0.707	2.159	0.968	14.964	33.467	21.626	9.266	6.384	8.049	2.410	2.866	3.834	18.798	52.265	73.891	83.157	89.541	97.590	100.0
33/2/135-137	305.55	10.7563	0.513	2.033	0.378	14.079	34.091	22.093	9.890	6.678	7.930	2.315	2.546	2.924	17.003	51.094	73.187	83.077	89.755	97.685	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
33/3/1- 3	305.71	10.7605	0.423	1.450	0.329	16.741	35.695	20.503	8.950	6.256	7.784	1.869	1.873	2.202	18.943	54.638	75.141	84.091	90.347	98.131	100.0
33/3/23-25	305.93	10.7664	0.620	1.960	0.684	15.116	33.472	21.233	9.745	6.704	8.049	2.416	2.580	3.264	18.380	51.852	73.085	82.830	89.534	97.583	100.0
33/3/41-43	306.11	10.7711	0.630	2.216	0.541	14.166	34.570	22.045	9.357	6.345	7.804	2.326	2.846	3.387	17.553	52.123	74.168	83.525	89.870	97.674	100.0
33/3/57-59	306.27	10.7754	0.461	1.694	0.175	13.984	35.947	22.110	9.237	6.478	7.846	2.069	2.155	2.330	16.314	52.261	74.371	83.608	90.086	97.932	100.0
33/3/84-86	306.54	10.7825	0.511	1.819	0.518	14.551	34.727	21.724	9.631	6.578	7.849	2.091	2.330	2.848	17.399	52.126	73.850	83.481	90.059	97.908	100.0
33/3/105-107	306.75	10.7881	0.306	1.363	0.215	15.034	34.826	21.481	9.999	6.771	8.083	1.923	1.669	1.884	16.918	51.744	73.225	83.224	89.995	98.078	100.0
33/3/116-118	306.86	10.7910	0.498	1.765	0.458	15.946	35.585	21.088	9.068	6.073	7.513	2.007	2.263	2.721	18.667	54.252	75.340	84.408	90.481	97.994	100.0
33/3/138-140	307.08	10.7968	0.766	2.070	0.554	14.575	34.752	21.730	9.194	6.303	7.771	2.287	2.836	3.390	17.965	52.717	74.447	83.641	89.944	97.715	100.0
33/4/10- 12	307.30	10.8027	0.405	1.602	0.218	15.333	35.221	20.790	9.617	6.677	8.007	2.130	2.007	2.225	17.558	52.779	73.569	83.186	89.863	97.870	100.0
33/4/29-31	307.49	10.8077	0.543	2.144	0.397	15.936	35.293	20.626	9.112	6.139	7.568	2.243	2.687	3.084	19.020	54.313	74.939	84.051	90.190	97.758	100.0
33/4/50-52	307.70	10.8133	0.563	2.209	0.407	15.729	35.461	20.882	9.031	6.123	7.423	2.171	2.772	3.179	18.908	54.369	75.251	84.282	90.405	97.828	100.0
33/4/73-75	307.93	10.8193	0.518	1.910	0.202	14.752	36.077	21.445	9.429	6.245	7.475	1.947	2.428	2.630	17.382	53.459	74.904	84.333	90.578	98.053	100.0
33/4/94-96	308.14	10.8249	0.397	1.711	0.334	14.508	36.098	21.664	9.262	6.425	7.646	1.955	2.108	2.442	16.950	53.048	74.712	83.974	90.399	98.045	100.0
33/4/110-112	308.30	10.8292	0.478	1.773	0.254	14.008	36.966	22.402	8.796	6.123	7.321	1.880	2.251	2.505	16.513	53.479	75.881	84.677	90.800	98.121	100.0
33/4/133/135	308.53	10.8352	0.455	1.731	0.184	13.971	35.564	21.810	9.910	6.689	7.673	2.013	2.186	2.370	16.341	51.905	73.715	83.625	90.314	97.987	100.0
33/5/1- 3	308.71	10.8400	0.501	1.882	0.289	15.827	34.614	20.611	10.004	6.585	7.496	2.192	2.383	2.672	18.499	53.113	73.724	83.728	90.313	97.809	100.0
33/5/29-31	308.99	10.8474	0.496	1.999	0.445	16.481	35.263	20.184	9.257	6.321	7.382	2.170	2.495	2.940	19.421	54.684	74.868	84.125	90.446	97.828	100.0
33/5/41-43	309.11	10.8516	0.451	1.655	0.140	14.539	35.365	21.377	9.954	6.644	7.781	2.094	2.106	2.246	16.785	52.150	73.527	83.481	90.125	97.906	100.0
33/5/58-60	309.28	10.8543	0.422	1.568	0.140	14.878	35.025	21.066	10.211	6.718	7.867	2.105	1.990	2.130	17.008	52.033	73.099	83.310	90.028	97.895	100.0
33/5/84-86	309.54	10.8583	0.473	1.679	0.183	14.247	34.460	21.434	10.414	6.955	7.996	2.156	2.153	2.336	16.583	51.043	72.477	82.892	89.847	97.843	100.0
33/5/104-106	309.74	10.8615	0.549	2.092	0.266	15.091	36.506	21.036	9.306	6.144	7.002	2.008	2.641	2.907	17.998	54.504	75.540	84.846	90.990	97.992	100.0
34/1/1- 3	312.31	10.9018	0.430	1.591	0.098	14.138	34.548	21.334	10.872	7.192	7.795	2.002	2.021	2.119	16.257	50.805	72.139	83.011	90.203	97.998	100.0
34/1/24-26	312.54	10.9054	0.401	1.568	0.579	18.525	35.998	19.629	8.454	5.769	7.191	1.886	1.969	2.548	21.073	57.071	76.700	85.154	90.923	98.114	100.0
34/1/37-39	312.67	10.9075	0.527	1.723	0.549	18.604	36.091	19.621	8.404	5.657	6.991	1.832	2.250	2.799	21.403	57.494	77.115	85.519	91.176	98.167	100.0
34/1/57-59	312.87	10.9106	0.480	1.530	0.371	18.297	36.566	19.509	8.852	5.888	6.902	1.605	2.010	2.381	20.678	57.244	76.753	85.605	91.493	98.395	100.0
34/1/77-79	313.07	10.9138	0.614	2.059	0.330	18.329	35.881	19.576	8.905	5.675	6.820	1.812	2.673	3.003	21.332	57.213	76.789	85.694	91.369	98.189	100.0
34/1/101-103	313.31	10.9175	0.451	1.532	0.480	19.625	35.055	18.686	9.159	5.996	7.116	1.901	1.983	2.463	22.088	57.143	75.829	84.988	90.984	98.100	100.0
34/1/123-125	313.53	10.9210	0.578	1.905	1.072	21.924	35.268	17.378	8.297	5.369	6.325	1.885	2.483	3.555	25.479	60.747	78.125	86.422	91.791	98.116	100.0
34/1/141-143	313.71	10.9238	0.473	1.578	0.326	18.456	35.661	19.122	9.439	6.159	6.941	1.845	2.051	2.377	20.833	56.494	75.616	85.055	91.214	98.155	100.0
34/2/10- 12	313.90	10.9268	0.434	1.506	0.426	18.066	35.420	19.596	9.554	6.213	6.964	1.820	1.940	2.366	20.432	55.852	75.448	85.002	91.215	98.179	100.0
34/2/29-31	314.09	10.9298	0.575	1.954	0.370	17.488	35.471	19.798	9.390	6.045	6.893	2.017	2.529	2.899	20.387	55.858	75.656	85.046	91.091	97.984	100.0
34/2/49-51	314.29	10.9329	0.522	1.901	0.767	18.133	35.198	19.785	8.877	5.874	6.905	2.039	2.423	3.190	21.323	56.521	76.306	85.183	91.057	97.962	100.0
34/2/65-67	314.45	10.9354	0.845	2.145	0.830	18.633	33.727	19.047	9.479	6.084	7.088	2.121	2.990	3.820	22.453	56.180	75.227	84.706	90.790	97.878	100.0
34/2/89-91	314.69	10.9392	0.431	1.533	0.438	17.819	35.972	19.543	9.271	6.111	7.038	1.844	1.964	2.402	20.221	56.193	75.736	85.007	91.118	98.156	100.0
34/2/110-112	314.90	10.9425	0.373	1.428	0.310	17.614	37.020	19.535	9.062	5.966	6.872	1.821	1.801	2.111	19.725	56.745	76.280	85.342	91.308	98.180	100.0
34/2/133-135	315.13	10.9461	0.413	1.654	0.160	15.694	35.919	20.183	9.812	6.588	7.554	2.023	2.067	2.227	17.921	53.840	74.023	83.835	90.423	97.977	100.0
34/3/0- 2	315.30	10.9496	0.477	1.839	0.186	16.167	35.526	20.148	9.642	6.498	7.526	1.990	2.316	2.502	18.669	54.195	74.343	83.985	90.483	98.009	100.0
34/3/22-24	315.52	10.9569	0.666	2.324	0.447	14.905	35.767	20.898	9.469	6.287	7.151	2.087	2.990	3.437	18.342	54.109	75.007	84.476	90.763	97.914	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
34/3/41-43	315.71	10.9631	0.328	1.494	0.192	15.339	36.360	20.556	9.625	6.719	7.431	1.955	1.822	2.014	17.353	53.713	74.269	83.894	90.613	98.044	100.0
34/3/76-78	316.06	10.9746	0.635	2.185	0.400	15.918	36.852	20.293	8.740	5.945	6.980	2.053	2.820	3.220	19.138	55.990	76.283	85.023	90.968	97.948	100.0
34/3/97-99	316.27	10.9815	0.391	1.786	0.198	14.639	36.639	20.717	9.740	6.724	7.304	1.862	2.177	2.375	17.014	53.653	74.370	84.110	90.834	98.138	100.0
34/3/118-120	316.48	10.9884	0.291	1.350	0.091	14.298	36.630	20.991	10.260	6.973	7.387	1.727	1.642	1.733	16.031	52.661	73.653	83.913	90.886	98.273	100.0
34/3/137-139	316.67	10.9947	0.202	1.227	0.033	13.209	36.578	21.342	10.772	7.406	7.528	1.704	1.429	1.462	14.671	51.249	72.591	83.363	90.769	98.297	100.0
34/4/8- 10	316.88	11.0016	0.233	1.150	0.144	16.967	38.230	19.815	9.183	6.207	6.678	1.394	1.383	1.527	18.494	56.724	76.539	85.722	91.929	98.607	100.0
34/4/30-32	317.10	11.0088	0.411	1.630	0.197	16.539	37.683	20.276	8.793	5.877	6.798	1.796	2.041	2.238	18.777	56.460	76.736	85.529	91.406	98.204	100.0
34/4/50-52	317.30	11.0154	0.462	1.706	0.288	15.526	35.696	20.587	9.580	6.748	7.503	1.903	2.168	2.456	17.982	53.678	74.265	83.845	90.593	98.096	100.0
34/4/70-72	317.50	11.0220	0.595	2.167	0.383	16.017	36.850	20.305	9.062	5.942	6.687	1.993	2.762	3.145	19.162	56.012	76.317	85.379	91.321	98.008	100.0
34/4/88-90	317.68	11.0279	0.423	1.588	0.162	16.214	36.231	19.990	9.853	6.525	7.154	1.859	2.011	2.173	18.387	54.618	74.608	84.461	90.986	98.140	100.0
34/4/110-112	317.90	11.0351	0.441	1.836	0.298	15.266	36.392	20.598	9.681	6.435	6.998	2.054	2.277	2.575	17.841	54.233	74.831	84.512	90.947	97.945	100.0
34/4/133-135	318.13	11.0427	0.283	1.361	0.046	13.254	36.139	21.202	10.857	7.248	7.794	1.817	1.644	1.690	14.944	51.083	72.285	83.142	90.390	98.184	100.0
34/5/5- 7	318.35	11.0499	0.373	1.658	0.087	14.837	38.279	20.752	9.407	6.002	6.936	1.669	2.031	2.118	16.955	55.234	75.986	85.393	91.395	98.331	100.0
34/5/30-32	318.60	11.0582	0.758	1.790	0.091	15.163	36.827	20.014	9.385	6.305	7.616	2.049	2.548	2.639	17.802	54.629	74.643	84.028	90.333	97.949	100.0
35/1/1- 3	321.91	11.1670	0.210	1.354	0.057	12.853	35.330	21.004	11.687	7.897	7.838	1.770	1.564	1.621	14.474	49.804	70.808	82.495	90.392	98.230	100.0
35/1/23-25	322.13	11.1742	0.433	1.739	0.272	17.330	38.749	19.311	8.171	5.632	6.629	1.735	2.172	2.444	19.774	58.523	77.834	86.005	91.637	98.266	100.0
35/1/43-45	322.33	11.1808	0.236	1.292	0.133	16.660	39.166	19.688	8.579	5.996	6.803	1.447	1.528	1.661	18.321	57.487	77.175	85.754	91.750	98.553	100.0
35/1/64-66	322.54	11.1877	0.319	1.680	0.296	16.448	38.466	19.639	8.370	6.048	6.979	1.754	1.999	2.295	18.743	57.209	76.848	85.219	91.267	98.246	100.0
35/1/82-84	322.72	11.1936	0.389	1.657	0.265	16.292	37.707	19.670	8.591	6.176	7.297	1.958	2.046	2.311	18.603	56.310	75.980	84.571	90.747	98.044	100.0
35/1/100-102	322.90	11.1996	0.463	1.886	0.271	15.618	37.658	20.410	8.682	5.866	7.170	1.976	2.349	2.620	18.238	55.896	76.306	84.988	90.854	98.024	100.0
35/1/119-121	323.09	11.2058	0.388	1.735	0.182	15.015	37.570	20.733	9.122	6.112	7.218	1.925	2.123	2.305	17.320	54.890	75.623	84.745	90.857	98.075	100.0
35/1/141-143	323.31	11.2130	0.323	1.600	0.102	15.949	39.010	19.794	8.607	6.074	6.928	1.615	1.923	2.025	17.974	56.984	76.778	85.385	91.459	98.387	100.0
35/2/8- 10	323.48	11.2186	0.381	1.569	0.113	15.446	35.793	19.982	10.171	6.707	7.736	2.101	1.950	2.063	17.509	53.302	73.284	83.455	90.162	97.898	100.0
35/2/32-34	323.72	11.2265	0.588	2.073	0.197	15.995	35.430	20.047	9.813	6.223	7.413	2.220	2.661	2.858	18.853	54.283	74.330	84.143	90.366	97.779	100.0
35/2/51-53	323.91	11.2328	0.453	1.517	0.320	16.876	35.265	19.840	9.379	6.367	7.823	2.160	1.970	2.290	19.166	54.431	74.271	83.650	90.017	97.840	100.0
35/2/90-92	324.30	11.2456	0.413	1.641	0.145	16.250	37.134	19.500	9.064	6.469	7.567	1.817	2.054	2.199	18.449	55.583	75.083	84.147	90.616	98.183	100.0
35/2/110-112	324.50	11.2522	0.386	1.466	0.148	17.097	37.821	19.439	8.847	6.132	7.013	1.651	1.852	2.000	19.097	56.918	76.357	85.204	91.336	98.349	100.0
35/2/130-132	324.70	11.2587	0.491	1.789	0.184	15.400	36.413	20.434	9.383	6.423	7.522	1.961	2.280	2.464	17.864	54.277	74.711	84.094	90.517	98.039	100.0
35/3/1- 3	324.91	11.2657	0.323	1.615	0.151	15.301	37.359	20.687	9.207	6.301	7.333	1.722	1.938	2.089	17.390	54.749	75.436	84.643	90.944	98.277	100.0
35/3/22-24	325.12	11.2726	0.346	1.413	0.146	15.871	38.084	20.491	8.633	5.997	7.286	1.733	1.759	1.905	17.776	55.860	76.351	84.984	90.981	98.267	100.0
35/3/43-45	325.33	11.2795	0.231	1.151	0.084	14.858	37.027	20.756	9.868	6.722	7.724	1.580	1.382	1.466	16.324	53.351	74.107	83.975	90.696	98.421	100.0
35/3/67-69	325.57	11.2874	0.269	1.118	0.062	14.182	37.346	21.398	9.883	6.637	7.641	1.465	1.387	1.449	15.631	52.977	74.375	84.258	90.895	98.536	100.0
35/3/81-83	325.71	11.2920	0.223	1.177	0.099	14.389	36.691	21.459	9.767	6.538	7.798	1.860	1.400	1.499	15.888	52.579	74.038	83.805	90.343	98.141	100.0
35/3/104-106	325.94	11.2995	0.210	1.030	0.088	15.300	38.083	20.940	9.208	6.220	7.474	1.446	1.240	1.328	16.628	54.711	75.651	84.859	91.079	98.553	100.0
35/3/117-119	326.07	11.3038	0.141	1.099	0.086	14.636	36.491	21.322	10.186	6.522	7.798	1.720	1.240	1.326	15.962	52.453	73.775	83.961	90.483	98.281	100.0
35/3/138-140	326.28	11.3107	0.382	1.548	0.238	17.509	37.920	19.459	8.254	5.880	7.120	1.690	1.930	2.168	19.677	57.597	77.056	85.310	91.190	98.310	100.0
35/4/10- 12	326.50	11.3179	0.249	1.119	0.127	16.386	37.001	19.986	9.372	6.491	7.656	1.613	1.368	1.495	17.881	54.882	74.868	84.240	90.731	98.387	100.0
35/4/30-32	326.70	11.3245	0.358	1.233	0.135	16.349	36.160	20.250	9.703	6.595	7.589	1.627	1.591	1.726	18.075	54.235	74.485	84.188	90.783	98.372	100.0

Hole 593 Sampl;e No.	Depth (mbsf)	Age (Ma)	<4	'4-5	'5-6	'6-7	'7-8	'8-9	'9-10	'10-11	'11-12	>12	up to 4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
35/4/48-50	326.88	11.3304	0.338	1.245	0.162	16.667	36.379	19.939	9.098	6.551	7.759	1.863	1.583	1.745	18.412	54.791	74.730	83.828	90.379	98.138	100.0
35/4/69-71	327.09	11.3373	0.153	1.116	0.141	16.926	37.292	19.909	9.002	6.433	7.521	1.506	1.269	1.410	18.336	55.628	75.537	84.539	90.972	98.493	100.0
35/4/88-90	327.28	11.3436	0.210	1.140	0.162	16.453	37.510	20.613	8.593	6.371	7.434	1.514	1.350	1.512	17.965	55.475	76.088	84.681	91.052	98.486	100.0
35/4/110-112	327.50	11.3508	0.304	1.220	0.241	15.910	35.544	21.049	9.600	6.586	7.727	1.817	1.524	1.765	17.675	53.220	74.269	83.869	90.456	98.183	100.0
35/4/134-136	327.74	11.3587	0.402	1.626	0.298	14.742	36.012	21.682	9.451	6.292	7.513	1.982	2.028	2.326	17.068	53.080	74.762	84.213	90.505	98.018	100.0
35/5/1- 3	327.91	11.3643	0.526	2.130	0.247	12.979	35.119	22.298	9.831	6.882	7.908	2.080	2.656	2.903	15.882	51.001	73.299	83.130	90.012	97.920	100.0
35/5/16-18	328.06	11.3692	0.350	1.674	0.202	12.206	35.382	22.950	9.779	7.039	8.262	2.156	2.024	2.226	14.432	49.814	72.764	82.543	89.582	97.844	100.0
35/5/37-39	328.27	11.3761	0.402	1.692	0.193	11.726	35.190	23.474	10.089	6.864	8.216	2.152	2.094	2.287	14.013	49.203	72.677	82.766	89.630	97.846	100.0
35/5/57-59	328.47	11.3827	0.110	0.966	0.197	12.593	34.930	22.685	10.457	7.416	8.586	2.060	1.076	1.273	13.866	48.796	71.481	81.938	89.354	97.940	100.0
35/5/82-84	328.72	11.3909	0.000	0.000	0.000	11.522	39.354	23.495	8.996	6.164	7.885	2.585	0.000	0.000	11.522	50.876	74.371	83.367	89.531	97.416	100.0

Appendix B Table 11: Hole 593 sediment texture data at quarter phi intervals between 3 and 7.75 phi (120-329 mbsf). (File on CD: App B Table11 up to 7.75 phi)

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
14/1/0 avg	120.3	5.1273	0	0.14	0.45	0.92	1.56	2.28	2.97	3.52	3.89	4.13	4.39	4.97	6.22	8.47	11.95	16.68	22.49	29.08	36.11	43.12	49.7	55.77
14/1/21 avg	120.51	5.1326	0	0.12	0.39	0.8	1.35	1.98	2.6	3.1	3.43	3.65	3.9	4.48	5.72	7.95	11.37	16.01	21.69	28.1	34.92	41.73	48.13	54.06
14/1/39	120.69	5.1372	0	0.01	0.24	0.71	1.4	2.23	3.05	3.73	4.21	4.53	4.87	5.5	6.75	8.93	12.24	16.74	22.31	28.69	35.59	42.54	49.08	55.12
14/1/60	120.9	5.1425	0	0	0.29	0.77	1.47	2.31	3.14	3.83	4.31	4.61	4.88	5.39	6.48	8.51	11.75	16.33	22.21	29.16	36.82	44.57	51.73	58.18
14/1/81	121.11	5.1479	0	0	0.14	0.54	1.18	2.03	2.92	3.7	4.25	4.58	4.85	5.36	6.52	8.73	12.3	17.32	23.66	30.98	38.72	46.12	53.05	59.25
14/1/96	121.26	5.1517	0	0	0.02	0.28	0.75	1.42	2.23	2.98	3.52	3.82	4.02	4.44	5.5	7.64	11.16	16.14	22.44	29.7	37.38	44.77	51.74	58.03
14/1/119	121.49	5.1576	0	0.07	0.34	0.81	1.48	2.23	2.95	3.51	3.86	4.04	4.23	4.73	5.91	8.14	11.67	16.57	22.69	29.69	37.18	44.63	51.52	57.77
14/1/139	121.69	5.1626	0	0	0.07	0.25	0.61	1.16	1.87	2.64	3.39	4.08	4.64	5.58	7.22	9.88	13.75	18.81	24.86	31.56	38.49	45.16	51.48	57.27
14/2/10	121.9	5.168	0	0	0.15	0.52	1.09	1.82	2.6	3.31	3.85	4.22	4.56	5.15	6.36	8.55	11.98	16.69	22.52	29.14	36.2	43.25	49.86	55.95
14/2/29	122.09	5.1728	0	0	0.23	0.66	1.27	2.03	2.8	3.45	3.9	4.18	4.44	4.96	6.09	8.17	11.45	15.98	21.62	28.07	34.99	41.92	48.42	54.42
14/2/46	122.26	5.1771	0	0	0.02	0.46	1.23	2.22	3.17	3.9	4.33	4.54	4.75	5.27	6.46	8.64	12.04	16.73	22.59	29.34	36.53	43.54	50.24	56.38
14/2/71	122.51	5.1835	0	0	0.01	0.33	0.98	1.92	2.96	3.9	4.6	5.05	5.41	5.98	7.13	9.21	12.46	16.92	22.48	28.89	35.79	42.63	49.3	55.54
14/2/91	122.71	5.1886	0	0	0	0.03	0.37	0.98	1.81	2.69	3.47	4.09	4.64	5.37	6.62	8.72	11.91	16.29	21.77	28.15	35.05	41.91	48.6	54.86
14/2/112	122.92	5.1939	0	0	0	0.01	0.11	0.29	0.52	0.72	0.83	0.87	0.97	1.38	2.43	4.45	7.68	12.19	17.88	24.5	31.76	39.18	46.25	52.85
14/2/130	123.1	5.1979	0	0	0.01	0.11	0.48	1.19	2.18	3.23	4.11	4.73	5.23	5.78	6.97	9.13	12.5	17.13	22.92	29.6	36.76	43.78	50.54	56.77
14/3/0	123.3	5.2009	0	0	0	0.08	0.32	0.81	1.47	2.16	2.71	3.06	3.36	3.78	4.78	6.65	9.62	13.78	19.09	25.4	32.49	39.89	47.02	53.72
14/3/23	123.53	5.2044	0	0	0.02	0.5	1.37	2.54	3.74	4.73	5.38	5.74	6.02	6.55	7.69	9.74	12.91	17.27	22.75	29.19	36.25	43.34	50.29	56.79
14/3/39	123.69	5.2069	0	0	0.01	0.34	0.93	1.71	2.48	3.06	3.35	3.4	3.41	3.62	4.4	6.09	8.94	13.09	18.52	25.07	32.47	40.17	47.51	54.34
14/3/58	123.88	5.2098	0	0	0.27	0.86	1.75	2.8	3.8	4.59	5.1	5.39	5.62	6.06	7.04	8.88	11.84	16.04	21.46	27.92	35.14	42.56	49.56	56.01
14/3/81	124.11	5.2132	0	0	0.21	0.75	1.56	2.51	3.4	4.12	4.64	5.03	5.46	6.17	7.41	9.44	12.45	16.54	21.69	27.76	34.54	41.55	48.23	54.45
14/3/100	124.3	5.2161	0	0.18	0.55	1.11	1.84	2.63	3.38	4.06	4.66	5.24	5.92	6.91	8.47	10.87	14.31	18.85	24.42	30.81	37.66	44.41	50.94	56.99
14/3/120	124.5	5.2192	1.21	1.21	1.36	1.86	2.67	3.63	4.55	5.28	5.74	6	6.27	6.87	8.14	10.39	13.79	18.38	24.04	30.54	37.48	44.28	50.82	56.86
14/3/138	124.68	5.2219	0	0	0.01	0.34	0.9	1.65	2.39	2.99	3.42	3.77	4.21	4.99	6.4	8.73	12.17	16.79	22.5	29.09	36.16	43.14	49.89	56.16
14/4/10	124.9	5.2252	0	0	0.09	0.36	0.82	1.42	2.04	2.56	2.93	3.23	3.53	4.18	5.43	7.52	10.65	14.91	20.28	26.61	33.69	41.03	48.04	54.57
14/4/30	125.1	5.2283	0	0	0.17	0.67	1.47	2.53	3.6	4.49	5.11	5.54	6.01	6.81	8.26	10.58	13.89	18.18	23.37	29.33	35.84	42.48	49.12	55.48
14/4/50	125.3	5.2313	0	0	0.01	0.32	0.98	1.94	3	3.94	4.64	5.1	5.48	6.01	6.98	8.64	11.2	14.78	19.43	25.12	31.75	38.95	46.14	53.12
14/4/68	125.48	5.234	0	0	0.01	0.12	0.42	0.97	1.79	2.73	3.61	4.34	4.93	5.41	6.28	7.76	10.08	13.4	17.81	23.32	29.85	37.24	44.82	51.97
14/4/91	125.71	5.2375	0	0	0.07	0.24	0.58	1.09	1.7	2.29	2.75	3.04	3.26	3.55	4.26	5.65	7.99	11.45	16.13	22	28.93	36.69	44.57	51.93
14/4/111	125.91	5.2406	0	0	0.02	0.25	0.66	1.25	1.97	2.7	3.34	3.85	4.29	4.82	5.69	7.21	9.66	13.27	18.15	24.27	31.49	39.28	46.9	54.13
14/4/130	126.1	5.2435	0	0	0.06	0.32	0.75	1.34	1.99	2.59	3.07	3.43	3.74	4.18	4.99	6.42	8.71	12.03	16.49	22.1	28.76	36.3	44.02	51.29
14/5/0	126.3	5.2465	0	0	0.02	0.27	0.76	1.42	2.13	2.75	3.21	3.55	3.92	4.53	5.66	7.57	10.5	14.57	19.82	26.13	33.31	40.85	48.12	54.93
14/5/26	126.56	5.2504	0	0	0.02	0.28	0.76	1.44	2.31	3.29	4.31	5.33	6.39	7.61	9.22	11.49	14.67	18.91	24.22	30.49	37.41	44.4	51.3	57.77
14/5/40	126.7	5.2526	0	0	0.05	0.16	0.36	0.66	1.06	1.48	1.82	2.03	2.23	2.6	3.55	5.45	8.61	13.18	19.12	26.17	33.98	41.93	49.35	56.1

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
14/5/60	126.9	5.2556	0	0.3	0.9	1.8	2.96	4.18	5.26	6.07	6.57	6.86	7.15	7.75	9.01	11.22	14.57	19.11	24.73	31.21	38.19	45.1	51.81	58.06
14/5/82	127.12	5.2589	0	0	0.01	0.1	0.35	0.82	1.52	2.29	2.94	3.39	3.77	4.25	5.33	7.32	10.47	14.85	20.38	26.82	33.86	41.02	47.78	54.04
14/5/100	127.3	5.2617	0	0	0.13	0.55	1.24	2.18	3.2	4.17	5.01	5.71	6.37	7.22	8.56	10.72	13.96	18.37	23.89	30.3	37.19	43.99	50.58	56.71
14/5/121	127.51	5.2649	0	0.01	0.21	0.62	1.2	1.84	2.42	2.86	3.18	3.48	3.94	4.78	6.27	8.67	12.19	16.9	22.73	29.42	36.65	43.91	50.71	56.95
14/5/140	127.7	5.2678	0	0	0.01	0.34	0.99	1.92	2.92	3.77	4.33	4.62	4.83	5.29	6.44	8.68	12.31	17.38	23.72	30.95	38.5	45.68	52.41	58.47
14/6/10	127.9	5.2708	0	0	0.01	0.2	0.72	1.47	2.28	2.96	3.42	3.7	3.99	4.59	5.85	8.1	11.57	16.32	22.22	28.98	36.23	43.45	50.15	56.25
14/6/30	128.1	5.2738	0	0	0.22	0.74	1.52	2.41	3.21	3.77	4.07	4.21	4.44	5.11	6.59	9.19	13.1	18.31	24.62	31.67	39	46.04	52.7	58.78
14/6/49	128.29	5.2767	0	0	0.01	0.2	0.73	1.49	2.31	3.01	3.49	3.79	4.1	4.75	6.11	8.52	12.2	17.18	23.29	30.21	37.48	44.54	51.28	57.48
14/6/69	128.49	5.2798	0	0	0	0.05	0.64	1.6	2.75	3.81	4.6	5.12	5.54	6.19	7.47	9.76	13.31	18.17	24.18	31.02	38.21	45.17	51.79	57.85
14/6/92	128.72	5.2832	0	0	0.06	0.29	0.79	1.59	2.51	3.31	3.8	4.01	4.17	4.71	6	8.37	12.05	17.07	23.27	30.34	37.78	44.96	51.75	57.91
14/6/112	128.92	5.2863	0	0	0	0.04	0.29	0.74	1.25	1.71	2.05	2.31	2.66	3.38	4.82	7.28	10.94	15.78	21.61	28.14	35.08	42.05	48.66	54.82
14/6/130	129.1	5.289	0	0	0	0.07	0.32	0.85	1.56	2.27	2.8	3.12	3.37	4	5.37	7.8	11.47	16.36	22.3	29.01	36.11	43.1	49.86	56.15
14/7/0	129.3	5.2921	0	0.21	0.71	1.49	2.52	3.61	4.58	5.31	5.81	6.2	6.68	7.54	9.07	11.54	15.12	19.84	25.59	32.13	39.09	45.91	52.46	58.48
14/7/20	129.5	5.2951	0	0	0.01	0.14	0.53	1.19	2.05	2.92	3.64	4.2	4.74	5.39	6.72	9	12.44	17.07	22.78	29.34	36.39	43.37	50.13	56.39
14cc/10	129.69	5.298	0	0	0.01	0.14	0.5	1.1	1.88	2.7	3.45	4.11	4.76	5.44	6.69	8.79	11.98	16.34	21.82	28.22	35.29	42.54	49.42	55.78
15/1/0	129.9	5.3012	0	0	0.01	0.12	0.43	1.02	1.89	2.83	3.62	4.17	4.61	5.08	6.1	7.93	10.81	14.84	20.02	26.24	33.31	40.76	47.96	54.72
15/1/22	130.12	5.3045	0	0	0.2	0.6	1.18	1.91	2.63	3.22	3.61	3.85	4.11	4.66	5.83	7.95	11.27	15.86	21.64	28.34	35.65	43.04	49.98	56.35
15/1/39	130.29	5.3071	0	0.25	0.8	1.64	2.72	3.78	4.62	5.16	5.44	5.61	5.91	6.61	7.99	10.32	13.76	18.35	23.99	30.46	37.39	44.24	50.88	57.05
15/1/60	130.5	5.3103	0	0.05	0.25	0.59	1.06	1.57	2.03	2.36	2.54	2.61	2.73	3.15	4.21	6.26	9.57	14.26	20.25	27.25	34.88	42.55	49.68	56.16
15/1/79	130.69	5.3132	0	0	0.14	0.46	0.94	1.56	2.21	2.76	3.14	3.37	3.58	4.04	5.1	7.13	10.42	15.1	21.1	28.14	35.83	43.55	50.68	57.12
15/1/99	130.89	5.3162	0	0	0.04	0.18	0.49	0.98	1.56	2.07	2.37	2.46	2.56	2.94	4.04	6.25	9.87	15.01	21.51	29	36.99	44.82	51.91	58.19
15/1/120	131.1	5.3194	0	0	0.02	0.11	0.34	0.72	1.19	1.63	1.91	2.02	2.15	2.53	3.58	5.65	9.02	13.79	19.86	26.91	34.57	42.25	49.38	55.86
15/1/140	131.3	5.3224	0	0	0.01	0.1	0.35	0.78	1.34	1.9	2.31	2.53	2.72	3.12	4.18	6.26	9.63	14.35	20.29	27.11	34.44	41.77	48.6	54.85
15/2/11	131.51	5.3256	0	0	0.06	0.19	0.44	0.81	1.25	1.65	1.91	2.02	2.14	2.47	3.4	5.28	8.41	12.92	18.74	25.58	33.05	40.57	47.57	53.95
15/2/30	131.7	5.3285	0	0	0.02	0.12	0.36	0.74	1.2	1.61	1.84	1.85	1.86	2.07	2.85	4.57	7.55	11.98	17.84	24.89	32.72	40.77	48.31	55.01
15/2/51	131.91	5.3317	0	0	0.01	0.1	0.35	0.75	1.24	1.7	2	2.11	2.2	2.52	3.48	5.47	8.83	13.72	20.07	27.54	35.66	43.69	50.95	57.37
15/2/71	132.11	5.3347	0	0	0.04	0.17	0.45	0.89	1.44	1.99	2.43	2.76	3.01	3.57	4.75	6.92	10.34	15.11	21.12	28.05	35.5	42.89	49.7	55.85
15/2/93	132.33	5.3381	0	0.02	0.1	0.26	0.52	0.89	1.28	1.58	1.67	1.67	1.7	2.1	3.28	5.63	9.42	14.68	21.19	28.54	36.26	43.79	50.66	56.82
15/2/113	132.53	5.3411	0	0	0.03	0.15	0.42	0.84	1.33	1.72	1.86	1.86	1.88	2.25	3.39	5.69	9.44	14.69	21.24	28.69	36.55	44.21	51.16	57.34
15/2/134 avg	132.74	5.3443	0	0	0.09	0.28	0.58	0.96	1.34	1.6	1.67	1.67	1.67	1.85	2.71	4.65	8.03	12.98	19.4	26.91	35.01	43.01	50.28	56.76
15/3/0	132.9	5.3467	0	0	0.06	0.19	0.43	0.78	1.18	1.53	1.74	1.84	1.96	2.38	3.44	5.46	8.7	13.24	18.96	25.56	32.68	39.85	46.59	52.77
15/3/17	133.07	5.3493	0	0	0.07	0.24	0.56	0.97	1.39	1.7	1.85	1.9	2.03	2.54	3.76	6.03	9.58	14.45	20.47	27.31	34.59	41.8	48.48	54.57
15/3/39	133.29	5.3526	0	0	0	0.04	0.18	0.48	0.88	1.25	1.44	1.44	1.51	2	3.32	5.85	9.8	15.13	21.54	28.59	35.85	42.88	49.36	55.26
15/3/56	133.46	5.3552	0	0	0.05	0.16	0.38	0.7	1.05	1.33	1.45	1.46	1.59	2.15	3.52	6.04	9.93	15.16	21.49	28.5	35.78	42.88	49.43	55.4
15/3/78	133.68	5.3586	0	0	0.03	0.13	0.34	0.68	1.08	1.42	1.58	1.58	1.61	1.97	3.03	5.16	8.63	13.52	19.66	26.68	34.15	41.53	48.34	54.52
15/3/99	133.89	5.3617	0	0	0	0.07	0.25	0.57	0.97	1.36	1.64	1.8	1.95	2.4	3.49	5.55	8.85	13.49	19.35	26.14	33.49	40.86	47.75	54.07
15/3/120	134.1	5.3649	0	0	0.07	0.29	0.71	1.35	2.1	2.82	3.39	3.81	4.13	4.76	6.02	8.23	11.63	16.28	22.06	28.67	35.76	42.83	49.41	55.42

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
15/3/140	134.3	5.368	0	0	0.07	0.24	0.57	1.02	1.51	1.92	2.18	2.33	2.51	3.05	4.28	6.54	10.08	14.95	20.98	27.81	35.05	42.2	48.82	54.86
15/4/10	134.5	5.371	0	0	0.03	0.14	0.38	0.75	1.21	1.67	2.01	2.2	2.36	2.69	3.58	5.37	8.33	12.57	18.01	24.37	31.3	38.43	45.28	51.53
15/4/30	134.7	5.374	0	0	0.01	0.16	0.56	1.17	1.86	2.42	2.71	2.77	2.85	3.19	4.14	6.02	9.09	13.45	19.03	25.58	32.76	40.03	46.85	53.12
15/4/50	134.9	5.3771	0	0	0.05	0.19	0.49	0.95	1.5	2.05	2.52	2.89	3.15	3.66	4.68	6.53	9.49	13.72	19.2	25.73	32.99	40.39	47.32	53.68
15/4/70	135.1	5.3801	0	0.02	0.11	0.35	0.76	1.3	1.86	2.35	2.72	3.04	3.33	3.96	5.18	7.28	10.46	14.81	20.26	26.6	33.55	40.62	47.3	53.48
15/4/90	135.3	5.3832	0	0	0.07	0.25	0.6	1.09	1.64	2.14	2.54	2.9	3.24	3.95	5.3	7.55	10.88	15.32	20.76	26.96	33.65	40.43	46.87	52.89
15/4/110	135.5	5.3862	0	0	0.09	0.28	0.62	1.11	1.65	2.12	2.42	2.58	2.72	3.18	4.3	6.44	9.89	14.76	20.96	28.18	35.99	43.73	50.79	57.09
15/4/130	135.7	5.3892	0	0	0.07	0.26	0.63	1.14	1.71	2.24	2.66	2.99	3.24	3.76	4.81	6.7	9.69	13.91	19.35	25.79	32.94	40.26	47.19	53.61
15/5/0	135.9	5.3923	0	0.02	0.1	0.28	0.6	1.06	1.59	2.08	2.41	2.59	2.74	3.19	4.27	6.3	9.53	14.05	19.79	26.48	33.78	41.14	48.03	54.35
15/5/16	136.06	5.3947	0	0	0.1	0.31	0.68	1.21	1.8	2.32	2.66	2.85	3.02	3.53	4.72	6.93	10.4	15.2	21.2	28.1	35.52	42.92	49.77	55.98
15/5/42	136.32	5.3986	0	0	0.06	0.2	0.47	0.87	1.32	1.71	1.93	2	2.07	2.42	3.37	5.27	8.41	12.94	18.82	25.78	33.44	41.19	48.38	54.86
15/5/61	136.51	5.4015	0	0	0	0.06	0.24	0.55	0.96	1.41	1.82	2.18	2.55	3.11	4.13	5.94	8.85	13.04	18.51	25.04	32.32	39.76	46.76	53.21
15/5/102	136.92	5.4078	0	0.02	0.11	0.32	0.67	1.13	1.63	2.06	2.34	2.47	2.58	2.96	3.94	5.87	9.03	13.54	19.32	26.07	33.39	40.7	47.46	53.6
15/5/123	137.13	5.4109	0	0	0.16	0.53	1.09	1.77	2.46	3.05	3.49	3.8	4.11	4.66	5.77	7.77	10.91	15.28	20.79	27.17	34.06	40.95	47.36	53.23
15/5/142	137.32	5.4138	0	0	0.2	0.53	0.98	1.52	2.03	2.42	2.63	2.72	2.84	3.25	4.27	6.19	9.22	13.42	18.68	24.76	31.34	38.1	44.64	50.68
15/6/12	137.52	5.4169	0	0	0.03	0.15	0.44	0.92	1.52	2.1	2.54	2.84	3.06	3.54	4.54	6.3	9	12.73	17.49	23.17	29.58	36.5	43.42	49.92
15/6/31	137.71	5.4197	0	0	0.16	0.46	0.89	1.41	1.91	2.29	2.54	2.71	2.94	3.44	4.46	6.24	8.96	12.72	17.5	23.17	29.52	36.32	43.08	49.41
15/6/51	137.91	5.4228	0	0.02	0.11	0.31	0.65	1.13	1.68	2.17	2.52	2.74	2.96	3.31	4.15	5.75	8.36	12.13	17.06	23	29.68	36.76	43.67	50
15/6/65	138.05	5.4249	0	0	0.03	0.14	0.39	0.78	1.27	1.75	2.13	2.4	2.59	3.02	3.96	5.73	8.58	12.64	17.87	24.08	30.95	38.15	45.14	51.56
15/6/87	138.27	5.4282	0	0	0.05	0.18	0.43	0.8	1.23	1.63	1.94	2.16	2.34	2.76	3.69	5.43	8.24	12.26	17.49	23.75	30.75	38.15	45.37	51.98
15/6/126	138.47	5.4313	0	0.02	0.09	0.22	0.44	0.74	1.09	1.45	1.77	2.04	2.25	2.71	3.69	5.54	8.54	12.84	18.4	24.97	32.19	39.7	46.92	53.46
15/6/107	138.66	5.4342	0	0	0.04	0.17	0.45	0.88	1.41	1.95	2.41	2.78	3.05	3.59	4.67	6.6	9.64	13.92	19.4	25.87	33.02	40.35	47.31	53.78
15/7/0	138.9	5.4378	0	0	0	0.06	0.21	0.51	0.97	1.5	2	2.42	2.84	3.35	4.41	6.33	9.37	13.66	19.16	25.65	32.81	40.13	47.06	53.49
15/7/17	139.07	5.4404	0	0	0.01	0.1	0.36	0.81	1.39	1.98	2.43	2.68	2.88	3.23	4.14	5.95	8.94	13.25	18.82	25.42	32.71	40.12	47.09	53.5
15cc/9	139.22	5.4427	0	0	0.14	0.4	0.78	1.26	1.75	2.17	2.48	2.71	2.98	3.51	4.58	6.46	9.39	13.49	18.75	25	31.95	39.29	46.42	52.91
16/1/0	139.5	5.4469	0	0	0.14	0.45	0.91	1.49	2.06	2.53	2.84	3.05	3.29	3.8	4.84	6.69	9.58	13.61	18.73	24.73	31.3	38.12	44.73	50.82
16/1/25	139.75	5.4507	0	0	0.18	0.49	0.93	1.48	2.02	2.44	2.69	2.81	2.98	3.48	4.65	6.81	10.17	14.76	20.39	26.73	33.41	40.04	46.3	52.15
16/1/43	139.93	5.4535	0	0	0.07	0.27	0.61	1.05	1.49	1.86	2.14	2.43	2.78	3.55	5.02	7.48	11.11	15.93	21.75	28.22	34.98	41.63	47.83	53.55
16/1/67	140.17	5.4571	0	0	0.03	0.15	0.43	0.89	1.48	2.06	2.48	2.67	2.78	3.08	3.98	5.85	8.97	13.43	19.09	25.62	32.62	39.63	46.25	52.43
16/1/84	140.34	5.4597	0	0.04	0.18	0.47	0.94	1.54	2.16	2.69	3.06	3.32	3.55	4.12	5.36	7.59	11.04	15.76	21.6	28.23	35.25	42.19	48.65	54.58
16/1/104	140.54	5.4627	0	0	0.07	0.27	0.65	1.19	1.81	2.37	2.75	2.94	3.12	3.5	4.5	6.45	9.62	14.08	19.7	26.14	33.03	39.92	46.43	52.52
16/1/123	140.73	5.4656	0	0	0.06	0.21	0.49	0.9	1.38	1.81	2.07	2.16	2.28	2.66	3.71	5.79	9.17	13.93	19.92	26.76	34.04	41.25	47.97	54.15
16/1/142	140.92	5.4685	0	0	0.07	0.24	0.58	1.09	1.71	2.31	2.78	3.08	3.35	3.75	4.69	6.48	9.35	13.38	18.49	24.45	30.99	37.86	44.64	51.02
16/2/13	141.13	5.4717	0	0	0.01	0.29	0.71	1.25	1.79	2.23	2.54	2.76	3.04	3.6	4.71	6.63	9.58	13.66	18.82	24.88	31.59	38.52	45.22	51.58
16/2/36	141.36	5.4752	0	0	0	0.05	0.22	0.58	1.05	1.48	1.7	1.7	1.7	1.88	2.65	4.35	7.27	11.53	17.07	23.59	30.7	38.01	45.03	51.45
16/2/54	141.54	5.4779	0	0	0.05	0.2	0.54	1.07	1.7	2.26	2.59	2.67	2.73	3.04	3.98	5.91	9.12	13.71	19.57	26.36	33.65	40.88	47.6	53.77
16/2/79	141.79	5.4817	0	0	0.01	0.12	0.4	0.9	1.62	2.39	3.02	3.46	3.84	4.34	5.5	7.67	11.14	15.99	22.05	28.95	36.24	43.37	49.9	55.79

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
16/2/92	141.92	5.4837	0	0	0.01	0.13	0.45	0.94	1.51	2	2.28	2.36	2.47	2.85	3.91	5.99	9.34	14.03	19.92	26.66	33.87	41.04	47.74	53.91
16/2/112	142.12	5.4867	0	0.03	0.14	0.39	0.78	1.22	1.57	1.75	1.79	1.84	2.11	2.83	4.28	6.72	10.35	15.21	21.17	27.92	35.1	42.21	48.84	54.92
16/2/132	142.32	5.4897	0	0	0.01	0.2	0.68	1.36	2.07	2.63	2.95	3.09	3.22	3.63	4.65	6.61	9.74	14.13	19.67	26.09	33.06	40.1	46.77	52.99
16/3/0	142.5	5.4925	0	0	0.04	0.15	0.37	0.71	1.14	1.56	1.86	2.01	2.16	2.5	3.44	5.32	8.42	12.84	18.48	25.04	32.17	39.43	46.36	52.77
16/3/25	142.75	5.4963	0	0	0.03	0.12	0.31	0.6	0.94	1.24	1.39	1.39	1.41	1.69	2.61	4.54	7.77	12.4	18.3	25.12	32.43	39.85	46.92	53.36
16/3/43	142.93	5.499	0	0	0.01	0.1	0.28	0.6	1	1.4	1.68	1.81	1.92	2.23	3.12	4.96	8.04	12.49	18.22	24.94	32.25	39.75	46.92	53.43
16/3/65	143.15	5.5023	0	0	0.01	0.11	0.34	0.74	1.32	1.99	2.61	3.1	3.51	3.96	4.94	6.8	9.84	14.2	19.82	26.43	33.67	41	47.9	54.29
16/3/82	143.32	5.5049	0	0	0.07	0.24	0.55	1.01	1.54	2.03	2.42	2.74	3.01	3.58	4.71	6.7	9.79	14.1	19.57	25.98	33.02	40.21	47.07	53.5
16/3/103	143.53	5.5081	0	0	0.06	0.2	0.43	0.73	1.06	1.37	1.59	1.7	1.78	2.03	2.75	4.31	7.03	11.08	16.46	22.94	30.17	37.78	45.19	52
16/3/124	143.74	5.5116	0	0	0.02	0.1	0.25	0.52	0.89	1.3	1.62	1.77	1.82	2.02	2.72	4.32	7.17	11.46	17.16	24.01	31.59	39.49	47.09	53.99
16/3/134	143.84	5.5145	0	0	0.06	0.21	0.51	0.95	1.51	2.13	2.69	3.11	3.43	3.8	4.68	6.48	9.56	14.1	20.04	27.06	34.71	42.34	49.37	55.74
16/4/7	144.07	5.5211	0	0.01	0.07	0.21	0.47	0.84	1.28	1.71	2.03	2.21	2.34	2.6	3.35	4.96	7.78	12.02	17.68	24.51	32.1	39.97	47.47	54.2
16/4/26	144.26	5.5266	0	0.05	0.18	0.42	0.8	1.34	1.95	2.54	2.99	3.26	3.44	3.71	4.45	5.98	8.61	12.51	17.69	23.97	31.03	38.52	45.86	52.62
16/4/46	144.46	5.5324	0	0	0.04	0.16	0.39	0.74	1.16	1.57	1.89	2.08	2.24	2.51	3.25	4.78	7.4	11.28	16.4	22.55	29.42	36.67	43.79	50.41
16/4/67	144.67	5.5385	0	0	0.07	0.27	0.65	1.22	1.9	2.54	2.99	3.21	3.37	3.71	4.66	6.58	9.74	14.22	19.89	26.43	33.46	40.52	47.22	53.5
16/4/93	144.93	5.546	0	0	0.16	0.45	0.86	1.36	1.84	2.19	2.33	2.33	2.34	2.57	3.49	5.51	8.93	13.87	20.18	27.45	35.2	42.84	49.89	56.3
16/4/113	145.13	5.5518	0	0	0.05	0.22	0.62	1.24	1.97	2.64	3.1	3.37	3.63	4.07	5.16	7.25	10.62	15.39	21.46	28.48	36	43.45	50.33	56.59
16/4/132	145.32	5.5573	0	0	0.05	0.3	0.73	1.33	1.97	2.53	2.9	3.08	3.19	3.54	4.52	6.56	9.97	14.87	21.1	28.28	35.93	43.48	50.46	56.83
16/5/0	145.5	5.5626	0	0	0.1	0.33	0.67	1.06	1.39	1.57	1.58	1.58	1.58	1.74	2.6	4.53	7.84	12.64	18.81	25.99	33.75	41.53	48.83	55.59
16/5/14	145.64	5.5666	0	0	0.09	0.29	0.59	0.96	1.29	1.47	1.48	1.48	1.48	1.66	2.66	4.89	8.69	14.14	21.02	28.85	37.06	45.01	52.21	58.64
16/5/43	145.93	5.575	0	0	0.06	0.22	0.56	1.07	1.65	2.14	2.42	2.5	2.58	3	4.13	6.34	9.91	14.91	21.19	28.38	36.04	43.61	50.61	56.97
16/5/63	146.13	5.5808	0	0	0.01	0.13	0.45	0.92	1.43	1.86	2.11	2.2	2.27	2.62	3.66	5.82	9.45	14.69	21.41	29.17	37.41	45.44	52.7	59.17
16/5/86	146.36	5.5875	0	0	0.11	0.4	0.86	1.46	2.06	2.57	2.96	3.32	3.85	4.82	6.57	9.41	13.55	19.01	25.59	32.9	40.4	47.5	54.14	60.17
16/5/102	146.52	5.5921	0	0	0.02	0.46	1.13	2.01	2.9	3.69	4.37	5.03	5.88	7.18	9.25	12.37	16.73	22.31	28.88	35.99	42.91	49.54	55.7	61.25
16/5/121	146.71	5.5976	0	0	0.06	0.23	0.59	1.15	1.82	2.45	2.9	3.16	3.42	3.86	4.97	7.13	10.64	15.63	21.97	29.28	37.06	44.67	51.6	57.82
16/5/142	146.92	5.6037	0	0	0.19	0.5	0.93	1.45	2	2.52	3	3.47	4.03	4.86	6.21	8.38	11.63	16.11	21.76	28.33	35.47	42.64	49.35	55.54
16/6/6	147.06	5.6077	0	0	0.15	0.5	1.04	1.75	2.52	3.25	3.85	4.31	4.73	5.33	6.42	8.33	11.32	15.52	20.86	27.11	33.94	40.89	47.52	53.74
16/6/26	147.26	5.6135	0	0	0.06	0.2	0.44	0.8	1.29	1.83	2.3	2.6	2.75	2.93	3.51	4.85	7.29	11.04	16.11	22.3	29.29	36.73	44.06	50.88
16/6/47	147.47	5.6196	0	0	0.01	0.12	0.55	1.36	2.42	3.41	4.07	4.39	4.66	5.14	6.32	8.53	12.02	16.86	22.94	29.95	37.39	44.58	51.41	57.65
16/6/64	147.64	5.6245	0	0	0.06	0.2	0.46	0.85	1.32	1.77	2.09	2.23	2.34	2.66	3.61	5.59	8.94	13.79	20.02	27.25	35	42.66	49.73	56.18
16/6/93	147.93	5.6329	0	0	0.17	0.47	0.9	1.43	1.94	2.31	2.46	2.46	2.47	2.78	3.88	6.21	10.11	15.64	22.56	30.33	38.33	45.93	52.74	58.79
16/6/115	148.15	5.6393	0	0	0.19	0.55	1.08	1.73	2.37	2.86	3.12	3.18	3.23	3.6	4.73	7.06	10.89	16.27	22.94	30.39	38.04	45.33	51.91	57.81
16/6/133	148.33	5.6445	0	0	0.01	0.32	0.9	1.72	2.58	3.32	3.88	4.33	4.87	5.8	7.46	10.17	14.12	19.33	25.59	32.52	39.61	46.31	52.57	58.26
16/7/0	148.5	5.6494	0	0	0.22	0.61	1.16	1.83	2.47	3	3.39	3.7	4.1	4.85	6.29	8.76	12.48	17.51	23.68	30.63	37.85	44.75	51.26	57.22
16/7/17	148.67	5.6544	0	0	0.05	0.19	0.47	0.9	1.44	1.99	2.42	2.66	2.83	3.18	4.17	6.23	9.7	14.69	21.04	28.33	36.04	43.57	50.45	56.65
16cc/8	148.77	5.6573	0	0	0.21	0.62	1.22	1.98	2.75	3.39	3.83	4.11	4.4	5.01	6.33	8.72	12.42	17.45	23.61	30.5	37.64	44.52	51	56.98
17/1/0	149.1	5.6668	0	0.07	0.22	0.5	0.93	1.52	2.18	2.79	3.24	3.53	3.81	4.27	5.41	7.6	11.14	16.12	22.37	29.5	37.02	44.36	51.06	57.09

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
17/1/26	149.36	5.6743	0	0	0.23	0.61	1.15	1.78	2.36	2.8	3.11	3.39	3.83	4.68	6.22	8.73	12.4	17.28	23.24	29.98	37.04	43.87	50.38	56.39
17/1/42	149.52	5.679	0	0	0.02	0.54	1.25	2.24	3.38	4.45	5.29	5.89	6.39	7.06	8.25	10.32	13.55	18.05	23.74	30.32	37.33	44.16	50.72	56.81
17/1/82	149.92	5.6906	0	0	0.05	0.19	0.47	0.9	1.44	1.98	2.38	2.56	2.6	2.75	3.37	4.85	7.55	11.7	17.31	24.13	31.72	39.58	47.06	53.76
17/1/101	150.11	5.6961	0	0	0.2	0.64	1.28	2.04	2.8	3.49	4.08	4.61	5.19	6.02	7.34	9.4	12.42	16.5	21.64	27.67	34.34	41.2	47.78	54
17/1/121	150.31	5.7019	0	0	0.02	0.5	1.37	2.58	3.87	4.98	5.79	6.33	6.78	7.42	8.58	10.54	13.5	17.53	22.56	28.42	34.82	41.31	47.78	54.02
17/1/141	150.51	5.7076	0	0	0.29	0.88	1.79	2.95	4.15	5.21	6.03	6.62	7.11	7.73	8.76	10.5	13.17	16.88	21.6	27.16	33.35	39.81	46.14	52.25
17/2/7	150.67	5.7123	0	0.03	0.12	0.31	0.63	1.08	1.58	2	2.23	2.32	2.45	2.97	4.26	6.7	10.57	15.92	22.55	30.01	37.76	45.2	51.89	57.82
17/2/27	150.87	5.7181	0	0	0.32	0.86	1.64	2.6	3.58	4.49	5.27	5.97	6.75	7.89	9.75	12.65	16.79	22.16	28.51	35.39	42.11	48.58	54.6	60.03
17/2/47	151.07	5.7239	0	0	0.24	0.68	1.31	2.09	2.86	3.52	4.04	4.49	5.01	5.84	7.29	9.68	13.25	18.08	24.04	30.82	37.93	44.78	51.27	57.21
17/2/73	151.33	5.7314	0	0.09	0.46	1.11	2.01	2.97	3.83	4.53	5.12	5.7	6.44	7.52	9.16	11.57	14.92	19.29	24.62	30.72	37.24	43.67	49.91	55.75
17/2/92	151.52	5.7369	0	0	0.02	0.25	0.82	1.64	2.56	3.39	4.01	4.44	4.85	5.52	6.78	8.94	12.2	16.62	22.09	28.36	35.12	41.94	48.4	54.44
17/2/115	151.75	5.7436	0	0	0.35	0.88	1.63	2.52	3.41	4.17	4.74	5.17	5.62	6.34	7.62	9.76	12.97	17.33	22.76	29.01	35.79	42.64	49.12	55.14
17/2/136	151.96	5.7496	0	0	0.22	0.67	1.32	2.14	2.98	3.72	4.32	4.85	5.49	6.51	8.21	10.88	14.73	19.8	25.96	32.88	40.07	46.91	53.31	59.07
17/3/0	152.1	5.7537	0	0	0.13	0.41	0.82	1.33	1.85	2.31	2.65	2.86	3.01	3.28	3.97	5.42	7.98	11.88	17.16	23.65	30.99	38.77	46.31	53.16
17/3/15	152.25	5.758	0	0	0.17	0.63	1.36	2.31	3.26	4.06	4.63	5.03	5.43	6.06	7.2	9.13	12.07	16.13	21.29	27.39	34.17	41.18	47.93	54.31
17/3/37	152.47	5.7644	0	0	0.01	0.36	1.11	2.2	3.41	4.48	5.26	5.76	6.18	6.84	8.09	10.26	13.56	18.05	23.63	30.04	36.85	43.52	49.96	55.99
17/3/65	152.75	5.7725	0	0	0.11	0.43	0.95	1.64	2.38	3.04	3.53	3.84	4.08	4.51	5.51	7.48	10.75	15.46	21.52	28.59	36.18	43.68	50.56	56.78
17/3/81	152.91	5.7772	0	0	0.08	0.34	0.85	1.56	2.35	3.12	3.86	4.35	4.99	5.94	7.44	9.76	13.13	17.69	23.37	29.91	36.83	43.52	49.89	55.77
17/3/102	153.12	5.7832	0	0	0.07	0.23	0.54	1	1.55	2.04	2.32	2.32	2.32	2.38	2.99	4.58	7.51	11.97	17.91	25	32.73	40.46	47.59	53.99
17/3/116	153.26	5.7873	0	0	0.02	0.48	1.3	2.39	3.56	4.6	5.39	5.96	6.5	7.32	8.79	11.23	14.86	19.72	25.64	32.27	39.09	45.53	51.54	56.99
17/3/135	153.45	5.7928	0	0	0.01	0.39	1.12	2.17	3.34	4.44	5.34	6.02	6.63	7.44	8.79	11.01	14.35	18.87	24.43	30.69	37.19	43.42	49.35	54.86
17/4/6	153.66	5.7989	0	0	0.02	0.59	1.4	2.54	3.87	5.14	6.14	6.82	7.33	7.96	9.08	11.05	14.12	18.37	23.69	29.79	36.24	42.53	48.58	54.25
17/4/37	153.97	5.8079	0	0.08	0.34	0.77	1.37	2.02	2.61	3.1	3.53	4	4.62	5.54	6.93	8.98	11.89	15.79	20.71	26.52	32.99	39.69	46.17	52.33
17/4/53	154.13	5.8125	0	0	0.02	0.29	0.81	1.51	2.28	3	3.61	4.12	4.63	5.33	6.49	8.39	11.29	15.32	20.48	26.58	33.35	40.31	46.98	53.28
17/4/72	154.32	5.818	0	0	0.01	0.33	0.79	1.44	2.21	3	3.72	4.34	4.9	5.56	6.58	8.31	11.06	15.04	20.27	26.56	33.56	40.69	47.41	53.64
17/4/94	154.54	5.8244	0	0	0.02	0.44	1.16	2.16	3.24	4.25	5.08	5.71	6.23	6.85	7.91	9.78	12.78	17.08	22.62	29.12	36.19	43.26	49.83	55.87
17/4/117	154.77	5.831	0	0	0.13	0.44	0.93	1.55	2.16	2.68	3.09	3.4	3.7	4.16	5.03	6.63	9.26	13.13	18.25	24.43	31.31	38.49	45.43	51.79
17/4/135	154.95	5.8362	0	0	0.02	0.28	0.88	1.72	2.63	3.46	4.16	4.72	5.23	5.86	6.87	8.57	11.27	15.16	20.29	26.48	33.41	40.5	47.2	53.44
17/5/0	155.1	5.8406	0	0	0.06	0.21	0.5	0.9	1.35	1.73	1.9	1.9	1.9	1.96	2.51	3.94	6.59	10.67	16.18	22.88	30.36	38.15	45.63	52.41
17/5/14	155.24	5.8446	0	0	0.1	0.36	0.75	1.2	1.66	2.12	2.6	3.14	3.83	4.8	6.25	8.42	11.57	15.86	21.31	27.73	34.8	41.97	48.71	54.95
17/5/38	155.48	5.8516	0	0	0.1	0.43	0.96	1.68	2.5	3.31	4.03	4.64	5.23	6	7.24	9.28	12.4	16.74	22.26	28.72	35.75	42.81	49.43	55.54
17/5/57	155.67	5.8571	0	0	0.06	0.27	0.73	1.39	2.15	2.9	3.58	4.18	4.59	5.24	6.37	8.29	11.27	15.46	20.85	27.2	34.15	41.16	47.73	53.81
17/5/84	155.94	5.8649	0	0	0.16	0.42	0.78	1.21	1.66	2.06	2.38	2.63	2.9	3.39	4.41	6.31	9.43	13.95	19.85	26.84	34.46	42.03	48.96	55.21
17/5/103	156.13	5.8704	0	0	0.01	0.1	0.36	0.87	1.65	2.56	3.47	4.3	5.02	5.6	6.63	8.41	11.29	15.46	20.9	27.35	34.38	41.4	47.89	53.82
17/5/117	156.27	5.8745	0	0	0.01	0.31	0.87	1.64	2.46	3.19	3.75	4.16	4.53	5.1	6.18	8.11	11.2	15.59	21.2	27.72	34.69	41.54	47.84	53.59
17/5/137	156.47	5.8803	0	0.17	0.51	1	1.63	2.3	2.92	3.45	3.89	4.29	4.73	5.38	6.49	8.34	11.19	15.18	20.27	26.19	32.6	39.03	45.11	50.83
17/6/11	156.71	5.8872	0	0	0.28	0.69	1.26	1.94	2.65	3.39	4.19	5.06	6.02	7.17	8.71	10.92	14.11	18.48	24.03	30.53	37.47	44.15	50.49	56.3

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
17/6/35	156.95	5.8942	0	0	0.02	0.24	0.68	1.26	1.89	2.48	2.99	3.44	3.96	4.77	6.2	8.58	12.17	17.09	23.22	30.23	37.58	44.58	51.13	57.04
17/6/52	157.12	5.8991	0	0	0.02	0.26	0.83	1.64	2.55	3.41	4.11	4.68	5.26	6.13	7.61	10.03	13.63	18.5	24.51	31.35	38.49	45.28	51.63	57.37
17/6/77	157.37	5.9063	0	0	0	0.04	0.45	1.02	1.81	2.74	3.73	4.75	5.83	7.1	8.82	11.29	14.79	19.44	25.15	31.61	38.33	44.74	50.79	56.34
17/6/92	157.52	5.9107	0	0	0.02	0.29	0.85	1.49	2.12	2.71	3.33	4.1	5.15	6.63	8.72	11.61	15.47	20.38	26.25	32.78	39.33	45.76	51.85	57.42
17/6/116	157.76	5.9176	0	0.02	0.12	0.36	0.76	1.27	1.81	2.31	2.73	3.06	3.28	3.7	4.59	6.29	9.12	13.27	18.73	25.27	32.48	39.76	46.56	52.81
17/6/133	157.93	5.9225	0	0	0.02	0.24	0.62	1.12	1.68	2.28	2.94	3.69	4.56	5.64	7.1	9.21	12.25	16.43	21.77	28.07	34.98	41.94	48.41	54.33
17/7/0	158.1	5.9275	0	0.2	0.64	1.22	1.81	2.28	2.61	2.87	3.17	3.62	4.29	5.27	6.72	8.89	12.05	16.38	21.88	28.33	35.36	42.39	48.89	54.81
17/7/17	158.27	5.9324	0.9	0.91	1.08	1.47	2.07	2.79	3.52	4.18	4.76	5.33	6.01	6.98	8.46	10.71	13.97	18.36	23.84	30.18	36.92	43.45	49.67	55.38
17cc/6	158.52	5.9396	0	0	0.01	0.11	0.42	0.98	1.74	2.59	3.45	4.3	5.13	5.84	7.04	9	12.03	16.27	21.68	27.99	34.79	41.54	47.8	53.53
18/1/0	158.7	5.9448	0	0	0.01	0.15	0.44	0.84	1.31	1.75	2.06	2.18	2.19	2.29	2.84	4.24	6.85	10.89	16.33	22.9	30.13	37.52	44.51	50.81
18/1/25	158.95	5.9521	0	0.1	0.31	0.62	1	1.37	1.73	2.12	2.59	3.16	3.86	4.82	6.3	8.62	12.07	16.77	22.58	29.12	35.87	42.32	48.18	53.49
18/1/43	159.13	5.9573	0	0	0.02	0.15	0.42	0.77	1.15	1.48	1.69	1.78	1.89	2.29	3.37	5.54	9.1	14.12	20.39	27.44	34.7	41.59	47.8	53.37
18/1/65	159.35	5.9637	0	0	0.29	0.76	1.39	1.97	2.39	2.68	2.99	3.51	4.46	6.03	8.39	11.68	15.98	21.25	27.28	33.74	40.18	46.17	51.69	56.69
18/1/79	159.49	5.9677	0.97	0.98	1.23	1.78	2.55	3.36	4.07	4.66	5.2	5.84	6.74	8.07	10.06	12.95	16.93	22.03	28.07	34.64	41.01	47.08	52.67	57.69
18/1/102	159.72	5.9744	0	0	0.19	0.51	0.94	1.5	2.14	2.77	3.28	3.64	3.93	4.38	5.33	7.18	10.28	14.8	20.63	27.4	34.6	41.6	47.96	53.68
18/1/116	159.86	5.9784	0	0	0.01	0.19	0.7	1.43	2.22	2.89	3.36	3.65	3.92	4.41	5.43	7.31	10.31	14.56	19.99	26.31	33.12	39.88	46.16	51.93
18/1/141	160.11	5.9857	0	0	0.02	0.48	1.19	2.21	3.44	4.67	5.75	6.62	7.38	8.3	9.76	12.16	15.79	20.7	26.7	33.32	39.77	45.95	51.69	56.88
18/2/13	160.33	5.9921	0	0	0.16	0.61	1.32	2.25	3.2	4	4.56	4.91	5.22	5.76	6.88	8.94	12.19	16.7	22.3	28.6	35.15	41.49	47.36	52.79
18/2/34	160.54	5.9981	0	0	0.02	0.48	1.28	2.48	3.93	5.31	6.37	7.04	7.49	8.06	9.18	11.26	14.56	19.14	24.78	31.08	37.49	43.52	49.17	54.4
18/2/53	160.73	6.0036	0	0	0.04	0.17	0.43	0.83	1.33	1.85	2.27	2.5	2.61	2.84	3.6	5.31	8.33	12.83	18.69	25.5	32.73	39.79	46.29	52.25
18/2/79	160.99	6.0112	0	0	0.02	0.22	0.62	1.2	1.91	2.58	3.07	3.33	3.46	3.71	4.44	6.04	8.82	12.88	18.09	24.11	30.51	36.92	43.04	48.76
18/2/96	161.16	6.0161	0	0	0.25	0.85	1.73	2.76	3.8	4.78	5.7	6.61	7.63	8.96	10.84	13.51	17.12	21.69	27.04	32.83	38.54	44.1	49.4	54.38
18/2/112	161.32	6.0207	0	0	0	0.04	0.29	0.82	1.54	2.32	2.99	3.49	3.9	4.49	5.62	7.68	10.96	15.55	21.27	27.72	34.42	40.89	46.86	52.36
18/2/133	161.53	6.0268	0	0	0.02	0.22	0.62	1.15	1.73	2.28	2.74	3.11	3.5	4.12	5.28	7.32	10.51	14.97	20.57	26.97	33.73	40.35	46.53	52.27
18/3/0	161.7	6.0317	0	0	0.15	0.48	0.98	1.64	2.41	3.26	4.12	4.95	5.79	6.84	8.38	10.7	14	18.33	23.54	29.36	35.4	41.25	46.88	52.19
18/3/14 2nd run	161.84	6.0358	0	0	0.06	0.21	0.5	0.93	1.45	1.93	2.24	2.34	2.38	2.66	3.57	5.52	8.83	13.6	19.66	26.61	33.95	41.13	47.8	53.94
18/3/42 2nd run	162.12	6.0439	0	0.11	0.37	0.77	1.32	1.98	2.65	3.22	3.61	3.85	4.1	4.67	5.96	8.39	12.23	17.52	23.99	31.14	38.32	44.97	51.11	56.69
18/3/56 2nd run	162.26	6.0479	0	0	0.07	0.28	0.66	1.21	1.85	2.46	2.89	3.09	3.21	3.54	4.51	6.55	9.97	14.86	21.03	28.03	35.31	42.32	48.73	54.58
18/3/85	162.55	6.0563	0	0.03	0.14	0.38	0.77	1.29	1.88	2.45	2.9	3.2	3.45	3.79	4.65	6.4	9.37	13.76	19.54	26.43	33.97	41.52	48.52	54.92
18/3/117	162.87	6.0656	0	0	0.01	0.1	0.25	0.47	0.71	0.89	0.93	0.93	0.93	0.98	1.54	3.13	6.16	10.84	17.1	24.54	32.52	40.29	47.33	53.66
18/3/135	163.05	6.0708	0	0.04	0.17	0.42	0.84	1.43	2.11	2.74	3.16	3.28	3.28	3.36	3.95	5.46	8.29	12.65	18.5	25.5	33.12	40.65	47.58	53.9
18/4/13	163.33	6.0789	0	0.04	0.18	0.42	0.76	1.18	1.61	1.95	2.12	2.12	2.12	2.22	2.93	4.68	7.9	12.8	19.32	27.05	35.36	43.43	50.65	57.03
18/4/36	163.56	6.0856	0	0.04	0.16	0.41	0.82	1.41	2.1	2.76	3.24	3.46	3.53	3.73	4.47	6.2	9.31	14.01	20.22	27.55	35.41	43.03	49.89	56.01
18/4/56	163.73	6.0905	0	0	0.08	0.28	0.64	1.17	1.8	2.39	2.79	2.89	2.89	2.97	3.63	5.34	8.53	13.42	19.93	27.6	35.76	43.58	50.52	56.62
18/4/73	163.93	6.0963	0	0	0.08	0.29	0.66	1.19	1.81	2.39	2.77	2.87	2.87	2.97	3.63	5.31	8.42	13.16	19.44	26.82	34.67	42.23	49.01	55.05
18/4/93	164.13	6.1021	0	0.12	0.4	0.83	1.42	2.13	2.85	3.46	3.86	4.03	4.08	4.28	5.05	6.87	10.15	15.09	21.58	29.16	37.17	44.82	51.61	57.59
18/4/111 2nd run	164.31	6.1073	0	0	0.14	0.45	0.91	1.48	2.07	2.55	2.83	2.89	2.89	3.08	3.96	6.05	9.78	15.33	22.53	30.81	39.39	47.4	54.32	60.25

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
18/4/132 avg	164.52	6.1134	0	0.08	0.29	0.61	1.06	1.6	2.12	2.54	2.76	2.79	2.79	2.95	3.76	5.69	9.15	14.33	21.11	28.99	37.27	45.11	51.98	57.96
18/5/0 avg	164.7	6.1186	0	0.04	0.23	0.58	1.1	1.74	2.38	2.88	3.12	3.12	3.14	3.55	4.95	7.92	12.91	20.1	29.14	39.23	48.99	58.13	66.3	73.34
18/5/26 avg	164.96	6.1261	0	0.1	0.38	0.81	1.41	2.09	2.75	3.26	3.54	3.6	3.64	4.07	5.43	8.31	13.14	20.1	28.89	38.74	48.32	57.36	65.52	72.61
18/5/43	165.13	6.1311	0	0	0.03	0.17	0.43	0.77	1.13	1.41	1.53	1.53	1.53	1.71	2.57	4.54	7.96	12.97	19.39	26.74	34.39	41.67	48.19	54.01
18/5/65	165.35	6.1374	0	0	0.01	0.13	0.37	0.7	1.05	1.33	1.45	1.45	1.45	1.55	2.31	4.16	7.5	12.52	19.1	26.8	34.98	42.86	49.9	56.11
18/5/80	165.5	6.1418	0	0	0.04	0.17	0.41	0.73	1.07	1.34	1.46	1.46	1.46	1.62	2.39	4.18	7.34	12.05	18.22	25.49	33.33	41.04	48.07	54.39
18/5/104	165.74	6.1487	0	0.06	0.2	0.46	0.87	1.43	2.09	2.75	3.32	3.76	4.15	4.63	5.72	7.82	11.28	16.28	22.7	30.13	38	45.6	52.4	58.39
18/5/125	165.95	6.1548	0	0	0.04	0.19	0.46	0.82	1.2	1.5	1.64	1.65	1.68	2.05	3.19	5.52	9.36	14.78	21.56	29.23	37.19	44.78	51.53	57.45
18/5/141	166.11	6.1594	0	0.03	0.13	0.33	0.67	1.15	1.71	2.26	2.68	2.95	3.19	3.63	4.73	6.92	10.55	15.78	22.46	30.16	38.26	45.99	52.8	58.7
18/6/6	166.26	6.1638	0	0	0.01	0.12	0.32	0.6	0.92	1.17	1.24	1.24	1.24	1.3	1.99	3.88	7.41	12.8	19.93	28.32	37.23	45.7	53.05	59.3
18/6/26	166.46	6.1696	0	0	0.04	0.2	0.5	0.9	1.32	1.64	1.76	1.76	1.76	1.86	2.7	4.72	8.32	13.67	20.63	28.71	37.21	45.24	52.22	58.18
18/6/46	166.66	6.1754	0	0	0	0.09	0.28	0.59	0.97	1.31	1.49	1.49	1.49	1.63	2.5	4.62	8.47	14.28	21.88	30.7	39.88	48.37	55.52	61.43
18/6/66	166.86	6.1812	0	0	0.01	0.15	0.37	0.67	1.02	1.3	1.4	1.4	1.4	1.45	2.11	4.04	7.74	13.48	21.14	30.12	39.51	48.21	55.51	61.52
18/6/86	167.06	6.187	0	0	0.01	0.14	0.43	0.85	1.31	1.69	1.88	1.88	1.88	1.95	2.67	4.59	8.17	13.64	20.87	29.31	38.14	46.37	53.38	59.27
18/6/104	167.24	6.1922	0	0	0.02	0.22	0.52	0.93	1.39	1.76	1.91	1.91	1.91	1.97	2.7	4.72	8.49	14.18	21.58	30.05	38.73	46.7	53.47	59.16
18/6/124	167.44	6.198	0	0	0.01	0.17	0.44	0.81	1.24	1.61	1.79	1.79	1.79	1.93	2.85	5.07	9.03	14.91	22.48	31.12	39.99	48.14	55.05	60.82
18cc/7(2nd attempt)	167.57	6.2017	0	0	0.17	0.54	1.09	1.77	2.44	2.97	3.25	3.29	3.29	3.41	4.22	6.2	9.78	15.15	22.16	30.3	38.83	46.85	53.77	59.66
19/1/0	168.3	6.2229	0	0	0	0	0	0	0	0	0	0	0	0.11	1.24	3.58	7.3	12.48	19.19	26.91	34.79	41.92	48.24	53.65
19/1/22	168.52	6.2292	0	0.18	0.52	1	1.62	2.35	3.05	3.61	3.96	4.13	4.32	4.87	6.23	8.87	13.11	19.04	26.39	34.6	42.85	50.27	56.83	62.43
19/1/41	168.71	6.2347	0	0	0.08	0.27	0.62	1.14	1.76	2.33	2.7	2.82	2.88	3.2	4.24	6.44	10.15	15.48	22.22	29.86	37.75	45.19	51.76	57.5
19/1/62	168.92	6.2408	0	0	0.21	0.57	1.06	1.66	2.25	2.72	2.98	3.06	3.14	3.58	4.86	7.47	11.76	17.8	25.31	33.68	42.04	49.48	56	61.53
19/1/83	169.13	6.2469	0	0.12	0.37	0.74	1.23	1.81	2.37	2.8	3.03	3.09	3.16	3.59	4.82	7.3	11.37	17.09	24.19	32.13	40.11	47.32	53.75	59.31
19/1/104	169.34	6.253	0	0.03	0.13	0.36	0.75	1.32	1.99	2.6	3.01	3.17	3.28	3.63	4.68	6.87	10.53	15.77	22.39	29.88	37.61	44.88	51.29	56.89
19/1/121	169.51	6.2579	0	0.06	0.21	0.5	0.97	1.63	2.36	3.01	3.43	3.58	3.65	3.98	5.01	7.17	10.81	16.02	22.61	30.08	37.8	45.07	51.48	57.08
19/1/142	169.72	6.264	0	0	0.17	0.52	1.03	1.64	2.24	2.72	2.99	3.05	3.06	3.27	4.1	5.99	9.3	14.18	20.48	27.76	35.41	42.72	49.21	54.93
19/2/5	169.85	6.2678	0	0.01	0.09	0.28	0.62	1.14	1.77	2.36	2.76	2.87	2.88	3.1	3.97	5.97	9.5	14.72	21.48	29.29	37.47	45.22	52.01	57.89
19/2/26	170.06	6.2738	0	0.12	0.39	0.79	1.34	1.99	2.63	3.15	3.47	3.59	3.67	4.01	5.04	7.22	10.92	16.27	23.06	30.78	38.73	46.16	52.64	58.23
19/2/52	170.32	6.2814	0	0	0.08	0.27	0.62	1.14	1.75	2.31	2.66	2.77	2.87	3.29	4.53	7.05	11.19	16.99	24.14	32.03	39.85	46.84	53.03	58.39
19/2/72	170.52	6.2872	0	0.01	0.17	0.52	1.02	1.62	2.21	2.68	2.95	3.07	3.23	3.79	5.21	7.95	12.34	18.42	25.89	34.15	42.35	49.67	56.11	61.63
19/2/93	170.73	6.2933	0	0	0.19	0.51	0.95	1.49	2.02	2.43	2.63	2.65	2.67	2.98	4.07	6.42	10.43	16.25	23.66	32.11	40.69	48.41	55.23	61.04
19/2/114	170.94	6.2993	0	0	0.16	0.51	1.02	1.63	2.24	2.73	3.02	3.12	3.19	3.56	4.7	7.1	11.15	16.99	24.4	32.82	41.36	49.05	55.85	61.64
19/2/135	171.15	6.3054	0	0.12	0.38	0.78	1.32	1.97	2.61	3.12	3.4	3.45	3.45	3.61	4.45	6.48	10.12	15.56	22.63	30.78	39.26	47.21	54.09	59.96
19/3/0	171.3	6.3098	0	0.01	0.19	0.57	1.12	1.78	2.45	3	3.32	3.4	3.4	3.5	4.21	6.01	9.32	14.35	20.98	28.75	36.98	44.85	51.78	57.8
19/3/27	171.57	6.3176	0	0.01	0.08	0.27	0.63	1.17	1.83	2.45	2.83	2.87	2.87	2.95	3.71	5.7	9.39	15.01	22.41	31.05	40.05	48.35	55.51	61.52
19/3/42	171.72	6.3219	0	0.09	0.35	0.76	1.33	2.04	2.79	3.49	4.08	4.55	5.02	5.76	7.17	9.7	13.72	19.38	26.53	34.67	42.96	50.44	57.06	62.69
19/3/62	171.92	6.3277	0	0.1	0.35	0.75	1.31	1.99	2.69	3.29	3.72	3.99	4.24	4.77	5.99	8.34	12.16	17.56	24.34	32.01	39.82	46.96	53.39	58.99
19/3/83	172.13	6.3338	0	0	0.13	0.43	0.88	1.45	2.04	2.56	2.94	3.18	3.44	4.02	5.34	7.84	11.86	17.48	24.49	32.38	40.4	47.71	54.28	59.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
19/3/102	172.32	6.3393	0	0	0.15	0.48	0.97	1.58	2.22	2.78	3.18	3.42	3.63	4.11	5.27	7.57	11.39	16.88	23.88	31.91	40.18	47.76	54.57	60.46
19/3/117	172.47	6.3436	0	0.17	0.51	1	1.65	2.43	3.23	3.95	4.53	4.98	5.43	6.14	7.47	9.83	13.57	18.83	25.5	33.17	41.11	48.44	55.07	60.83
19/3/136	172.66	6.3491	0	0.08	0.27	0.58	1	1.51	2.02	2.43	2.68	2.77	2.85	3.21	4.27	6.49	10.26	15.76	22.87	31.13	39.87	48.17	55.35	61.43
19/4/6	172.86	6.3549	0	0.11	0.38	0.79	1.36	2.05	2.75	3.35	3.78	4.06	4.36	4.99	6.38	8.98	13.15	19.01	26.35	34.68	43.15	50.8	57.55	63.28
19/4/27	173.07	6.361	0	0.11	0.37	0.77	1.33	2	2.69	3.3	3.76	4.1	4.47	5.17	6.61	9.22	13.32	19.01	26.07	33.98	41.94	49.11	55.46	60.9
19/4/47	173.27	6.3668	0	0.07	0.28	0.62	1.1	1.69	2.3	2.84	3.23	3.5	3.79	4.4	5.76	8.31	12.4	18.14	25.32	33.44	41.7	49.19	55.85	61.56
19/4/72	173.52	6.3741	0	0.01	0.19	0.56	1.09	1.74	2.42	3.03	3.51	3.88	4.31	5.12	6.73	9.59	14.02	20.09	27.56	35.9	44.29	51.84	58.49	64.11
19/4/92	173.72	6.3798	0	0.03	0.13	0.36	0.75	1.33	2.01	2.65	3.13	3.43	3.75	4.31	5.67	8.25	12.37	18.09	25.17	33.07	41.04	48.26	54.7	60.26
19/4/113	173.93	6.3859	0	0	0.13	0.41	0.82	1.32	1.83	2.24	2.48	2.56	2.64	3.03	4.16	6.49	10.36	15.88	22.85	30.76	38.84	46.24	52.87	58.64
19/4/134	174.14	6.392	0	0.11	0.35	0.71	1.19	1.76	2.33	2.8	3.11	3.28	3.46	3.93	5.08	7.32	10.98	16.19	22.79	30.34	38.25	45.77	52.4	58.16
19/5/0	174.3	6.3966	0	0.05	0.18	0.43	0.83	1.38	2	2.55	2.88	2.95	2.96	3.18	4.03	5.94	9.28	14.23	20.68	28.23	36.29	44.06	50.95	56.96
19/5/24	174.54	6.4036	0	0.01	0.14	0.41	0.8	1.27	1.71	2.03	2.16	2.16	2.16	2.34	3.22	5.24	8.79	14.07	20.97	29.07	37.7	45.97	53.18	59.34
19/5/42	174.72	6.4088	0	0	0.15	0.41	0.77	1.21	1.64	1.97	2.13	2.16	2.21	2.62	3.82	6.3	10.45	16.42	24.05	32.86	41.94	50.17	57.42	63.47
19/5/56	174.86	6.4129	0	0.01	0.14	0.42	0.82	1.29	1.74	2.08	2.24	2.24	2.25	2.48	3.41	5.5	9.17	14.62	21.78	30.23	39.3	48	55.54	61.9
19/5/96	175.26	6.4244	0	0.01	0.15	0.44	0.86	1.37	1.89	2.32	2.6	2.74	2.87	3.27	4.34	6.54	10.28	15.78	23.01	31.6	40.74	49.24	56.75	63.08
19/5/117	175.47	6.4305	0	0	0.13	0.42	0.84	1.36	1.89	2.32	2.58	2.65	2.65	2.83	3.59	5.4	8.7	13.76	20.58	28.8	37.79	46.51	54.11	60.56
19/5/141	175.71	6.4375	0	0.01	0.15	0.43	0.84	1.33	1.81	2.19	2.38	2.38	2.38	2.45	3.13	4.88	8.13	13.15	19.92	28.07	36.95	45.55	53.07	59.5
19/6/6	175.86	6.4418	0	0.07	0.24	0.51	0.89	1.35	1.79	2.13	2.3	2.32	2.34	2.67	3.73	5.97	9.79	15.37	22.61	31.06	40.02	48.51	55.8	61.92
19/6/26	176.06	6.4476	0	0.12	0.36	0.7	1.16	1.7	2.21	2.6	2.81	2.88	2.98	3.42	4.63	7.08	11.13	16.93	24.34	32.9	41.75	49.8	56.93	62.95
19/6/52	176.32	6.4551	0	0.14	0.4	0.78	1.28	1.87	2.44	2.88	3.11	3.14	3.14	3.31	4.13	6.06	9.53	14.74	21.61	29.72	38.41	46.74	53.99	60.18
19/6/67	176.47	6.4595	0	0	0.14	0.4	0.76	1.21	1.65	1.99	2.16	2.16	2.17	2.39	3.31	5.39	9.04	14.47	21.57	29.89	38.75	47.19	54.51	60.74
19/6/84	176.64	6.4644	0	0	0.13	0.37	0.72	1.15	1.58	1.91	2.07	2.07	2.08	2.3	3.21	5.29	8.96	14.44	21.64	30.13	39.2	47.85	55.33	61.64
19/6/112	176.92	6.4725	0	0.12	0.37	0.73	1.21	1.77	2.32	2.77	3.06	3.22	3.39	3.85	4.98	7.2	10.84	16.06	22.76	30.57	38.9	46.91	53.94	60.01
19/6/134	177.14	6.4789	0	0	0.07	0.25	0.61	1.12	1.71	2.26	2.62	2.71	2.71	2.85	3.55	5.27	8.42	13.25	19.74	27.54	36.04	44.32	51.63	57.98
19/7/0	177.3	6.4835	0.26	0.44	0.76	1.25	1.89	2.61	3.3	3.85	4.19	4.33	4.41	4.73	5.71	7.82	11.46	16.85	23.89	32.14	40.75	48.61	55.62	61.59
19/7/22	177.52	6.4899	0	0	0.12	0.36	0.71	1.15	1.61	2	2.21	2.21	2.21	2.23	2.67	4.13	7.09	11.88	18.54	26.69	35.63	44.29	51.84	58.3
19cc/0	177.82	6.4986	0	0	0.15	0.45	0.89	1.44	2.02	2.5	2.78	2.83	2.83	2.89	3.51	5.22	8.48	13.57	20.44	28.66	37.49	45.9	53.18	59.38
20/1/0	177.9	6.5009	0	0.08	0.3	0.65	1.14	1.74	2.34	2.82	3.09	3.13	3.13	3.18	3.74	5.33	8.4	13.24	19.83	27.8	36.5	44.96	52.42	58.9
20/1/15	178.05	6.5052	0	0	0.15	0.43	0.83	1.33	1.83	2.24	2.47	2.5	2.5	2.59	3.29	5.09	8.46	13.68	20.73	29.2	38.4	47.26	54.95	61.48
20/1/37	178.27	6.5116	0	0	0.12	0.38	0.77	1.27	1.81	2.29	2.63	2.78	2.82	2.95	3.53	5	7.81	12.28	18.49	26.2	34.88	43.56	51.38	58.28
20/1/58	178.48	6.5177	0	0	0.12	0.36	0.71	1.16	1.63	2.03	2.29	2.37	2.37	2.46	3.03	4.53	7.41	11.99	18.35	26.22	35.06	43.87	51.76	58.66
20/1/78	178.68	6.5235	0	0	0.14	0.43	0.86	1.39	1.95	2.44	2.76	2.87	2.87	2.91	3.36	4.67	7.28	11.51	17.47	24.94	33.43	42.01	49.82	56.77
20/1/97	178.87	6.529	0	0	0.11	0.35	0.71	1.17	1.65	2.06	2.31	2.37	2.37	2.45	3.07	4.7	7.81	12.7	19.4	27.58	36.62	45.5	53.36	60.16
20/1/118	179.08	6.5351	0	0	0.11	0.34	0.69	1.14	1.61	2.02	2.29	2.38	2.38	2.44	2.96	4.38	7.17	11.67	17.99	25.88	34.79	43.7	51.69	58.68
20/1/137	179.27	6.5406	0	0	0.09	0.3	0.63	1.06	1.52	1.92	2.18	2.27	2.27	2.36	2.89	4.31	7.06	11.49	17.71	25.5	34.33	43.19	51.15	58.13
20/2/5	179.45	6.5458	0	0	0.1	0.31	0.63	1.03	1.44	1.78	1.96	1.97	1.97	2.03	2.64	4.28	7.41	12.34	19.12	27.43	36.64	45.69	53.66	60.5
20/2/27	179.67	6.5522	0	0	0.09	0.3	0.62	1.03	1.46	1.82	2.04	2.08	2.08	2.14	2.72	4.27	7.26	12.01	18.6	26.74	35.84	44.86	52.87	59.79

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
20/2/46	179.86	6.5577	0	0	0.11	0.33	0.66	1.08	1.51	1.85	2.03	2.03	2.03	2.06	2.52	3.97	6.9	11.66	18.33	26.62	35.92	45.13	53.27	60.26
20/2/77	180.17	6.5666	0	0.08	0.28	0.6	1.04	1.58	2.13	2.59	2.86	2.92	2.92	2.95	3.39	4.79	7.63	12.28	18.82	26.98	36.14	45.22	53.23	60.09
20/2/93	180.33	6.5713	0	0	0.13	0.41	0.83	1.37	1.94	2.43	2.72	2.77	2.77	2.8	3.27	4.8	7.91	12.94	19.91	28.43	37.76	46.77	54.55	61.1
20/2/106	180.46	6.575	0	0	0.11	0.35	0.71	1.18	1.66	2.04	2.21	2.21	2.21	2.25	2.84	4.63	8.11	13.59	21	29.83	39.26	48.16	55.74	62.05
20/2/133	180.73	6.5829	0	0	0.16	0.44	0.84	1.34	1.85	2.27	2.51	2.55	2.55	2.6	3.14	4.69	7.69	12.45	18.96	26.86	35.52	43.97	51.45	57.94
20/3/1	180.91	6.5881	0	0.03	0.18	0.46	0.86	1.36	1.88	2.31	2.56	2.59	2.59	2.63	3.14	4.64	7.58	12.24	18.62	26.38	34.9	43.26	50.7	57.18
20/3/24	181.14	6.5947	0	0	0.12	0.4	0.82	1.36	1.94	2.46	2.82	2.95	2.95	2.98	3.38	4.67	7.31	11.64	17.72	25.25	33.66	41.98	49.42	55.96
20/3/42	181.32	6.6	0	0	0.13	0.4	0.79	1.3	1.83	2.27	2.53	2.55	2.55	2.55	2.83	4.07	6.76	11.26	17.63	25.54	34.33	42.95	50.56	57.15
20/3/67	181.57	6.6072	0	0	0.15	0.42	0.81	1.3	1.81	2.22	2.44	2.44	2.44	2.49	3.09	4.84	8.22	13.53	20.71	29.28	38.46	47.18	54.68	61.01
20/3/82 avg	181.72	6.6115	0	0	0.11	0.35	0.7	1.16	1.63	2.01	2.21	2.22	2.22	2.25	2.75	4.33	7.47	12.47	19.33	27.61	36.58	45.2	52.69	59.08
20/3/96	181.86	6.6156	0	0	0.09	0.3	0.62	1.04	1.49	1.87	2.08	2.08	2.08	2.11	2.57	4.07	7.08	11.92	18.57	26.65	35.45	43.97	51.46	57.94
20/3/116	182.06	6.6214	0	0	0.07	0.23	0.54	0.98	1.52	2.04	2.41	2.53	2.53	2.6	3.17	4.69	7.58	12.12	18.3	25.78	33.98	42.03	49.28	55.72
20/3/133	182.23	6.6263	0	0.08	0.32	0.72	1.29	2	2.76	3.45	3.96	4.25	4.38	4.57	5.21	6.75	9.64	14.16	20.31	27.76	35.91	43.88	51	57.28
20/4/7	182.47	6.6333	0	0	0.18	0.52	1.01	1.63	2.29	2.87	3.25	3.38	3.38	3.41	3.83	5.19	7.95	12.43	18.65	26.26	34.6	42.73	49.93	56.22
20/4/28	182.68	6.6393	0	0	0.15	0.44	0.86	1.4	1.97	2.46	2.77	2.84	2.84	2.87	3.32	4.76	7.68	12.4	18.94	26.93	35.69	44.19	51.65	58.08
20/4/48	182.88	6.6451	0	0.02	0.16	0.43	0.82	1.32	1.84	2.29	2.56	2.6	2.6	2.62	3.03	4.42	7.28	11.95	18.47	26.49	35.33	43.94	51.48	57.95
20/4/68	183.08	6.6509	0	0.01	0.15	0.43	0.83	1.33	1.86	2.33	2.64	2.73	2.73	2.73	3.01	4.17	6.71	11.02	17.19	24.95	33.66	42.27	49.89	56.5
20/4/86	183.26	6.6561	0	0	0.15	0.47	0.94	1.52	2.14	2.68	3.03	3.13	3.13	3.13	3.41	4.6	7.2	11.59	17.84	25.64	34.34	42.89	50.43	56.96
20/4/105	183.45	6.6616	0	0.02	0.18	0.5	0.97	1.57	2.21	2.76	3.12	3.22	3.22	3.25	3.73	5.27	8.38	13.39	20.3	28.67	37.72	46.37	53.82	60.13
20/4/132	183.72	6.6695	0	0	0.15	0.44	0.86	1.39	1.95	2.43	2.72	2.78	2.78	2.79	3.17	4.54	7.39	12.07	18.62	26.67	35.51	44.08	51.59	58.06
20/5/1 avg	183.91	6.675	0	0.02	0.18	0.49	0.93	1.47	2.02	2.46	2.71	2.74	2.74	2.82	3.5	5.28	8.64	13.87	20.91	29.32	38.38	47.03	54.5	60.83
20/5/25	184.15	6.6819	0	0.04	0.2	0.5	0.94	1.49	2.07	2.58	2.91	3.02	3.02	3.05	3.46	4.79	7.52	11.99	18.28	26.06	34.7	43.18	50.69	57.24
20/5/42 2nd attempt	184.32	6.6868	0	0.04	0.21	0.52	0.96	1.51	2.08	2.55	2.82	2.87	2.87	2.94	3.62	5.45	8.93	14.34	21.63	30.31	39.57	48.32	55.79	62.03
20/5/61	184.51	6.6923	0	0.15	0.45	0.89	1.48	2.19	2.89	3.46	3.79	3.84	3.84	3.87	4.37	5.96	9.12	14.17	21.08	29.42	38.44	47.06	54.49	60.77
20/5/82	184.72	6.6984	0	0.03	0.2	0.51	0.96	1.52	2.1	2.57	2.84	2.87	2.87	2.93	3.56	5.32	8.69	13.97	21.11	29.66	38.85	47.6	55.12	61.44
20/5/101	184.91	6.7039	0	0.02	0.15	0.41	0.79	1.27	1.78	2.21	2.47	2.53	2.53	2.63	3.33	5.13	8.53	13.82	20.99	29.61	38.94	47.89	55.58	62.03
20/5/117	185.07	6.7086	0	0	0.14	0.46	0.94	1.53	2.13	2.62	2.9	2.95	2.95	3.09	3.89	5.87	9.51	15.07	22.47	31.23	40.56	49.37	56.83	62.98
20/5/137	185.27	6.7144	0	0	0.16	0.5	1.01	1.64	2.3	2.88	3.26	3.41	3.42	3.54	4.18	5.84	9	13.95	20.69	28.85	37.74	46.33	53.78	60.1
20/6/7	185.47	6.7201	0	0	0.15	0.45	0.88	1.43	2.01	2.49	2.77	2.82	2.82	2.89	3.61	5.49	9.03	14.51	21.85	30.54	39.77	48.42	55.72	61.77
20/6/34	185.74	6.728	0	0.07	0.27	0.59	1.04	1.59	2.14	2.57	2.79	2.8	2.8	2.89	3.66	5.61	9.21	14.69	21.94	30.45	39.42	47.82	54.98	60.98
20/6/52	185.92	6.7332	0	0	0.16	0.46	0.89	1.43	1.98	2.42	2.67	2.71	2.71	2.89	3.74	5.76	9.38	14.82	21.97	30.33	39.16	47.49	54.65	60.7
20/6/68	186.08	6.7378	0	0.12	0.36	0.71	1.18	1.73	2.27	2.69	2.91	2.93	2.93	3.13	4.03	6.14	9.89	15.49	22.8	31.32	40.29	48.72	55.92	61.95
20/6/92	186.32	6.7448	0	0.05	0.22	0.52	0.95	1.48	2.01	2.42	2.63	2.64	2.64	2.78	3.63	5.67	9.34	14.86	22.09	30.54	39.44	47.81	54.97	60.98
20/6/111	186.51	6.7503	0	0.04	0.18	0.43	0.79	1.24	1.69	2.04	2.21	2.21	2.21	2.25	2.79	4.42	7.61	12.65	19.5	27.74	36.63	45.16	52.57	58.89
20/6/132	186.72	6.7563	0	0	0.1	0.33	0.68	1.14	1.63	2.05	2.31	2.36	2.36	2.4	2.93	4.47	7.5	12.31	18.88	26.82	35.45	43.79	51.11	57.43
20/7/0	186.9	6.7616	0	0.01	0.08	0.25	0.56	1.01	1.56	2.1	2.48	2.59	2.59	2.63	3.13	4.57	7.41	11.94	18.17	25.77	34.13	42.31	49.57	55.91
20/7/17	187.07	6.7665	0	0	0.06	0.22	0.54	1.01	1.58	2.13	2.52	2.63	2.63	2.7	3.31	4.94	8.04	12.9	19.5	27.45	36.08	44.41	51.69	57.92

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
20CC/7	187.22	6.7708	0	0	0.06	0.22	0.52	0.97	1.53	2.1	2.56	2.81	2.9	3.06	3.67	5.17	8	12.46	18.58	26.06	34.32	42.44	49.68	56.02
21/1/1 avg	187.51	6.7792	0	0	0.06	0.22	0.53	0.97	1.49	2	2.34	2.42	2.42	2.45	2.91	4.29	7.03	11.46	17.6	25.13	33.42	41.6	48.89	55.2
21/1/26	187.76	6.7865	0	0	0.11	0.36	0.74	1.22	1.73	2.18	2.47	2.55	2.55	2.56	2.85	3.99	6.44	10.54	16.38	23.7	31.89	40.19	47.76	54.24
21/1/43	187.93	6.7914	0	0	0.11	0.35	0.71	1.16	1.63	2.02	2.24	2.25	2.25	2.28	2.78	4.31	7.36	12.24	18.95	27.1	35.98	44.54	51.96	58.26
21/1/58	188.08	6.7957	0	0	0.06	0.21	0.49	0.9	1.4	1.88	2.19	2.22	2.22	2.22	2.49	3.66	6.2	10.47	16.56	24.18	32.7	41.29	49.07	55.63
21/1/82	188.32	6.8027	0	0.02	0.13	0.34	0.65	1.04	1.44	1.76	1.92	1.92	1.92	1.94	2.38	3.83	6.78	11.56	18.22	26.39	35.39	44.13	51.74	58.2
21/1/102	188.52	6.8085	0	0	0.1	0.33	0.68	1.11	1.55	1.9	2.07	2.07	2.07	2.11	2.67	4.33	7.57	12.7	19.71	28.19	37.39	46.19	53.73	60.03
21/1/117	188.67	6.8128	0	0	0.11	0.34	0.67	1.08	1.51	1.87	2.07	2.08	2.08	2.09	2.44	3.74	6.46	10.96	17.3	25.17	33.92	42.49	50.02	56.51
21/1/142	188.92	6.8201	0	0	0.11	0.35	0.71	1.16	1.63	2.04	2.29	2.33	2.33	2.34	2.69	3.96	6.62	11.01	17.19	24.82	33.26	41.53	48.86	55.27
21/2/8	189.08	6.8247	0	0	0.15	0.42	0.8	1.27	1.75	2.13	2.32	2.32	2.32	2.35	2.86	4.47	7.66	12.75	19.7	28.06	37.06	45.62	52.96	59.13
21/2/33	189.33	6.8319	0	0	0.1	0.32	0.64	1.05	1.48	1.83	2	2	2	2.03	2.51	4.07	7.19	12.19	19.05	27.33	36.28	44.84	52.25	58.54
21/2/46 avg	189.46	6.8357	0	0	0.1	0.31	0.63	1.04	1.47	1.82	1.99	1.99	1.99	2.03	2.56	4.18	7.37	12.41	19.27	27.51	36.36	44.8	52.11	58.33
21/2/75	189.75	6.8441	0	0.03	0.16	0.39	0.72	1.14	1.56	1.89	2.04	2.04	2.04	2.07	2.56	4.15	7.32	12.4	19.36	27.77	36.85	45.51	52.95	59.21
21/2/93	189.93	6.8493	0	0	0.07	0.24	0.51	0.87	1.26	1.6	1.79	1.79	1.79	1.82	2.3	3.82	6.88	11.81	18.62	26.92	35.98	44.72	52.3	58.73
21/2/117	190.17	6.8563	0	0	0.11	0.36	0.73	1.19	1.66	2.04	2.25	2.25	2.25	2.28	2.76	4.3	7.38	12.32	19.12	27.39	36.41	45.1	52.62	58.99
21/2/142	190.42	6.8635	0	0	0.13	0.42	0.85	1.38	1.94	2.42	2.71	2.77	2.77	2.8	3.24	4.68	7.6	12.32	18.86	26.84	35.56	43.99	51.35	57.67
21/3/1	190.51	6.8661	0	0	0.12	0.36	0.72	1.18	1.66	2.07	2.3	2.31	2.31	2.34	2.82	4.35	7.4	12.28	18.97	27.05	35.79	44.17	51.47	57.74
21/3/16	190.66	6.8705	0	0	0.11	0.35	0.71	1.18	1.69	2.14	2.43	2.5	2.5	2.53	2.97	4.39	7.27	11.94	18.41	26.31	34.92	43.23	50.49	56.75
21/3/37	190.87	6.8765	0	0	0.08	0.26	0.6	1.1	1.71	2.32	2.79	2.99	2.99	3.06	3.61	5.13	8.1	12.82	19.29	27.11	35.6	43.76	50.9	57.06
21/3/62	191.12	6.8838	0	0	0.12	0.39	0.78	1.27	1.78	2.21	2.46	2.49	2.49	2.52	2.97	4.42	7.34	12.04	18.5	26.34	34.86	43.09	50.32	56.59
21/3/82	191.32	6.8896	0	0.01	0.14	0.42	0.82	1.32	1.84	2.29	2.58	2.66	2.66	2.7	3.21	4.67	7.55	12.16	18.5	26.21	34.63	42.81	50.04	56.34
21/3/102 avg	191.52	6.8954	0	0.02	0.14	0.4	0.77	1.24	1.71	2.09	2.29	2.29	2.29	2.31	2.8	4.38	7.54	12.63	19.63	28.12	37.33	46.15	53.7	60.03
21/3/121	191.71	6.9009	0	0	0.14	0.45	0.9	1.47	2.07	2.6	2.95	3.06	3.06	3.08	3.46	4.75	7.44	11.87	18.1	25.81	34.36	42.75	50.15	56.57
21/3/136	191.86	6.9052	0	0	0.1	0.31	0.63	1.05	1.49	1.86	2.06	2.06	2.06	2.08	2.53	4.04	7.12	12.13	19.07	27.53	36.75	45.6	53.21	59.62
21/4/7	192.07	6.9113	0	0	0.13	0.39	0.77	1.25	1.74	2.14	2.35	2.35	2.35	2.38	2.89	4.49	7.67	12.74	19.68	28.07	37.15	45.84	53.31	59.58
21/4/36	192.36	6.9197	0	0	0.12	0.38	0.76	1.24	1.74	2.16	2.41	2.43	2.43	2.43	2.66	3.85	6.48	10.93	17.3	25.28	34.2	42.94	50.61	57.21
21/4/52	192.52	6.9243	0	0	0.13	0.36	0.69	1.1	1.51	1.81	1.9	1.9	1.9	1.94	2.56	4.43	8.06	13.77	21.49	30.68	40.44	49.51	57.04	63.13
21/4/73	192.73	6.9304	0	0	0.13	0.37	0.72	1.16	1.6	1.94	2.08	2.08	2.08	2.08	2.47	4.01	7.23	12.51	19.86	28.82	38.55	47.79	55.6	62.03
21/4/96	192.96	6.9371	0	0.01	0.08	0.25	0.57	1.05	1.63	2.16	2.48	2.48	2.48	2.52	3.05	4.67	7.88	13.01	20.06	28.62	37.93	46.85	54.48	60.84
21/4/112	193.12	6.9417	0	0	0.07	0.25	0.59	1.07	1.65	2.21	2.61	2.74	2.74	2.78	3.24	4.63	7.41	11.91	18.2	25.98	34.65	43.21	50.79	57.36
21/4/133	193.33	6.9478	0	0	0.12	0.38	0.77	1.25	1.75	2.17	2.42	2.46	2.46	2.47	2.84	4.16	6.91	11.44	17.83	25.77	34.62	43.34	51.03	57.68
21/5/0 avg	193.5	6.9527	0	0.01	0.12	0.35	0.73	1.26	1.87	2.45	2.86	3.01	3.01	3.05	3.55	4.98	7.81	12.37	18.71	26.51	35.17	43.69	51.24	57.77
21/5/22	193.72	6.9591	0	0	0.13	0.42	0.84	1.36	1.89	2.32	2.56	2.58	2.58	2.62	3.14	4.7	7.77	12.67	19.39	27.55	36.44	45.02	52.47	58.8
21/5/42	193.92	6.9649	0	0	0.12	0.4	0.81	1.34	1.91	2.43	2.8	2.98	3.03	3.15	3.68	5.07	7.76	12.04	17.97	25.28	33.42	41.5	48.75	55.15
21/5/62	194.12	6.9707	0	0.05	0.21	0.48	0.86	1.33	1.8	2.17	2.36	2.36	2.36	2.45	3.18	5.03	8.45	13.7	20.72	29.08	38.06	46.63	54.02	60.24
21/5/84	194.34	6.977	0	0.07	0.24	0.55	1.04	1.71	2.47	3.18	3.7	3.94	3.99	4.14	4.78	6.35	9.27	13.79	19.92	27.36	35.55	43.61	50.82	57.14
21/5/102	194.52	6.9822	0	0.19	0.54	1.02	1.65	2.39	3.13	3.76	4.19	4.4	4.48	4.67	5.35	6.95	9.89	14.44	20.6	28.07	36.3	44.41	51.66	58.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
21/5/122	194.72	6.988	0	0	0.16	0.5	1.01	1.63	2.25	2.75	3.02	3.05	3.05	3.13	3.89	5.83	9.43	14.93	22.24	30.86	40.01	48.62	55.95	62.06
21/5/140	194.9	6.9932	0	0.01	0.2	0.59	1.15	1.83	2.52	3.11	3.49	3.63	3.63	3.77	4.46	6.21	9.47	14.51	21.31	29.46	38.28	46.77	54.15	60.44
21/6/7	195.07	6.9982	0	0.01	0.18	0.52	1.02	1.63	2.26	2.81	3.18	3.35	3.43	3.68	4.51	6.4	9.79	14.95	21.84	30.07	38.97	47.55	55.02	61.37
21/6/33	195.33	7.0057	0	0	0.16	0.5	1.01	1.68	2.42	3.12	3.68	4.06	4.35	4.78	5.72	7.64	10.95	15.92	22.52	30.41	38.96	47.22	54.44	60.62
21/6/49 avg	195.49	7.0103	0	0	0.14	0.45	0.92	1.53	2.2	2.84	3.33	3.61	3.73	3.91	4.52	6.02	8.9	13.46	19.75	27.46	35.99	44.36	51.81	58.3
21/6/66	195.66	7.0153	0	0	0.16	0.51	1.03	1.69	2.41	3.07	3.57	3.86	4.01	4.24	4.95	6.6	9.66	14.41	20.86	28.66	37.17	45.43	52.69	58.97
21/6/87	195.87	7.0213	0	0.02	0.2	0.56	1.09	1.77	2.51	3.21	3.77	4.14	4.39	4.74	5.57	7.33	10.47	15.27	21.72	29.46	37.85	45.96	53.07	59.2
21/6/107	196.07	7.0271	0	0.01	0.21	0.62	1.22	1.96	2.74	3.42	3.9	4.15	4.27	4.54	5.38	7.31	10.78	16.04	23.03	31.29	40.11	48.48	55.67	61.74
21/6/134	196.34	7.035	0	0	0.17	0.52	1.04	1.72	2.46	3.14	3.64	3.92	4.07	4.34	5.13	6.92	10.16	15.11	21.72	29.59	38.06	46.21	53.34	59.47
21/7/0	196.5	7.0396	0	0.1	0.41	0.93	1.68	2.61	3.64	4.64	5.51	6.19	6.76	7.43	8.57	10.63	14	18.91	25.31	32.83	40.71	47.99	54.56	60.26
21/7/22	196.72	7.046	0	0.01	0.18	0.54	1.07	1.76	2.52	3.25	3.84	4.25	4.55	4.97	5.89	7.77	11.05	15.98	22.53	30.31	38.67	46.69	53.69	59.69
21CC/6	197	7.0541	0	0.12	0.46	1.01	1.77	2.71	3.72	4.66	5.41	5.93	6.3	6.74	7.62	9.39	12.47	17.13	23.35	30.8	38.75	46.2	53.03	59.04
22/1/1	197.11	7.0573	0	0.04	0.17	0.42	0.83	1.41	2.08	2.7	3.11	3.24	3.24	3.41	4.16	5.97	9.27	14.31	21.04	29.08	37.77	46.17	53.51	59.8
22/1/16	197.26	7.0616	0	0.01	0.16	0.48	0.94	1.51	2.1	2.61	2.95	3.11	3.17	3.37	4.08	5.75	8.81	13.52	19.87	27.52	35.89	44.09	51.39	57.78
22/1/38 avg	197.48	7.068	0	0.01	0.17	0.5	0.97	1.55	2.16	2.69	3.06	3.25	3.36	3.64	4.5	6.38	9.72	14.74	21.42	29.39	38.02	46.4	53.75	60.07
22/1/58	197.68	7.0738	0	0.11	0.35	0.72	1.23	1.84	2.46	2.98	3.32	3.48	3.56	3.82	4.64	6.49	9.78	14.78	21.47	29.5	38.27	46.8	54.25	60.59
22/1/84	197.94	7.0813	0	0	0.14	0.47	0.96	1.58	2.25	2.87	3.35	3.68	3.93	4.34	5.27	7.16	10.44	15.37	21.95	29.85	38.45	46.8	54.1	60.32
22/1/104	198.14	7.0871	0	0.04	0.23	0.58	1.08	1.71	2.38	2.99	3.44	3.71	3.87	4.14	4.88	6.56	9.62	14.35	20.79	28.62	37.24	45.66	53.07	59.45
22/1/122	198.32	7.0923	0	0.03	0.19	0.49	0.92	1.47	2.05	2.56	2.92	3.1	3.18	3.37	4.04	5.64	8.63	13.32	19.78	27.71	36.51	45.16	52.78	59.32
22/1/142	198.52	7.0981	0	0.08	0.29	0.63	1.1	1.68	2.29	2.83	3.22	3.43	3.52	3.7	4.32	5.82	8.64	13.09	19.23	26.77	35.15	43.42	50.78	57.18
22/2/13	198.73	7.1042	0	0.08	0.32	0.71	1.26	1.94	2.66	3.33	3.85	4.19	4.43	4.79	5.62	7.35	10.4	15.03	21.23	28.68	36.79	44.68	51.66	57.74
22/2/32	198.92	7.1097	0	0.18	0.52	1	1.63	2.37	3.1	3.7	4.08	4.26	4.38	4.75	5.82	8.07	11.91	17.51	24.71	33.01	41.53	49.21	55.98	61.7
22/2/54	199.14	7.116	0	0.16	0.46	0.89	1.45	2.11	2.74	3.24	3.53	3.64	3.77	4.28	5.66	8.4	12.89	19.24	27.18	36.07	44.92	52.66	59.27	64.67
22/2/74	199.34	7.1218	0	0.11	0.36	0.75	1.28	1.92	2.58	3.16	3.58	3.84	4.08	4.58	5.77	8.1	11.97	17.56	24.74	33.04	41.61	49.39	56.28	62.13
22/2/93 avg	199.53	7.1273	0	0.01	0.17	0.47	0.91	1.45	2.02	2.5	2.8	2.89	2.89	3.07	3.87	5.8	9.3	14.62	21.72	30.13	39.14	47.73	55.13	61.35
22/2/112	199.72	7.1328	0	0.11	0.35	0.71	1.2	1.78	2.35	2.79	3.02	3.06	3.08	3.4	4.49	6.85	10.89	16.77	24.3	32.96	41.82	49.77	56.72	62.52
22/2/133	199.93	7.1389	0	0	0.18	0.56	1.12	1.81	2.51	3.1	3.48	3.65	3.76	4.12	5.18	7.45	11.35	17.06	24.42	32.89	41.54	49.27	56.02	61.68
22/3/1	200.11	7.1441	0	0.14	0.42	0.83	1.38	2.04	2.7	3.26	3.64	3.85	4.04	4.53	5.76	8.21	12.26	18.07	25.44	33.83	42.34	49.93	56.55	62.09
22/3/15	200.25	7.1482	0	0.11	0.35	0.71	1.2	1.79	2.37	2.84	3.12	3.22	3.29	3.66	4.78	7.15	11.17	17	24.45	32.99	41.7	49.52	56.38	62.15
22/3/42	200.52	7.156	0	0.11	0.37	0.78	1.35	2.04	2.76	3.39	3.83	4.04	4.1	4.24	4.87	6.46	9.47	14.18	20.59	28.35	36.83	45.08	52.35	58.63
22/3/56	200.66	7.1601	0	0.2	0.54	1	1.59	2.28	2.95	3.5	3.86	4.06	4.27	4.81	6.12	8.67	12.82	18.7	26.12	34.57	43.17	50.89	57.65	63.32
22/3/82	200.92	7.1676	0	0.14	0.43	0.86	1.43	2.1	2.77	3.31	3.64	3.77	3.85	4.21	5.32	7.69	11.75	17.66	25.25	33.96	42.82	50.71	57.57	63.26
22/3/95	201.05	7.1714	0	0.13	0.4	0.8	1.33	1.96	2.59	3.09	3.37	3.42	3.42	3.49	4.19	6.02	9.46	14.78	21.91	30.38	39.42	47.97	55.28	61.4
22/3/117	201.27	7.1777	0	0.01	0.17	0.49	0.96	1.52	2.06	2.47	2.66	2.66	2.66	2.84	3.76	5.9	9.71	15.4	22.86	31.57	40.74	49.34	56.64	62.69
22/3/132 avg	201.42	7.1821	0	0	0.15	0.46	0.92	1.48	2.05	2.53	2.83	2.92	2.93	3.1	3.85	5.69	9.08	14.28	21.24	29.56	38.52	47.09	54.5	60.75
22/4/7	201.67	7.1893	0	0.01	0.17	0.51	1.01	1.63	2.29	2.89	3.31	3.49	3.5	3.54	3.98	5.34	8.11	12.67	19.11	27.14	36.13	44.99	52.75	59.36
22/4/33	201.93	7.1968	0	0.09	0.32	0.69	1.19	1.81	2.45	3.01	3.4	3.59	3.65	3.82	4.48	6.13	9.25	14.17	20.93	29.2	38.31	47.17	54.86	61.35

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
22/4/73	202.33	7.2084	0	0.1	0.34	0.72	1.25	1.89	2.54	3.09	3.45	3.63	3.76	4.15	5.26	7.61	11.64	17.58	25.32	34.35	43.68	52.04	59.29	65.21
22/4/92	202.52	7.2139	0	0.01	0.19	0.58	1.14	1.83	2.54	3.15	3.58	3.84	4.08	4.61	5.88	8.39	12.55	18.54	26.2	34.99	43.95	51.91	58.77	64.38
22/4/113	202.73	7.22	0	0.06	0.29	0.68	1.22	1.83	2.39	2.8	3.02	3.13	3.37	4.16	5.99	9.35	14.54	21.59	30.13	39.46	48.57	56.39	62.9	68.06
22/4/133	202.93	7.2258	0	0.1	0.33	0.67	1.14	1.7	2.25	2.72	3.08	3.44	4.05	5.3	7.66	11.57	17.27	24.72	33.52	42.86	51.39	58.89	65.11	69.99
22CC/7	203.17	7.2328	0	0	0.15	0.5	1.03	1.72	2.49	3.24	3.86	4.25	4.41	4.47	4.7	5.51	7.36	10.67	15.66	22.27	30.08	38.45	46.4	53.35
23/1/1	206.71	7.3502	0	0	0.12	0.36	0.71	1.15	1.6	1.96	2.16	2.19	2.2	2.42	3.3	5.31	8.88	14.21	21.21	29.45	38.25	46.67	53.98	60.2
23/1/15	206.85	7.3549	0	0.01	0.15	0.45	0.88	1.39	1.87	2.22	2.37	2.37	2.39	2.76	3.98	6.53	10.8	16.9	24.61	33.38	42.31	50.32	57.32	63.15
23/1/43 avg	207.13	7.3643	0	0.08	0.31	0.68	1.18	1.77	2.36	2.81	3.05	3.1	3.12	3.44	4.54	6.9	10.93	16.79	24.3	32.93	41.81	49.85	56.95	62.91
23/1/58	207.28	7.3693	0	0.11	0.34	0.69	1.16	1.73	2.31	2.8	3.14	3.33	3.49	3.92	5.04	7.3	11.09	16.57	23.6	31.74	40.19	47.94	54.89	60.85
23/1/78	207.48	7.376	0	0.1	0.34	0.71	1.22	1.83	2.44	2.94	3.24	3.35	3.4	3.7	4.68	6.8	10.45	15.8	22.73	30.79	39.34	47.51	54.62	60.69
23/1/103	207.73	7.3844	0	0.12	0.37	0.74	1.24	1.84	2.44	2.92	3.2	3.29	3.34	3.66	4.69	6.9	10.7	16.27	23.48	31.88	40.65	48.68	55.8	61.84
23/1/118	207.88	7.3894	0	0.08	0.28	0.59	1.01	1.52	2.01	2.37	2.52	2.52	2.52	2.75	3.76	6.04	10	15.82	23.33	32.03	41.08	49.38	56.58	62.62
23/1/142	208.12	7.3974	0	0.07	0.24	0.5	0.86	1.29	1.69	1.96	2.03	2.03	2.03	2.29	3.43	5.98	10.36	16.71	24.81	34.08	43.52	51.95	59.27	65.3
23/2/6	208.26	7.4021	0	0	0.16	0.44	0.84	1.33	1.81	2.17	2.33	2.33	2.34	2.57	3.56	5.79	9.68	15.4	22.81	31.42	40.52	49.15	56.59	62.84
23/2/32	208.52	7.4108	0	0.02	0.14	0.36	0.68	1.08	1.48	1.79	1.92	1.92	1.92	2.15	3.18	5.53	9.65	15.73	23.59	32.69	42.06	50.51	57.93	64.11
23/2/53	208.73	7.4179	0	0.09	0.3	0.63	1.08	1.62	2.14	2.51	2.66	2.66	2.66	2.88	3.94	6.35	10.53	16.65	24.51	33.55	42.81	51.13	58.4	64.44
23/2/86	209.06	7.4289	0	0.06	0.25	0.57	1.02	1.57	2.12	2.56	2.81	2.87	2.9	3.24	4.36	6.78	10.92	16.95	24.7	33.63	42.8	51.08	58.36	64.46
23/2/107 avg	209.27	7.436	0	0	0.13	0.37	0.71	1.15	1.56	1.86	1.95	1.95	1.95	2.18	3.26	5.72	9.96	16.13	24.01	33	42.19	50.49	57.79	63.91
23/2/134	209.54	7.445	0	0	0.17	0.44	0.81	1.26	1.68	1.96	2.03	2.03	2.03	2.29	3.42	5.91	10.15	16.27	24.03	32.86	41.85	49.96	57.09	63.08
23/3/0	209.7	7.4504	0	0	0.14	0.44	0.88	1.4	1.89	2.23	2.34	2.34	2.35	2.67	3.87	6.44	10.76	16.93	24.7	33.5	42.42	50.45	57.51	63.44
23/3/15	209.85	7.4554	0	0	0.18	0.47	0.87	1.35	1.81	2.15	2.29	2.29	2.32	2.77	4.13	6.91	11.48	17.93	25.97	35	44.08	52.19	59.25	65.12
23/3/42	210.12	7.4644	0	0	0.15	0.43	0.84	1.36	1.89	2.32	2.56	2.64	2.72	3.12	4.31	6.78	10.92	16.87	24.44	33.11	42.03	50.14	57.32	63.38
23/3/63	210.33	7.4715	0	0	0.26	0.79	1.59	2.59	3.66	4.67	5.54	6.28	7.06	8.17	9.99	12.89	17.14	22.78	29.6	37.12	44.45	51.43	57.78	63.33
23/3/83	210.53	7.4782	0	0	0.13	0.35	0.66	1.04	1.41	1.67	1.75	1.75	1.75	1.95	2.91	5.08	8.85	14.37	21.49	29.74	38.51	46.98	54.5	61.04
23/3/102	210.72	7.4845	0	0	0.07	0.24	0.57	1.02	1.5	1.86	1.98	1.98	2.03	2.54	3.96	6.73	11.16	17.28	24.83	33.29	41.9	49.81	56.92	63.05
23/3/117	210.87	7.4896	0	0	0.07	0.24	0.57	1.04	1.56	1.99	2.18	2.18	2.19	2.48	3.53	5.79	9.59	15.03	21.95	29.9	38.33	46.51	53.85	60.33
23/3/136	211.06	7.4959	0	0.01	0.14	0.41	0.8	1.25	1.67	1.95	2.04	2.04	2.06	2.46	3.73	6.32	10.57	16.55	24.02	32.47	41.14	49.15	56.4	62.68
23/4/7 avg	211.27	7.503	0	0.1	0.3	0.62	1.06	1.6	2.14	2.56	2.78	2.87	3.02	3.6	5.04	7.73	11.97	17.78	24.95	33	41.27	48.94	55.91	61.98
23/4/32	211.52	7.5113	0	0.07	0.26	0.55	0.96	1.45	1.91	2.23	2.34	2.34	2.35	2.7	3.93	6.53	10.88	17.08	24.89	33.73	42.71	50.8	57.92	63.9
23/4/52	211.72	7.518	0	0	0.15	0.41	0.78	1.24	1.68	2	2.12	2.12	2.13	2.42	3.58	6.11	10.4	16.56	24.35	33.19	42.18	50.29	57.44	63.47
23/4/73	211.93	7.5251	0	0	0.2	0.52	0.96	1.49	2.01	2.4	2.58	2.58	2.59	2.89	4.01	6.45	10.61	16.62	24.28	33.05	42.04	50.19	57.41	63.49
23/4/93	212.13	7.5318	0	0.01	0.2	0.59	1.15	1.83	2.52	3.09	3.45	3.61	3.72	4.09	5.15	7.38	11.17	16.68	23.77	31.99	40.54	48.41	55.49	61.57
23/4/112	212.32	7.5381	0	0	0.16	0.48	0.96	1.57	2.21	2.76	3.13	3.3	3.43	3.85	5.03	7.48	11.6	17.54	25.1	33.74	42.57	50.55	57.58	63.49
23/4/133	212.53	7.5452	0	0	0.17	0.48	0.93	1.49	2.05	2.48	2.68	2.69	2.71	3.1	4.44	7.27	12	18.7	27	36.17	45.2	53.08	59.8	65.31
23/5/1	212.71	7.5512	0	0	0.18	0.53	1.04	1.68	2.34	2.9	3.26	3.43	3.58	4.07	5.4	8.07	12.46	18.64	26.29	34.76	43.16	50.61	57.11	62.6
23/5/24	212.94	7.5589	0	0	0.2	0.55	1.05	1.67	2.29	2.77	3.01	3.02	3.03	3.36	4.6	7.32	11.92	18.48	26.65	35.69	44.59	52.37	59.04	64.55
23/5/42	213.12	7.5649	0	0	0.19	0.55	1.07	1.73	2.41	2.98	3.32	3.43	3.49	3.87	5.1	7.72	12.16	18.52	26.49	35.4	44.26	52.08	58.85	64.49

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
23/5/83 avg	213.53	7.5787	0	0	0.19	0.54	1.06	1.68	2.31	2.82	3.12	3.23	3.33	3.77	5.05	7.68	12.05	18.26	26.05	34.81	43.61	51.46	58.31	64.04
23/5/102	213.72	7.585	0	0	0.07	0.24	0.57	1.05	1.61	2.08	2.31	2.31	2.36	2.87	4.35	7.31	12.09	18.73	26.85	35.76	44.52	52.22	58.85	64.36
23/5/122	213.92	7.5917	0	0	0.17	0.48	0.93	1.49	2.03	2.43	2.61	2.61	2.64	3.09	4.49	7.36	12.06	18.63	26.72	35.65	44.49	52.29	59.05	64.68
23/5/142	214.12	7.5984	0	0	0.16	0.45	0.86	1.37	1.87	2.27	2.48	2.53	2.59	3.01	4.24	6.75	10.91	16.83	24.27	32.69	41.28	49.11	56.11	62.11
23/6/7	214.27	7.6034	0	0.01	0.18	0.52	1.02	1.62	2.23	2.73	3.03	3.16	3.27	3.68	4.85	7.26	11.31	17.16	24.66	33.32	42.28	50.47	57.76	63.92
23/6/31	214.51	7.6115	0	0.01	0.16	0.48	0.95	1.5	2.01	2.36	2.47	2.47	2.49	2.9	4.26	7.08	11.71	18.2	26.24	35.19	44.13	52.09	59.04	64.85
23/6/52	214.72	7.6185	0	0	0.21	0.55	1.02	1.58	2.11	2.49	2.64	2.64	2.67	3.13	4.55	7.43	12.12	18.65	26.68	35.53	44.29	52.06	58.81	64.46
23/6/85	215.05	7.6296	0	0	0.17	0.46	0.86	1.35	1.82	2.15	2.25	2.25	2.26	2.59	3.86	6.61	11.22	17.76	25.88	34.88	43.79	51.66	58.49	64.21
23/6/111	215.31	7.6383	0	0	0.16	0.44	0.84	1.33	1.78	2.08	2.13	2.13	2.13	2.43	3.74	6.62	11.47	18.36	26.9	36.32	45.58	53.66	60.56	66.21
23/6/133	215.53	7.6456	0	0	0.2	0.54	1.02	1.61	2.17	2.57	2.73	2.73	2.76	3.23	4.74	7.86	12.96	20.07	28.74	38.16	47.26	55.07	61.65	66.99
23/7/1 avg	215.71	7.6517	0	0	0.17	0.49	0.93	1.47	1.99	2.35	2.42	2.42	2.42	2.55	3.64	6.27	10.91	17.63	26.06	35.38	44.51	52.44	59.19	64.76
23/7/23	215.93	7.659	0	0.15	0.42	0.8	1.3	1.87	2.39	2.73	2.81	2.81	2.82	3.18	4.56	7.48	12.32	19.1	27.42	36.55	45.5	53.33	60.03	65.55
23CC/7	216.22	7.6688	0	0.16	0.47	0.91	1.5	2.19	2.85	3.34	3.58	3.6	3.62	4.02	5.38	8.23	12.96	19.62	27.84	36.88	45.75	53.5	60.15	65.66
24/1/1	216.31	7.6718	0	0	0.21	0.55	1.02	1.59	2.14	2.54	2.68	2.68	2.68	2.79	3.73	6.03	10.11	16.1	23.71	32.29	40.9	48.6	55.39	61.21
24/1/27	216.57	7.6805	0	0.08	0.28	0.58	1	1.5	1.98	2.31	2.4	2.4	2.4	2.58	3.67	6.19	10.57	16.9	24.87	33.8	42.71	50.63	57.54	63.37
24/1/43	216.73	7.6858	0	0	0.16	0.47	0.92	1.49	2.06	2.49	2.69	2.69	2.7	3.04	4.29	6.97	11.47	17.85	25.76	34.51	43.15	50.77	57.39	62.97
24/1/64	216.94	7.6929	0	0.08	0.29	0.68	1.31	2.19	3.16	3.99	4.46	4.52	4.54	4.93	6.33	9.32	14.28	21.23	29.71	38.87	47.67	55.2	61.53	66.69
24/1/82	217.12	7.6989	0	0.01	0.21	0.64	1.26	2	2.73	3.29	3.57	3.61	3.63	4.09	5.58	8.7	13.85	21.03	29.75	39.1	47.98	55.5	61.76	66.84
24/1/104	217.34	7.7063	0	0	0.1	0.34	0.76	1.38	2.06	2.59	2.77	2.77	2.79	3.25	4.86	8.22	13.74	21.42	30.72	40.62	49.77	57.51	63.87	68.94
24/1/123	217.53	7.7126	0	0.01	0.19	0.56	1.09	1.69	2.21	2.51	2.53	2.53	2.57	3.23	5.25	9.23	15.51	23.97	33.93	44.2	53.18	60.75	66.82	71.52
24/1/142 avg	217.72	7.719	0	0.02	0.2	0.59	1.13	1.76	2.3	2.61	2.63	2.63	2.63	3.01	4.66	8.2	14.03	22.11	31.81	41.94	50.84	58.4	64.52	69.34
24/2/12	217.92	7.7257	0	0.02	0.21	0.6	1.15	1.78	2.33	2.65	2.67	2.67	2.67	2.82	4.13	7.27	12.7	20.43	29.89	39.99	49.42	57.2	63.5	68.48
24/2/28	218.08	7.7311	0	0	0.16	0.51	1.02	1.61	2.12	2.41	2.43	2.43	2.43	2.63	4.05	7.27	12.75	20.49	29.91	39.95	49.35	57.14	63.47	68.51
24/2/46	218.26	7.7371	0	0	0.15	0.48	0.97	1.55	2.07	2.39	2.41	2.41	2.41	2.6	3.97	7.11	12.47	20.07	29.34	39.25	48.55	56.29	62.62	67.7
24/2/72	218.52	7.7458	0	0.01	0.15	0.44	0.86	1.33	1.73	1.92	1.93	1.93	1.93	2.27	3.83	7.2	12.76	20.47	29.72	39.48	48.59	56.2	62.47	67.55
24/2/87	218.67	7.7508	0	0	0.17	0.46	0.86	1.35	1.79	2.06	2.08	2.08	2.08	2.36	3.74	6.8	11.96	19.22	28.06	37.54	46.53	54.17	60.59	65.9
24/2/107	218.87	7.7575	0	0	0.21	0.55	1.01	1.55	2.04	2.35	2.38	2.38	2.38	2.67	4.03	7.02	12.03	19.07	27.67	36.95	45.84	53.49	59.99	65.4
24/2/135	219.15	7.7669	0	0.03	0.23	0.62	1.17	1.8	2.37	2.73	2.77	2.77	2.77	2.91	4.09	6.87	11.67	18.54	27.05	36.36	45.4	53.24	59.94	65.51
24/3/1	219.31	7.7723	0	0.01	0.19	0.57	1.11	1.73	2.28	2.61	2.63	2.63	2.63	2.89	4.33	7.53	12.91	20.47	29.67	39.55	48.91	56.8	63.32	68.56
24/3/23	219.53	7.7796	0	0	0.16	0.43	0.81	1.27	1.67	1.86	1.87	1.87	1.87	2.13	3.67	7.1	12.89	21.05	30.98	41.52	51.14	59.13	65.57	70.6
24/3/42 avg	219.72	7.786	0	0	0.16	0.44	0.84	1.3	1.71	1.92	1.93	1.93	1.93	2.1	3.49	6.72	12.3	20.29	30.15	40.76	50.7	58.86	65.4	70.5
24/3/56	219.86	7.7907	0	0	0.12	0.35	0.69	1.12	1.52	1.74	1.75	1.75	1.75	1.97	3.4	6.66	12.24	20.18	29.92	40.38	50.2	58.31	64.85	69.98
24/3/82	220.12	7.7994	0	0	0.19	0.53	1.01	1.6	2.16	2.55	2.67	2.67	2.69	3.11	4.66	7.95	13.41	21.07	30.42	40.48	50.01	57.97	64.47	69.63
24/3/102	220.32	7.8061	0	0.01	0.18	0.54	1.07	1.69	2.27	2.68	2.84	2.84	2.94	3.64	5.55	9.27	15.17	23.22	32.86	43	52.03	59.78	66.1	71.07
24/3/116	220.46	7.8108	0	0.01	0.2	0.59	1.15	1.81	2.43	2.85	2.96	2.96	2.96	3.14	4.39	7.29	12.32	19.56	28.57	38.47	48.03	56.16	62.92	68.35
24/3/133	220.63	7.8165	0	0	0.19	0.59	1.18	1.89	2.58	3.1	3.33	3.33	3.33	3.46	4.53	7.12	11.73	18.49	27.06	36.63	46.03	54.15	61.02	66.63
24/4/7	220.87	7.8245	0	0	0.23	0.62	1.16	1.82	2.46	2.92	3.09	3.09	3.09	3.31	4.57	7.47	12.48	19.67	28.6	38.37	47.8	55.82	62.51	67.91

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
24/4/32	221.12	7.8329	0	0	0.15	0.44	0.86	1.38	1.89	2.25	2.34	2.34	2.34	2.61	3.97	7.04	12.28	19.74	28.94	38.93	48.47	56.51	63.14	68.44
24/4/47	221.27	7.8379	0	0	0.18	0.5	0.95	1.5	2.01	2.35	2.4	2.4	2.4	2.69	4.14	7.38	12.87	20.64	30.17	40.45	50.21	58.37	65.02	70.26
24/4/72	221.52	7.8463	0	0	0.21	0.58	1.11	1.76	2.41	2.94	3.25	3.39	3.58	4.24	5.94	9.24	14.53	21.84	30.73	40.27	49.11	56.75	63.13	68.28
24/4/86 avg	221.66	7.851	0	0	0.15	0.44	0.85	1.34	1.79	2.06	2.08	2.08	2.08	2.31	3.65	6.67	11.84	19.23	28.38	38.35	47.91	55.99	62.68	68.03
24/4/112	221.92	7.8597	0	0	0.17	0.48	0.92	1.46	1.98	2.34	2.43	2.43	2.43	2.65	3.91	6.79	11.77	18.96	27.98	37.96	47.67	55.94	62.8	68.27
24/4/133	222.13	7.8667	0	0	0.18	0.5	0.96	1.52	2.06	2.45	2.58	2.58	2.58	2.74	3.87	6.55	11.27	18.17	26.92	36.72	46.37	54.68	61.66	67.29
24/5/1	222.31	7.8728	0	0	0.18	0.49	0.92	1.45	1.95	2.29	2.37	2.37	2.37	2.47	3.45	5.92	10.37	16.99	25.51	35.19	44.84	53.22	60.3	66.04
24/5/15	222.45	7.8774	0	0	0.16	0.44	0.84	1.34	1.83	2.2	2.35	2.35	2.35	2.52	3.56	6.04	10.44	16.95	25.3	34.79	44.26	52.5	59.49	65.18
24/5/43	222.73	7.8868	0	0	0.15	0.47	0.93	1.48	1.99	2.35	2.47	2.47	2.48	2.76	3.97	6.66	11.27	17.93	26.31	35.66	44.87	52.86	59.63	65.17
24/5/63	222.93	7.8935	0	0	0.08	0.3	0.64	1.08	1.5	1.76	1.77	1.77	1.77	1.92	3.18	6.16	11.35	18.84	28.18	38.37	48.11	56.27	62.95	68.23
24/5/84	223.14	7.9006	0	0	0.11	0.33	0.65	1.05	1.41	1.6	1.61	1.61	1.61	1.84	3.21	6.33	11.67	19.31	28.77	39.05	48.83	56.99	63.64	68.89
24/5/103	223.33	7.9069	0	0	0.18	0.46	0.85	1.31	1.71	1.92	1.93	1.93	1.93	2.08	3.34	6.27	11.35	18.67	27.79	37.77	47.34	55.41	62.07	67.4
24/5/118	223.48	7.9119	0	0	0.21	0.54	1	1.55	2.05	2.38	2.42	2.42	2.42	2.55	3.7	6.44	11.25	18.26	27.09	36.87	46.38	54.5	61.27	66.72
24/5/142 avg	223.72	7.92	0	0	0.15	0.46	0.91	1.44	1.9	2.17	2.18	2.18	2.18	2.37	3.65	6.61	11.71	19.03	28.15	38.18	47.87	56.09	62.89	68.32
24/6/7	223.87	7.925	0	0	0.19	0.52	0.97	1.52	2.03	2.37	2.44	2.44	2.44	2.56	3.65	6.28	10.94	17.76	26.4	36.06	45.56	53.76	60.67	66.3
24/6/27	224.07	7.9317	0	0.01	0.18	0.55	1.08	1.71	2.3	2.72	2.87	2.87	2.87	3.1	4.32	7.12	12	19.11	28.1	38.14	47.96	56.31	63.22	68.7
24/6/47	224.27	7.9384	0	0	0.26	0.64	1.18	1.82	2.43	2.87	3.03	3.03	3.03	3.26	4.47	7.27	12.16	19.3	28.34	38.44	48.3	56.64	63.5	68.92
24/6/67	224.47	7.9451	0	0	0.19	0.52	0.99	1.56	2.12	2.54	2.7	2.7	2.7	2.79	3.7	6.11	10.57	17.31	26.07	36.07	45.99	54.47	61.52	67.13
24/6/86	224.66	7.9515	0	0	0.16	0.5	1	1.59	2.15	2.55	2.7	2.7	2.72	3.1	4.49	7.47	12.49	19.67	28.64	38.58	48.25	56.45	63.22	68.6
24/6/107	224.87	7.9585	0	0	0.17	0.47	0.9	1.43	1.92	2.24	2.28	2.28	2.28	2.44	3.67	6.57	11.65	19.04	28.33	38.59	48.48	56.77	63.54	68.87
24/6/132	225.12	7.9669	0	0.01	0.2	0.59	1.15	1.81	2.44	2.91	3.13	3.14	3.17	3.63	5.09	8.12	13.14	20.22	28.96	38.54	47.83	55.75	62.35	67.65
24CC/9	225.36	7.9749	0	0.19	0.55	1.06	1.73	2.51	3.27	3.86	4.19	4.28	4.33	4.73	6.02	8.75	13.35	19.92	28.15	37.32	46.35	54.18	60.81	66.23
25/1/1	225.91	7.9933	0	0.05	0.29	0.72	1.35	2.13	2.95	3.66	4.14	4.37	4.47	4.78	5.8	8.09	12.12	18.11	25.88	34.8	43.81	51.72	58.51	64.11
25/1/23	226.13	8.0007	0	0.12	0.42	0.88	1.52	2.29	3.09	3.81	4.37	4.81	5.3	6.21	8	11.18	16.1	22.85	31.1	40.09	48.45	55.96	62.37	67.62
25/1/42 avg	226.32	8.0071	0	0.08	0.38	0.86	1.53	2.35	3.19	3.91	4.41	4.71	5.01	5.69	7.25	10.27	15.12	21.93	30.35	39.58	48.15	55.84	62.39	67.72
25/1/63	226.53	8.0141	0	0.12	0.43	0.92	1.6	2.44	3.3	4.06	4.62	4.98	5.29	5.88	7.23	9.84	14.11	20.16	27.73	36.22	44.69	52.17	58.67	64.15
25/1/85	226.75	8.0215	0	0.18	0.54	1.06	1.76	2.59	3.43	4.17	4.73	5.12	5.49	6.16	7.58	10.25	14.56	20.65	28.29	36.89	45.5	53.1	59.67	65.16
25/1/103	226.93	8.0275	0	0.18	0.53	1.03	1.69	2.47	3.25	3.9	4.34	4.58	4.79	5.29	6.56	9.09	13.29	19.3	26.9	35.52	44.21	51.94	58.68	64.33
25/1/125	227.13	8.0342	0	0.01	0.19	0.57	1.12	1.78	2.43	2.94	3.23	3.31	3.36	3.74	4.92	7.43	11.65	17.71	25.36	34.01	42.73	50.52	57.35	63.14
25/1/144	227.34	8.0412	0	0.21	0.58	1.1	1.77	2.55	3.32	3.96	4.41	4.72	5.11	5.92	7.59	10.55	15.09	21.24	28.73	36.98	45.16	52.43	58.77	64.12
25/2/5	227.45	8.0449	0	0.16	0.49	0.97	1.61	2.37	3.13	3.77	4.21	4.47	4.72	5.3	6.67	9.3	13.57	19.57	27.05	35.41	43.77	51.2	57.68	63.16
25/2/32	227.72	8.054	0	0.14	0.44	0.89	1.5	2.23	2.97	3.62	4.11	4.47	4.87	5.65	7.26	10.15	14.66	20.85	28.45	36.87	45.23	52.62	59.03	64.42
25/2/53	227.93	8.061	0	0.08	0.27	0.59	1.1	1.79	2.55	3.24	3.73	4.03	4.29	5	6.6	9.56	14.2	20.56	28.34	36.92	45.4	52.88	59.35	64.77
25/2/72	228.12	8.0674	0	0.18	0.52	1.01	1.66	2.43	3.18	3.79	4.19	4.42	4.68	5.34	6.87	9.74	14.27	20.53	28.23	36.78	45.3	52.86	59.45	65
25/2/95	228.35	8.0751	0	0.24	0.64	1.2	1.91	2.74	3.54	4.18	4.59	4.82	5.09	5.76	7.31	10.22	14.82	21.17	28.97	37.6	46.15	53.69	60.21	65.66
25/2/112 avg	228.52	8.0808	0	0.18	0.54	1.08	1.8	2.62	3.41	4.03	4.4	4.57	4.76	5.39	6.97	10.01	14.87	21.59	29.84	38.87	47.58	55.24	61.77	67.14
25/2/134	228.74	8.0881	0	0.18	0.55	1.1	1.83	2.7	3.56	4.27	4.74	5	5.23	5.79	7.17	9.86	14.23	20.39	28.07	36.67	45.24	52.8	59.34	64.81

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
25/3/0	228.9	8.0935	0	0.22	0.62	1.19	1.93	2.8	3.66	4.38	4.88	5.18	5.44	6	7.3	9.83	13.96	19.82	27.2	35.55	43.98	51.5	58.08	63.64
25/3/23	229.13	8.1012	0	0.19	0.56	1.1	1.81	2.66	3.51	4.25	4.79	5.13	5.43	6.01	7.31	9.81	13.88	19.66	26.95	35.23	43.62	51.15	57.79	63.43
25/3/43	229.33	8.1079	0	0.2	0.57	1.09	1.77	2.57	3.34	3.97	4.38	4.61	4.85	5.44	6.84	9.54	13.89	20	27.62	36.15	44.68	52.25	58.83	64.36
25/3/63	229.53	8.1146	0	0.16	0.51	1.03	1.73	2.57	3.42	4.15	4.67	5.02	5.37	6.06	7.55	10.31	14.7	20.83	28.48	37.08	45.72	53.4	60.08	65.67
25/3/95	229.85	8.1253	0	0.15	0.48	0.98	1.66	2.47	3.27	3.93	4.35	4.57	4.78	5.35	6.76	9.52	14	20.31	28.18	36.99	45.75	53.44	60.05	65.53
25/3/118	230.08	8.133	0	0.2	0.56	1.06	1.71	2.47	3.21	3.82	4.24	4.53	4.91	5.75	7.51	10.64	15.44	21.93	29.77	38.32	46.68	54	60.3	65.56
25/3/137	230.27	8.1394	0	0.11	0.47	1.06	1.88	2.82	3.73	4.47	4.97	5.27	5.6	6.33	7.95	10.93	15.59	21.98	29.78	38.3	46.31	53.64	60.03	65.41
25/4/7	230.47	8.1461	0	0.22	0.59	1.1	1.76	2.51	3.22	3.78	4.13	4.33	4.59	5.29	6.9	9.88	14.55	20.95	28.75	37.32	45.75	53.17	59.58	64.95
25/4/32	230.72	8.1545	0	0.06	0.2	0.46	0.88	1.45	2.06	2.56	2.79	2.79	2.81	3.2	4.49	7.2	11.72	18.15	26.19	35.17	44.08	51.9	58.64	64.26
25/4/53 avg	230.93	8.1615	0	0.09	0.3	0.62	1.09	1.66	2.25	2.71	2.97	3.05	3.16	3.68	5.08	7.87	12.39	18.72	26.56	35.28	43.91	51.51	58.09	63.6
25/4/74	231.14	8.1685	0	0.01	0.18	0.54	1.06	1.68	2.27	2.73	2.98	3.06	3.18	3.71	5.16	8.04	12.73	19.31	27.44	36.43	45.29	53.04	59.7	65.24
25/4/93	231.33	8.1749	0	0.08	0.31	0.69	1.21	1.77	2.26	2.58	2.71	2.78	3.08	4.08	6.3	10.22	16.07	23.72	32.65	41.95	50.33	57.66	63.79	68.76
25/4/112	231.52	8.1813	0	0.03	0.2	0.53	0.99	1.51	1.98	2.3	2.42	2.42	2.53	3.13	4.7	7.72	12.49	19.02	26.95	35.62	44.12	51.61	58.09	63.55
25/4/133	231.73	8.1883	0	0.01	0.18	0.53	1.04	1.65	2.25	2.75	3.08	3.29	3.59	4.34	6	9.01	13.68	20.03	27.73	36.15	44.43	51.75	58.13	63.54
25/5/1	231.91	8.1943	0	0.06	0.26	0.59	1.04	1.53	1.97	2.26	2.36	2.36	2.42	2.95	4.41	7.27	11.84	18.17	25.94	34.51	43	50.55	57.15	62.77
25/5/16	232.06	8.1994	0	0.04	0.25	0.63	1.16	1.76	2.31	2.7	2.9	2.98	3.17	3.85	5.5	8.56	13.33	19.81	27.65	36.21	44.63	52.07	58.54	64
25/5/38	232.28	8.2067	0	0.16	0.48	0.94	1.54	2.25	2.95	3.53	3.94	4.24	4.64	5.51	7.28	10.37	15.05	21.34	28.94	37.29	45.59	53	59.5	65.02
25/5/62	232.52	8.2148	0	0	0.29	0.71	1.3	2	2.68	3.23	3.57	3.75	3.98	4.61	6.13	9.02	13.64	20.07	28.02	36.88	45.7	53.48	60.2	65.79
25/5/82	232.72	8.2215	0	0.17	0.5	0.97	1.59	2.32	3.05	3.66	4.08	4.34	4.62	5.26	6.72	9.48	13.89	20.05	27.71	36.28	44.86	52.5	59.16	64.77
25/5/102 avg	232.92	8.2282	0	0.13	0.42	0.85	1.43	2.1	2.74	3.22	3.5	3.64	3.85	4.54	6.18	9.28	14.18	20.91	29.14	38.21	47.14	54.94	61.59	67.06
25/5/117	233.07	8.2332	0	0.1	0.38	0.85	1.49	2.21	2.89	3.42	3.78	4.06	4.52	5.54	7.58	11.06	16.24	23.09	31.24	39.98	48.1	55.43	61.74	66.96
25/5/137	233.27	8.2399	0	0.01	0.2	0.59	1.16	1.84	2.48	2.96	3.19	3.23	3.32	3.87	5.4	8.42	13.29	20.05	28.35	37.51	46.53	54.41	61.14	66.68
25/6/7	233.47	8.2466	0	0.15	0.45	0.89	1.48	2.17	2.84	3.36	3.65	3.74	3.82	4.24	5.5	8.12	12.5	18.78	26.74	35.77	44.86	52.9	59.85	65.62
25/6/27	233.67	8.2533	0	0.16	0.47	0.92	1.52	2.23	2.92	3.47	3.79	3.91	4.04	4.57	6.03	8.95	13.73	20.47	28.85	38.18	47.39	55.36	62.1	67.58
25/6/48	233.88	8.2603	0	0.01	0.19	0.55	1.07	1.7	2.33	2.86	3.22	3.45	3.71	4.31	5.7	8.36	12.68	18.83	26.6	35.44	44.38	52.31	59.18	64.9
25/6/75	234.15	8.2694	0	0.25	0.67	1.26	2.01	2.88	3.74	4.46	4.97	5.29	5.6	6.25	7.72	10.51	15.02	21.37	29.3	38.19	47.05	54.81	61.46	66.94
25/6/93	234.33	8.2754	0	0.21	0.58	1.09	1.75	2.53	3.3	3.95	4.42	4.72	5.02	5.65	7.05	9.72	14.06	20.22	28.01	36.87	45.85	53.84	60.78	66.55
25/6/112	234.52	8.2818	0	0.19	0.53	1.01	1.63	2.35	3.07	3.68	4.1	4.34	4.57	5.13	6.47	9.1	13.41	19.55	27.32	36.18	45.18	53.22	60.24	66.1
25/6/133	234.73	8.2888	0	0.04	0.27	0.68	1.27	1.94	2.57	3.04	3.31	3.41	3.54	4.03	5.34	7.95	12.24	18.35	26.09	34.94	43.96	52.06	59.15	65.09
25/7/1	234.91	8.2948	0	0.22	0.6	1.13	1.81	2.6	3.36	3.97	4.36	4.57	4.8	5.39	6.82	9.56	13.99	20.21	28	36.8	45.71	53.68	60.64	66.46
25/7/17 avg	235.07	8.3002	0	0.2	0.58	1.13	1.86	2.7	3.52	4.23	4.75	5.14	5.55	6.3	7.79	10.43	14.57	20.3	27.47	35.61	43.95	51.56	58.35	64.17
25cc/10	235.26	8.3065	0	0.1	0.39	0.86	1.51	2.25	2.97	3.59	4.07	4.46	4.92	5.73	7.28	9.98	14.16	19.95	27.19	35.44	43.91	51.63	58.51	64.39
26/1/1	235.51	8.3149	0	0.17	0.5	0.98	1.61	2.36	3.12	3.78	4.27	4.66	5.14	6.08	7.95	11.19	16.11	22.73	30.72	39.39	47.54	54.99	61.5	67
26/1/23	235.73	8.3223	0	0.16	0.44	0.83	1.33	1.91	2.46	2.89	3.18	3.42	3.84	4.82	6.8	10.18	15.19	21.8	29.64	38.09	46.34	53.62	59.94	65.29
26/1/58	236.08	8.334	0	0.17	0.46	0.85	1.36	1.95	2.52	2.99	3.33	3.64	4.14	5.2	7.26	10.73	15.86	22.62	30.64	39.24	47.3	54.64	61.05	66.46
26/1/82	236.32	8.342	0	0.16	0.45	0.84	1.35	1.93	2.46	2.84	3.05	3.19	3.5	4.35	6.17	9.37	14.19	20.61	28.29	36.63	44.85	52.17	58.59	64.08
26/1/102	236.52	8.3487	0	0.16	0.44	0.83	1.34	1.92	2.48	2.93	3.26	3.56	4.06	5.11	7.12	10.46	15.36	21.77	29.37	37.58	45.63	52.78	59.03	64.35

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
26/1/117	236.67	8.3538	0	0.01	0.2	0.6	1.17	1.84	2.48	2.99	3.35	3.66	4.15	5.19	7.2	10.57	15.55	22.11	29.92	38.33	46.25	53.5	59.86	65.25
26/1/142	236.92	8.3621	0	0.16	0.48	0.94	1.55	2.27	2.99	3.61	4.08	4.47	4.97	5.91	7.73	10.85	15.55	21.88	29.55	37.91	45.82	53.1	59.5	64.93
26/2/13	237.13	8.3692	0	0.1	0.4	0.9	1.6	2.4	3.19	3.87	4.41	4.87	5.44	6.44	8.26	11.3	15.84	21.94	29.35	37.47	45.19	52.33	58.64	64.03
26/2/32 avg	237.32	8.3755	0	0.03	0.24	0.65	1.22	1.92	2.64	3.29	3.8	4.24	4.79	5.78	7.62	10.74	15.43	21.76	29.46	37.88	45.86	53.19	59.64	65.1
26/2/56	237.56	8.3836	0	0.15	0.45	0.88	1.45	2.12	2.78	3.34	3.76	4.13	4.65	5.67	7.6	10.84	15.65	22.05	29.74	38.06	45.89	53.07	59.37	64.74
26/2/93	237.93	8.396	0	0.16	0.48	0.94	1.56	2.29	3.02	3.63	4.07	4.36	4.69	5.39	6.92	9.75	14.22	20.42	28.1	36.67	45.23	52.85	59.51	65.15
26/2/112	238.12	8.4023	0	0.23	0.66	1.28	2.09	3.04	4.01	4.86	5.51	5.98	6.42	7.15	8.61	11.26	15.46	21.32	28.62	36.83	45.09	52.47	58.96	64.48
26/2/133	238.33	8.4094	0	0.2	0.62	1.25	2.09	3.1	4.13	5.04	5.73	6.22	6.68	7.46	9.02	11.86	16.35	22.62	30.43	39.1	47.33	54.9	61.51	67.05
26/3/1	238.51	8.4154	0	0.18	0.54	1.07	1.78	2.63	3.5	4.26	4.82	5.18	5.5	6.11	7.46	10.05	14.26	20.24	27.77	36.28	44.85	52.46	59.1	64.7
26/3/22	238.72	8.4224	0	0	0.22	0.63	1.23	1.98	2.76	3.42	3.88	4.16	4.47	5.18	6.78	9.78	14.55	21.17	29.32	38.33	47.2	54.92	61.5	66.93
26/3/43	238.93	8.4295	0	0.01	0.21	0.64	1.26	2.03	2.81	3.49	3.97	4.29	4.63	5.36	6.96	9.92	14.61	21.09	29.05	37.82	46.43	53.94	60.37	65.7
26/3/56	239.06	8.4338	0	0	0.17	0.55	1.11	1.8	2.49	3.06	3.41	3.56	3.69	4.17	5.53	8.33	12.99	19.63	27.95	37.23	46.4	54.38	61.18	66.76
26/3/82	239.32	8.4425	0	0.2	0.58	1.13	1.85	2.7	3.54	4.23	4.7	5.01	5.41	6.3	8.2	11.59	16.77	23.71	32	40.82	48.92	56.14	62.3	67.38
26/3/102	239.52	8.4492	0	0.19	0.57	1.12	1.85	2.71	3.56	4.27	4.76	5.09	5.48	6.33	8.15	11.44	16.51	23.36	31.58	40.38	48.47	55.69	61.83	66.87
26/3/117 avg	239.67	8.4543	0	0.17	0.52	1.06	1.77	2.63	3.48	4.21	4.73	5.08	5.49	6.35	8.17	11.47	16.57	23.47	31.77	40.65	48.79	56.02	62.13	67.13
26/3/133	239.83	8.4596	0	0	0.26	0.77	1.53	2.43	3.33	4.06	4.52	4.75	4.98	5.61	7.17	10.2	15.08	21.86	30.17	39.21	47.6	55.14	61.58	66.87
26/4/7	240.07	8.4677	0	0.23	0.69	1.37	2.27	3.33	4.38	5.23	5.79	6.12	6.48	7.32	9.19	12.6	17.84	24.87	33.22	42.05	50.08	57.17	63.16	68.05
26/4/32	240.32	8.476	0	0.25	0.68	1.29	2.07	2.98	3.85	4.55	5.03	5.39	5.92	7.1	9.49	13.58	19.61	27.45	36.5	45.8	54.03	61.07	66.82	71.37
26/4/52	240.52	8.4827	0	0	0.25	0.62	1.14	1.75	2.31	2.69	2.86	2.93	3.22	4.25	6.59	10.75	16.95	25.01	34.29	43.78	52.19	59.43	65.42	70.23
26/4/72	240.72	8.4894	0	0.01	0.21	0.61	1.19	1.86	2.46	2.86	2.99	2.99	3.11	3.88	5.88	9.63	15.41	23.09	32.08	41.43	49.85	57.23	63.44	68.53
26/4/92	240.92	8.4961	0	0.12	0.47	1.03	1.79	2.62	3.37	3.89	4.15	4.27	4.56	5.53	7.74	11.7	17.65	25.43	34.44	43.71	51.96	59.11	65.06	69.88
26/4/112	241.12	8.5028	0	0.14	0.45	0.92	1.55	2.3	3.03	3.6	3.94	4.13	4.44	5.34	7.4	11.13	16.83	24.42	33.36	42.71	51.11	58.43	64.54	69.49
26/4/132	241.32	8.5095	0	0.08	0.35	0.8	1.42	2.13	2.81	3.35	3.7	3.94	4.32	5.25	7.24	10.78	16.16	23.35	31.9	40.98	49.28	56.65	62.89	67.99
26/5/0	241.5	8.5156	0	0.21	0.61	1.18	1.93	2.81	3.66	4.34	4.78	5.06	5.45	6.37	8.36	11.94	17.42	24.78	33.54	42.81	51.21	58.59	64.77	69.76
26/5/15	241.65	8.5206	0	0.2	0.61	1.22	2.04	3.02	3.99	4.79	5.34	5.7	6.1	6.96	8.81	12.17	17.36	24.38	32.81	41.81	50.03	57.32	63.47	68.48
26/5/42 avg	241.92	8.5296	0	0.26	0.72	1.35	2.17	3.11	4.01	4.71	5.13	5.32	5.56	6.3	8.09	11.47	16.73	23.84	32.33	41.34	49.55	56.81	62.95	67.98
26/5/63	242.13	8.5367	0	0.2	0.57	1.09	1.78	2.58	3.35	3.95	4.29	4.43	4.62	5.3	7.04	10.38	15.66	22.87	31.52	40.7	49.03	56.37	62.56	67.62
26/5/82	242.32	8.543	0	0.01	0.24	0.72	1.42	2.24	3.03	3.64	3.98	4.14	4.39	5.21	7.17	10.81	16.44	24	32.95	42.33	50.74	58.06	64.14	69.05
26/5/102	242.52	8.5497	0	0.18	0.52	1.01	1.66	2.41	3.11	3.63	3.9	4	4.19	4.91	6.7	10.07	15.33	22.44	30.93	39.95	48.21	55.56	61.82	66.99
26/5/117	242.67	8.5548	0	0.01	0.18	0.54	1.07	1.7	2.29	2.7	2.88	2.91	3.03	3.68	5.39	8.66	13.78	20.69	28.93	37.71	46.1	53.32	59.45	64.54
26/5/142	242.92	8.5631	0	0.07	0.31	0.71	1.25	1.85	2.39	2.77	2.95	3.03	3.28	4.16	6.19	9.85	15.38	22.65	31.11	39.88	47.77	54.69	60.55	65.39
26/6/7	243.07	8.5682	0	0.06	0.21	0.5	0.97	1.63	2.34	2.92	3.2	3.21	3.27	3.81	5.34	8.36	13.19	19.79	27.72	36.2	44.33	51.35	57.34	62.35
26/6/26	243.26	8.5745	0	0.14	0.52	1.13	1.96	2.9	3.8	4.52	5.01	5.41	6.04	7.39	9.99	14.27	20.38	28.07	36.69	45.32	52.87	59.31	64.63	68.94
26/6/47	243.47	8.5816	0	0.09	0.35	0.78	1.36	1.99	2.53	2.87	2.99	3.02	3.25	4.1	6.02	9.39	14.34	20.69	27.93	35.38	42.41	48.61	54.07	58.89
26/6/63	243.63	8.5869	0	0.03	0.2	0.53	0.98	1.48	1.9	2.15	2.19	2.19	2.28	2.9	4.47	7.35	11.69	17.38	24.04	31.13	38.07	44.43	50.24	55.52
26cc/13	243.86	8.5946	0	0.09	0.36	0.8	1.4	2.07	2.68	3.13	3.41	3.65	4.14	5.26	7.43	10.97	15.99	22.31	29.45	36.73	43.34	49.24	54.4	58.91
27/1/1 avg	245.11	8.6365	0	0.1	0.39	0.85	1.49	2.18	2.79	3.2	3.39	3.49	3.8	4.73	6.71	10.1	15.02	21.29	28.4	35.72	42.61	48.67	53.97	58.63

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
27/1/25	245.35	8.6445	0.05	0.22	0.52	0.95	1.49	2.07	2.61	3.03	3.32	3.58	4.04	5.06	7.02	10.27	14.96	20.98	27.94	35.27	42.35	48.7	54.37	59.38
27/1/43	245.53	8.6506	0	0.11	0.45	1	1.75	2.59	3.37	3.94	4.25	4.39	4.61	5.31	6.93	9.88	14.37	20.34	27.41	34.99	42.38	49	54.88	60.02
27/1/65	245.75	8.6579	0	0.09	0.34	0.74	1.29	1.9	2.48	2.94	3.27	3.54	3.95	4.79	6.41	9.1	13.02	18.1	24.06	30.49	36.93	43.01	48.74	54.11
27/1/81	245.91	8.6633	0	0.02	0.12	0.36	0.76	1.29	1.82	2.19	2.32	2.32	2.49	3.18	4.78	7.6	11.77	17.19	23.54	30.37	37.24	43.77	49.77	55.27
27/1/96	246.06	8.6683	0	0.05	0.25	0.6	1.09	1.64	2.13	2.47	2.65	2.76	3.04	3.82	5.45	8.2	12.18	17.27	23.15	29.41	35.68	41.71	47.41	52.83
27/1/117	246.27	8.6753	0	0.03	0.14	0.38	0.78	1.29	1.84	2.34	2.77	3.1	3.67	4.75	6.64	9.57	13.64	18.76	24.68	31.04	37.44	43.55	49.35	54.81
27/1/142	246.52	8.6837	0	0.03	0.17	0.47	0.96	1.61	2.3	2.9	3.33	3.65	3.98	4.74	6.27	8.87	12.69	17.68	23.57	29.97	36.47	42.72	48.56	54.01
27/2/5	246.65	8.6881	0	0.13	0.43	0.89	1.5	2.15	2.73	3.17	3.46	3.69	4.06	4.87	6.47	9.18	13.16	18.37	24.52	31.18	37.83	44.03	49.8	55.12
27/2/27	246.87	8.6954	0	0.05	0.26	0.64	1.17	1.77	2.34	2.8	3.13	3.4	3.81	4.65	6.26	8.93	12.8	17.81	23.66	29.95	36.23	42.15	47.74	53
27/2/53	247.13	8.7041	0	0.14	0.44	0.9	1.5	2.15	2.76	3.26	3.65	4.03	4.64	5.8	7.87	11.15	15.77	21.63	28.36	35.41	42.18	48.21	53.56	58.29
27/2/73 avg	247.33	8.7108	0	0.16	0.57	1.22	2.1	3.11	4.1	4.94	5.57	6.07	6.68	7.8	9.89	13.33	18.35	24.83	32.35	40.19	47.35	53.76	59.3	64
27/2/93	247.53	8.7175	0	0.26	0.74	1.43	2.34	3.41	4.48	5.41	6.14	6.72	7.36	8.43	10.38	13.64	18.45	24.78	32.26	40.2	47.52	54.11	59.8	64.57
27/2/107	247.67	8.7222	0	0.13	0.51	1.14	2	2.98	3.92	4.68	5.21	5.59	6.05	6.98	8.82	12	16.78	23.14	30.74	38.9	46.52	53.45	59.49	64.58
27/2/132	247.92	8.7306	0	0.09	0.41	0.94	1.68	2.52	3.32	3.97	4.43	4.78	5.24	6.17	8	11.13	15.79	21.96	29.29	37.12	44.41	51.03	56.84	61.81
27/3/1	248.11	8.737	0	0.15	0.57	1.25	2.18	3.23	4.23	5.04	5.61	6.02	6.51	7.46	9.34	12.57	17.4	23.79	31.36	39.4	46.81	53.48	59.24	64.1
27/3/16	248.26	8.742	0	0.21	0.61	1.19	1.95	2.85	3.75	4.53	5.12	5.58	6.1	7.04	8.86	12.02	16.82	23.29	31.06	39.39	47.07	53.94	59.84	64.76
27/3/37	248.47	8.749	0	0.23	0.67	1.32	2.19	3.21	4.22	5.06	5.66	6.11	6.65	7.67	9.64	13	18.01	24.62	32.42	40.64	48.14	54.79	60.47	65.2
27/3/56	248.66	8.7554	0	0.17	0.63	1.38	2.4	3.57	4.74	5.77	6.58	7.21	7.87	8.93	10.86	14.12	18.98	25.43	33.07	41.14	48.5	55.04	60.63	65.29
27/3/83	248.93	8.7644	0	0.23	0.66	1.29	2.12	3.1	4.07	4.9	5.51	5.94	6.4	7.27	8.99	12.01	16.61	22.78	30.16	38.04	45.33	51.91	57.63	62.49
27/3/104	249.14	8.7715	0	0.11	0.52	1.23	2.22	3.34	4.41	5.27	5.85	6.22	6.61	7.39	9.03	11.93	16.34	22.23	29.24	36.72	43.68	50.02	55.61	60.46
27/3/117	249.27	8.7758	0	0.2	0.62	1.25	2.1	3.11	4.1	4.91	5.44	5.73	5.99	6.58	7.94	10.52	14.61	20.24	27.11	34.64	42.07	48.71	54.59	59.73
27/3/142 avg	249.52	8.7842	0	0.17	0.57	1.2	2.04	3.01	3.98	4.82	5.47	5.98	6.5	7.35	8.93	11.65	15.78	21.37	28.14	35.56	42.87	49.39	55.13	60.09
27/4/7	249.67	8.7892	0	0.25	0.67	1.25	1.99	2.85	3.73	4.53	5.2	5.77	6.37	7.28	8.87	11.53	15.53	20.91	27.42	34.55	41.6	47.93	53.56	58.49
27/4/32	249.92	8.7976	0	0.04	0.16	0.42	0.85	1.48	2.2	2.87	3.34	3.62	3.91	4.43	5.71	8.11	11.9	17.08	23.38	30.3	37.22	43.58	49.39	54.66
27/4/52	250.12	8.8043	0	0.05	0.2	0.5	1	1.7	2.49	3.2	3.69	3.98	4.21	4.86	6.34	9.04	13.18	18.71	25.31	32.43	39.41	45.71	51.37	56.42
27/4/67	250.27	8.8093	0	0.17	0.53	1.06	1.78	2.64	3.53	4.34	5.01	5.58	6.21	7.2	8.95	11.83	16.1	21.77	28.54	35.87	43.06	49.48	55.16	60.11
27/4/86	250.46	8.8157	0	0.18	0.53	1.02	1.67	2.43	3.18	3.8	4.23	4.51	4.81	5.44	6.77	9.16	12.85	17.86	23.95	30.69	37.52	43.9	49.82	55.23
27/4/112	250.72	8.8244	0	0.06	0.21	0.49	0.93	1.54	2.21	2.81	3.21	3.44	3.66	4.29	5.74	8.4	12.53	18.14	24.97	32.53	40.13	47.05	53.26	58.67
27/4/132	250.92	8.8311	0	0.01	0.19	0.57	1.12	1.79	2.47	3.07	3.52	3.85	4.23	4.96	6.42	9	12.99	18.47	25.25	32.9	40.7	47.84	54.25	59.8
27/5/0	251.1	8.8371	0	0.06	0.29	0.69	1.27	1.99	2.74	3.39	3.86	4.14	4.35	4.76	5.77	7.83	11.33	16.48	23.21	31.13	39.47	47.23	54.17	60.17
27/5/23	251.33	8.8448	0	0.19	0.53	1	1.62	2.35	3.07	3.67	4.08	4.32	4.52	4.96	6.04	8.19	11.79	17.04	23.86	31.86	40.24	47.94	54.84	60.73
27/5/38	251.48	8.8499	0	0.18	0.53	1.03	1.69	2.47	3.26	3.96	4.5	4.89	5.28	5.94	7.25	9.63	13.42	18.76	25.53	33.33	41.4	48.8	55.43	61.12
27/5/57 avg	251.67	8.8562	0	0.09	0.32	0.69	1.23	1.9	2.62	3.27	3.74	4.03	4.24	4.63	5.61	7.61	11.01	15.99	22.47	30.06	38.17	45.98	52.88	58.88
27/5/83	251.93	8.8649	0	0.06	0.21	0.5	0.96	1.6	2.34	3.07	3.68	4.17	4.54	5.24	6.61	9.03	12.8	18.03	24.56	32.01	39.7	46.83	53.31	58.99
27/5/105	252.13	8.8716	0	0.15	0.47	0.94	1.58	2.34	3.12	3.8	4.32	4.68	5.01	5.58	6.78	9.01	12.63	17.78	24.35	31.95	39.88	47.25	53.95	59.81
27/5/118	252.28	8.8767	0	0.05	0.19	0.47	0.92	1.56	2.3	3.01	3.56	3.93	4.24	4.69	5.79	7.94	11.48	16.53	22.96	30.35	38.12	45.54	52.08	57.77
27/5/143	252.53	8.885	0	0.01	0.19	0.57	1.11	1.75	2.37	2.86	3.15	3.28	3.41	3.86	5.04	7.39	11.26	16.75	23.67	31.52	39.53	46.82	53.35	59

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
27/6/7	252.67	8.8897	0	0	0.22	0.64	1.25	2.01	2.78	3.42	3.81	3.95	4.02	4.36	5.43	7.72	11.6	17.19	24.26	32.29	40.45	47.85	54.44	60.12
27/6/32	252.92	8.8981	0	0.04	0.17	0.45	0.92	1.6	2.41	3.2	3.82	4.27	4.72	5.33	6.73	9.32	13.44	19.16	26.23	34.11	42.02	49.12	55.39	60.75
27/6/53	253.13	8.9051	0	0	0.18	0.57	1.15	1.85	2.54	3.07	3.35	3.41	3.45	3.84	5.08	7.68	11.98	18.06	25.61	34	42.36	49.78	56.26	61.73
27/6/73	253.33	8.9118	0	0	0.2	0.55	1.03	1.62	2.2	2.67	2.98	3.18	3.48	4.24	5.9	8.9	13.53	19.8	27.34	35.52	43.51	50.54	56.64	61.8
27/6/87	253.47	8.9165	0	0	0.28	0.7	1.29	1.99	2.66	3.16	3.41	3.45	3.47	3.85	5.08	7.66	11.95	18.03	25.58	33.98	42.35	49.8	56.33	61.88
27/6/107	253.67	8.9232	0	0.01	0.2	0.6	1.19	1.89	2.56	3.06	3.32	3.38	3.45	3.91	5.25	7.96	12.39	18.59	26.24	34.69	43.07	50.49	56.94	62.38
27/6/132 avg	253.92	8.9316	0	0.04	0.25	0.59	1.05	1.59	2.11	2.49	2.67	2.71	2.84	3.46	5.05	8.09	12.85	19.31	27.06	35.41	43.53	50.66	56.83	62.03
27/7/0	254.1	8.9376	0	0.17	0.49	0.95	1.56	2.28	2.95	3.44	3.68	3.73	3.84	4.43	6.03	9.14	14.08	20.83	28.97	37.76	46.28	53.7	60.06	65.36
27/7/17	254.27	8.9433	0	0.14	0.44	0.89	1.49	2.21	2.91	3.46	3.78	3.92	4.09	4.7	6.27	9.31	14.17	20.86	29	37.89	46.6	54.22	60.76	66.17
27CC/10	254.49	8.9533	0	0.14	0.43	0.86	1.43	2.1	2.73	3.18	3.36	3.36	3.38	3.82	5.28	8.31	13.27	20.15	28.51	37.58	46.37	53.97	60.42	65.73
28/1/4	254.74	8.9675	0	0.08	0.29	0.63	1.1	1.66	2.2	2.6	2.79	2.81	2.88	3.38	4.83	7.74	12.46	19.03	27.08	35.92	44.59	52.17	58.69	64.12
28/1/23	254.93	8.9783	0	0	0.21	0.56	1.04	1.62	2.17	2.57	2.73	2.73	2.75	3.2	4.68	7.76	12.83	19.94	28.7	38.32	47.71	55.81	62.64	68.16
28/1/42	255.12	8.9891	0	0	0.17	0.49	0.96	1.55	2.14	2.58	2.75	2.75	2.75	2.87	3.88	6.34	10.7	17.12	25.3	34.56	43.85	52.04	59.11	64.96
28/1/58	255.28	8.9982	0	0.01	0.18	0.54	1.05	1.66	2.23	2.64	2.78	2.78	2.78	2.95	4.04	6.59	11.04	17.52	25.73	34.98	44.22	52.36	59.36	65.15
28/1/83	255.53	9.0124	0	0.11	0.38	0.8	1.38	2.07	2.74	3.24	3.47	3.47	3.48	3.81	5.07	7.8	12.41	18.96	27.1	36.13	45.06	52.9	59.65	65.26
28/1/103	255.73	9.0237	0	0.14	0.42	0.82	1.36	1.99	2.59	3.02	3.19	3.19	3.21	3.6	4.96	7.82	12.56	19.19	27.33	36.24	44.97	52.63	59.23	64.74
28/1/121 avg	255.91	9.034	0	0.07	0.32	0.75	1.34	2.02	2.64	3.06	3.18	3.18	3.19	3.6	5.08	8.17	13.21	20.19	28.63	37.75	46.57	54.24	60.8	66.24
28/1/141	256.11	9.0453	0	0	0.23	0.61	1.14	1.78	2.39	2.81	2.95	2.95	2.96	3.33	4.74	7.72	12.63	19.44	27.7	36.65	45.34	52.95	59.5	64.99
28/2/7	256.27	9.0544	0	0.01	0.2	0.59	1.16	1.83	2.45	2.89	3.06	3.06	3.09	3.61	5.2	8.39	13.49	20.44	28.74	37.62	46.17	53.62	60.01	65.36
28/2/33	256.53	9.0692	0	0	0.25	0.64	1.2	1.87	2.51	2.98	3.19	3.2	3.26	3.85	5.52	8.82	14.06	21.18	29.68	38.75	47.44	54.97	61.39	66.72
28/2/54	256.74	9.0811	0	0.02	0.22	0.62	1.2	1.87	2.49	2.92	3.09	3.09	3.18	3.87	5.73	9.29	14.84	22.27	31.02	40.18	48.51	55.9	62.2	67.42
28/2/83	257.03	9.0976	0	0.05	0.31	0.78	1.45	2.21	2.9	3.38	3.57	3.57	3.69	4.43	6.37	10.03	15.67	23.14	31.86	40.9	49.05	56.23	62.32	67.35
28/2/98	257.18	9.1062	0	0.08	0.27	0.61	1.16	1.9	2.68	3.28	3.51	3.51	3.55	4.16	5.93	9.38	14.81	22.12	30.74	39.76	47.96	55.25	61.48	66.67
28/2/113	257.33	9.1147	0	0.06	0.22	0.54	1.06	1.79	2.57	3.17	3.41	3.41	3.47	4.13	5.96	9.5	15.05	22.5	31.28	40.45	48.76	56.11	62.35	67.51
28/2/133	257.53	9.1261	0	0.08	0.28	0.64	1.22	2.02	2.88	3.57	3.89	3.89	3.92	4.45	6.07	9.31	14.49	21.53	29.93	38.9	47.5	54.95	61.3	66.58
28/3/1	257.71	9.1363	0	0.14	0.45	0.92	1.56	2.32	3.05	3.6	3.87	3.9	3.93	4.4	5.88	8.93	13.9	20.77	29.09	38.07	46.77	54.33	60.81	66.21
28/3/25	257.95	9.1499	0	0.02	0.22	0.63	1.22	1.92	2.57	3.02	3.18	3.18	3.2	3.69	5.31	8.61	13.94	21.23	29.96	39.26	48.13	55.74	62.17	67.47
28/3/42	258.12	9.1596	0	0.06	0.25	0.61	1.22	2.08	3.02	3.79	4.15	4.15	4.18	4.74	6.46	9.89	15.37	22.8	31.64	40.93	49.35	56.79	63.09	68.28
28/3/55	258.25	9.167	0	0.06	0.33	0.8	1.47	2.21	2.87	3.28	3.36	3.36	3.38	3.91	5.67	9.23	14.9	22.56	31.6	41.02	49.49	56.92	63.19	68.35
28/3/84 avg	258.54	9.1835	0	0.02	0.2	0.55	1.07	1.71	2.35	2.79	2.91	2.91	2.93	3.42	5.08	8.47	13.9	21.28	30.01	39.17	47.66	55	61.22	66.39
28/3/118	258.88	9.2028	0	0.09	0.37	0.84	1.48	2.18	2.8	3.2	3.34	3.34	3.53	4.4	6.52	10.37	16.19	23.79	32.56	41.58	49.67	56.76	62.74	67.66
28/3/137	259.07	9.2136	0	0.03	0.26	0.7	1.33	2.05	2.7	3.13	3.3	3.31	3.48	4.3	6.34	10.09	15.79	23.3	32.02	41.05	49.18	56.33	62.38	67.36
28/4/6	259.26	9.2244	0	0	0.28	0.69	1.27	1.95	2.59	3.03	3.18	3.18	3.22	3.85	5.69	9.3	15	22.67	31.7	41.08	49.48	56.8	62.94	67.96
28/4/33	259.53	9.2397	0	0.07	0.24	0.55	1.05	1.74	2.46	3.01	3.23	3.23	3.36	4.13	6.12	9.84	15.54	23.06	31.79	40.8	48.89	55.99	61.99	66.95
28/4/47	259.67	9.2477	0	0.06	0.22	0.56	1.12	1.91	2.76	3.44	3.72	3.72	3.75	4.31	6.04	9.5	15.01	22.47	31.28	40.47	48.72	55.95	62.06	67.1
28/4/66	259.86	9.2585	0	0.01	0.22	0.66	1.29	2.03	2.73	3.22	3.41	3.41	3.43	3.89	5.44	8.62	13.78	20.84	29.27	38.21	46.69	53.97	60.15	65.3
28/4/93	260.13	9.2738	0	0.07	0.25	0.57	1.09	1.8	2.56	3.18	3.49	3.52	3.63	4.28	6.04	9.44	14.78	21.99	30.55	39.6	47.9	55.32	61.68	66.97

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
28/4/108	260.28	9.2824	0	0	0.25	0.62	1.14	1.75	2.32	2.72	2.88	2.88	3	3.68	5.47	8.88	14.2	21.35	29.81	38.78	47.34	54.74	61.03	66.25
28/4/134	260.54	9.2971	0	0.01	0.21	0.62	1.21	1.9	2.56	3.05	3.3	3.39	3.56	4.26	6.03	9.36	14.54	21.5	29.77	38.56	46.77	54.03	60.29	65.54
28/5/1	260.71	9.3068	0	0	0.13	0.38	0.74	1.19	1.6	1.87	1.95	1.95	2.15	3.05	5.23	9.21	15.26	23.24	32.55	42.2	50.86	58.42	64.74	69.88
28/5/16	260.86	9.3153	0	0.01	0.19	0.56	1.09	1.7	2.27	2.68	2.87	2.92	3.09	3.83	5.67	9.11	14.44	21.58	30.05	39.03	47.45	54.79	61.06	66.28
28/5/42	261.12	9.3301	0	0.01	0.21	0.63	1.24	1.95	2.62	3.11	3.35	3.43	3.62	4.38	6.25	9.74	15.12	22.31	30.79	39.68	47.76	54.94	61.08	66.21
28/5/61	261.31	9.3409	0	0.23	0.63	1.19	1.92	2.77	3.57	4.18	4.53	4.71	5	5.9	7.98	11.75	17.47	25	33.74	42.73	50.73	57.68	63.5	68.28
28/5/85	261.55	9.3546	0	0.01	0.19	0.56	1.1	1.74	2.34	2.78	3	3.09	3.33	4.18	6.19	9.84	15.37	22.64	31.1	39.85	47.73	54.67	60.58	65.52
28/5/102	261.72	9.3642	0	0.08	0.28	0.65	1.24	2.05	2.93	3.68	4.14	4.37	4.64	5.55	7.67	11.51	17.34	24.99	33.84	42.91	50.98	57.98	63.84	68.65
28/5/121	261.91	9.375	0	0.26	0.69	1.29	2.06	2.94	3.74	4.32	4.62	4.76	5.07	6.06	8.31	12.3	18.26	25.98	34.83	43.85	51.85	58.78	64.57	69.31
28/5/141	262.11	9.3864	0	0.22	0.62	1.2	1.96	2.85	3.7	4.36	4.76	4.99	5.34	6.29	8.41	12.19	17.88	25.34	33.98	42.87	50.82	57.75	63.58	68.37
28/6/8	262.28	9.396	0	0	0.32	0.81	1.5	2.32	3.1	3.69	3.99	4.07	4.21	4.89	6.7	10.18	15.63	22.97	31.67	40.8	49.09	56.44	62.7	67.89
28cc/8	262.45	9.4057	0	0.15	0.45	0.89	1.48	2.17	2.82	3.29	3.51	3.56	3.69	4.35	6.09	9.43	14.68	21.78	30.24	39.21	47.61	54.92	61.14	66.32
29/1/0	264.3	9.5109	0	0.15	0.49	1	1.69	2.51	3.31	3.94	4.3	4.45	4.61	5.21	6.79	9.86	14.76	21.48	29.58	38.29	46.66	53.88	60.02	65.14
29/1/34	264.64	9.5302	0	0.01	0.22	0.65	1.27	2	2.67	3.14	3.32	3.32	3.35	3.9	5.56	8.87	14.17	21.42	30.12	39.42	48.28	55.85	62.2	67.41
29/1/58	264.88	9.5438	0	0	0.27	0.67	1.22	1.88	2.51	2.98	3.22	3.3	3.47	4.17	5.95	9.34	14.68	21.94	30.66	39.96	48.55	56.11	62.53	67.79
29/1/80	265.1	9.5563	0	0.21	0.6	1.15	1.87	2.72	3.54	4.19	4.58	4.74	4.88	5.38	6.77	9.59	14.24	20.83	29.04	38.19	47.26	55.21	62.02	67.63
29/1/96 avg	265.26	9.5654	0	0.06	0.34	0.85	1.56	2.42	3.27	3.95	4.38	4.57	4.73	5.26	6.69	9.57	14.33	21.05	29.41	38.68	47.68	55.64	62.44	68.02
29/1/117	265.47	9.5774	0	0.01	0.27	0.79	1.56	2.49	3.42	4.2	4.73	5.02	5.27	5.88	7.37	10.31	15.1	21.85	30.23	39.43	48.04	55.85	62.58	68.13
29/1/142	265.72	9.5916	0	0.2	0.57	1.09	1.76	2.54	3.29	3.87	4.19	4.29	4.38	4.87	6.28	9.16	13.9	20.57	28.81	37.89	46.8	54.56	61.19	66.66
29/2/12	265.92	9.6029	0	0	0.23	0.65	1.24	1.98	2.73	3.34	3.71	3.84	3.93	4.37	5.71	8.5	13.16	19.79	28.05	37.24	46.32	54.25	61.04	66.64
29/2/32	266.12	9.6143	0	0.15	0.47	0.95	1.6	2.38	3.15	3.78	4.16	4.31	4.41	4.84	6.1	8.75	13.21	19.62	27.71	36.82	45.94	53.98	60.9	66.63
29/2/46	266.26	9.6223	0	0.11	0.37	0.77	1.32	1.98	2.62	3.1	3.35	3.39	3.41	3.8	5.08	7.77	12.27	18.68	26.68	35.6	44.46	52.26	58.99	64.61
29/2/64	266.44	9.6325	0	0	0.24	0.66	1.25	1.98	2.71	3.32	3.73	3.97	4.26	4.98	6.64	9.76	14.69	21.48	29.75	38.79	47.62	55.29	61.82	67.2
29/2/85	266.65	9.6444	0	0	0.28	0.7	1.28	1.97	2.63	3.11	3.34	3.37	3.44	3.99	5.58	8.75	13.87	20.94	29.53	38.83	47.8	55.52	62.03	67.37
29/2/107	266.87	9.6569	0	0	0.22	0.59	1.1	1.71	2.31	2.76	2.99	3.03	3.1	3.6	5.08	8.09	13.02	19.92	28.38	37.63	46.61	54.36	60.93	66.34
29/2/133	267.13	9.6717	0	0	0.24	0.65	1.23	1.95	2.7	3.36	3.88	4.3	4.82	5.83	7.82	11.28	16.54	23.61	32.06	41.06	49.28	56.57	62.74	67.8
29/3/1	267.31	9.682	0	0	0.21	0.58	1.11	1.76	2.42	2.96	3.32	3.53	3.8	4.53	6.23	9.42	14.45	21.35	29.69	38.69	47.34	54.75	60.99	66.11
29/3/23 avg	267.53	9.6945	0	0	0.14	0.43	0.88	1.47	2.1	2.62	2.89	2.92	2.95	3.34	4.7	7.61	12.51	19.5	28.19	37.76	47.09	55.12	61.88	67.38
29/3/42	267.72	9.7053	0	0	0.16	0.48	0.95	1.54	2.12	2.59	2.92	3.22	3.8	5.14	7.83	12.36	18.98	27.53	37.34	47.35	56.14	63.6	69.64	74.37
29/3/57	267.87	9.7138	0	0	0.2	0.54	1.02	1.61	2.19	2.62	2.79	2.79	2.79	3.08	4.34	7.14	11.91	18.75	27.27	36.68	45.88	53.83	60.57	66.11
29/3/84	268.14	9.7291	0	0	0.22	0.59	1.11	1.75	2.37	2.82	3	3	3.01	3.33	4.68	7.64	12.66	19.8	28.63	38.3	47.69	55.75	62.54	68.07
29/3/104	268.34	9.7405	0	0	0.15	0.46	0.93	1.52	2.1	2.52	2.66	2.66	2.66	2.78	3.86	6.49	11.17	18.04	26.77	36.55	46.2	54.55	61.61	67.36
29/3/117	268.47	9.7479	0	0	0.17	0.48	0.92	1.46	1.98	2.34	2.43	2.43	2.43	2.63	3.85	6.67	11.56	18.63	27.49	37.31	46.93	55.24	62.25	67.94
29/3/138	268.68	9.7598	0	0	0.14	0.41	0.81	1.31	1.8	2.14	2.23	2.23	2.23	2.34	3.36	5.85	10.29	16.82	25.13	34.5	43.84	52.03	59.06	64.88
29/4/6	268.86	9.7701	0	0	0.31	0.76	1.38	2.12	2.84	3.38	3.64	3.64	3.65	3.93	5.14	7.86	12.52	19.22	27.62	36.98	46.22	54.26	61.11	66.73
29/4/48	269.28	9.7885	0	0	0.16	0.5	1	1.65	2.33	2.92	3.33	3.57	3.8	4.36	5.74	8.46	12.94	19.34	27.43	36.6	45.83	53.97	60.96	66.71
29/4/72	269.52	9.7959	0	0	0.18	0.52	1	1.6	2.2	2.69	2.96	3	3	3.17	4.07	6.24	10.18	16.12	23.92	33.04	42.44	50.86	58.21	64.34

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
29/4/95	269.75	9.803	0	0	0.21	0.59	1.13	1.81	2.49	3.04	3.34	3.37	3.37	3.52	4.49	6.88	11.19	17.62	25.9	35.3	44.67	52.82	59.75	65.43
29/4/107	269.87	9.8067	0	0	0.17	0.48	0.92	1.47	2.02	2.44	2.62	2.62	2.62	2.71	3.61	5.92	10.14	16.48	24.7	34.09	43.52	51.77	58.84	64.68
29/4/135	270.15	9.8153	0	0	0.17	0.47	0.89	1.41	1.92	2.3	2.46	2.46	2.46	2.59	3.57	5.94	10.19	16.53	24.75	34.2	43.77	52.23	59.53	65.57
29/5/1	270.31	9.8203	0	0.05	0.25	0.6	1.1	1.72	2.34	2.84	3.1	3.11	3.11	3.22	4.11	6.33	10.39	16.52	24.54	33.85	43.38	51.85	59.19	65.27
29/5/15	270.45	9.8246	0	0.12	0.41	0.86	1.48	2.23	3	3.67	4.15	4.45	4.72	5.29	6.64	9.31	13.73	20.08	28.16	37.37	46.67	54.86	61.88	67.63
29/5/42 avg	270.72	9.8329	0	0	0.17	0.51	1.02	1.66	2.34	2.95	3.43	3.77	4.13	4.83	6.34	9.15	13.67	20.04	28.04	37.07	46.15	54.16	61.05	66.74
29/5/61	270.91	9.8384	0	0	0.3	0.92	1.87	3.09	4.46	5.85	7.17	8.41	9.71	11.37	13.79	17.4	22.5	29.14	37.04	45.04	52.83	59.96	66.09	71.1
29/5/85	271.15	9.8447	0	0.38	1.14	2.28	3.8	5.63	7.57	9.43	11.07	12.46	13.72	15.15	17.15	20.16	24.51	30.33	36.98	44.1	51.21	57.83	63.63	68.48
29/5/104	271.34	9.8498	0	0	0.35	1.06	2.15	3.56	5.19	6.94	8.71	10.48	12.35	14.54	17.35	21.12	26.07	32.27	39.05	46.12	53.08	59.52	65.16	69.89
29/5/118	271.48	9.8535	0	0.37	1.15	2.34	3.94	5.88	7.97	10.01	11.85	13.48	15.03	16.82	19.28	22.84	27.83	34.08	41.18	48.57	55.77	62.29	67.84	72.35
29/5/142	271.72	9.8598	0	0	0.18	0.48	0.9	1.41	1.9	2.24	2.32	2.32	2.32	2.43	3.43	5.86	10.14	16.37	24.2	32.88	41.44	48.98	55.55	61.16
29/6/14	271.94	9.8657	0	0.21	0.61	1.19	1.95	2.84	3.71	4.41	4.82	4.96	5.04	5.49	6.88	9.79	14.62	21.41	29.74	38.81	47.56	55.06	61.38	66.58
29cc/17	272.19	9.8723	0	0	0.13	0.42	0.86	1.41	1.96	2.36	2.5	2.5	2.5	2.74	3.97	6.77	11.58	18.44	26.91	36.15	45.06	52.71	59.18	64.54
30/1/1	273.91	9.9179	0	0	0.18	0.51	0.98	1.56	2.12	2.52	2.65	2.65	2.65	2.72	3.52	5.71	9.75	15.8	23.55	32.29	40.96	48.55	55.1	60.62
30/1/14	274.04	9.9213	0	0	0.15	0.44	0.87	1.41	1.96	2.39	2.59	2.59	2.59	2.72	3.71	6.14	10.49	16.94	25.2	34.54	43.82	51.91	58.81	64.51
30/1/42	274.32	9.9287	0	0	0.09	0.32	0.68	1.16	1.64	2	2.1	2.1	2.1	2.12	2.68	4.63	8.51	14.64	22.85	32.47	42.28	50.93	58.35	64.47
30/1/58	274.48	9.933	0	0	0.14	0.42	0.82	1.33	1.84	2.23	2.39	2.39	2.39	2.5	3.47	5.9	10.32	16.94	25.53	35.34	45.15	53.65	60.82	66.62
30/1/82	274.72	9.9393	0	0	0.19	0.52	0.99	1.57	2.14	2.57	2.74	2.74	2.74	2.77	3.35	5.25	9	14.91	22.85	32.21	41.85	50.42	57.79	63.88
30/1/103	274.93	9.9449	0	0.18	0.5	0.94	1.52	2.19	2.84	3.35	3.64	3.72	3.75	4.08	5.2	7.64	11.86	18.05	26.02	35.19	44.51	52.76	59.88	65.74
30/1/122 avg	275.12	9.9499	0	0	0.13	0.39	0.77	1.25	1.74	2.12	2.27	2.27	2.27	2.33	3	4.96	8.72	14.58	22.42	31.66	41.37	50.37	57.93	64.14
30/1/141	275.31	9.955	0	0	0.2	0.54	1.01	1.58	2.13	2.54	2.69	2.69	2.69	2.76	3.54	5.72	9.81	16.07	24.31	33.87	43.56	52.08	59.37	65.33
30/2/5	275.45	9.9587	0	0	0.14	0.42	0.84	1.36	1.89	2.31	2.53	2.56	2.57	2.89	4.04	6.57	10.92	17.28	25.4	34.63	43.9	52.04	59.03	64.8
30/2/32	275.72	9.9658	0	0	0.17	0.49	0.95	1.52	2.06	2.45	2.61	2.61	2.63	2.99	4.28	7.04	11.7	18.38	26.75	36.07	45.23	53.14	59.83	65.3
30/2/53	275.93	9.9714	0	0.1	0.35	0.75	1.3	1.96	2.59	3.04	3.2	3.2	3.2	3.44	4.69	7.56	12.51	19.63	28.49	38.21	47.59	55.55	62.18	67.53
30/2/92	276.32	9.9817	0	0	0.14	0.44	0.88	1.44	2	2.42	2.59	2.59	2.59	2.85	4.05	6.79	11.53	18.39	27.02	36.63	46.08	54.25	61.16	66.79
30/2/112	276.52	9.987	0	0	0.14	0.44	0.89	1.41	1.87	2.16	2.21	2.21	2.21	2.48	3.73	6.5	11.22	18.01	26.54	36.07	45.51	53.75	60.79	66.56
30/2/133	276.73	9.9926	0	0	0.17	0.48	0.93	1.5	2.05	2.45	2.59	2.59	2.59	2.69	3.66	6.11	10.52	17.07	25.46	34.95	44.41	52.69	59.78	65.61
30/3/1	276.91	9.9974	0	0	0.19	0.52	0.99	1.56	2.09	2.44	2.49	2.49	2.49	2.59	3.63	6.3	11.09	18.14	27.04	36.92	46.54	54.76	61.63	67.17
30/3/15	277.05	10.0011	0	0	0.15	0.43	0.83	1.32	1.78	2.07	2.09	2.09	2.09	2.23	3.44	6.32	11.35	18.59	27.56	37.32	46.65	54.54	61.08	66.36
30/3/43	277.33	10.0085	0	0.09	0.32	0.68	1.17	1.76	2.33	2.74	2.9	2.9	2.91	3.27	4.63	7.58	12.55	19.61	28.36	37.97	47.3	55.28	61.96	67.35
30/3/65	277.55	10.0143	0	0	0.15	0.44	0.87	1.4	1.9	2.24	2.31	2.31	2.31	2.42	3.47	6.14	10.94	18.03	27.02	37	46.7	54.96	61.85	67.42
30/3/84	277.74	10.0194	0	0	0.22	0.59	1.1	1.71	2.29	2.68	2.78	2.78	2.78	2.9	3.99	6.68	11.47	18.47	27.28	37.04	46.55	54.72	61.61	67.24
30/3/103	277.93	10.0244	0	0	0.22	0.56	1.03	1.58	2.08	2.4	2.43	2.43	2.43	2.56	3.7	6.44	11.25	18.24	27	36.67	46.07	54.12	60.88	66.37
30/3/117	278.07	10.0281	0	0	0.2	0.54	1.01	1.59	2.14	2.52	2.63	2.63	2.63	2.88	4.14	6.97	11.8	18.7	27.25	36.63	45.74	53.59	60.24	65.7
30/3/138 avg	278.28	10.0337	0	0	0.2	0.55	1.04	1.64	2.21	2.61	2.76	2.76	2.76	3.09	4.41	7.29	12.15	19.05	27.58	36.96	46.07	53.94	60.6	66.09
30/4/9	278.49	10.0392	0	0	0.19	0.51	0.95	1.48	1.96	2.25	2.27	2.27	2.27	2.54	4	7.24	12.69	20.36	29.69	39.7	49.2	57.19	63.78	69.04
30/4/32	278.72	10.0453	0	0	0.14	0.44	0.88	1.39	1.84	2.08	2.09	2.09	2.09	2.24	3.49	6.42	11.45	18.59	27.33	36.76	45.77	53.48	59.98	65.33

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
30/4/48	278.88	10.0496	0	0.01	0.19	0.56	1.09	1.72	2.3	2.68	2.76	2.76	2.76	2.87	3.9	6.47	11.03	17.7	26.11	35.46	44.64	52.6	59.38	64.98
30/4/73	279.13	10.0562	0	0	0.13	0.38	0.75	1.21	1.63	1.88	1.89	1.89	1.89	2	3.06	5.69	10.33	17.09	25.57	34.98	44.23	52.32	59.27	65.04
30/4/93	279.33	10.0615	0	0	0.18	0.47	0.88	1.37	1.84	2.16	2.22	2.22	2.22	2.3	3.19	5.54	9.84	16.25	24.49	33.83	43.18	51.42	58.53	64.43
30/4/113	279.53	10.0668	0	0.09	0.33	0.71	1.24	1.87	2.47	2.9	3.05	3.05	3.05	3.17	4.23	6.81	11.4	18.13	26.63	36.12	45.46	53.58	60.49	66.17
30/4/135	279.75	10.0726	0	0	0.15	0.44	0.87	1.41	1.94	2.34	2.49	2.49	2.49	2.54	3.2	5.16	8.9	14.68	22.35	31.32	40.73	49.53	57.04	63.32
30/5/6	279.96	10.0782	0	0	0.14	0.43	0.87	1.42	1.98	2.4	2.55	2.55	2.55	2.62	3.44	5.7	9.91	16.33	24.76	34.54	44.49	53.28	60.83	67
30/5/15	280.05	10.0806	0	0	0.14	0.42	0.83	1.35	1.87	2.27	2.43	2.43	2.43	2.49	3.2	5.23	9.08	15.03	22.93	32.18	41.74	50.37	57.85	64.1
30/5/35	280.25	10.0859	0	0	0.15	0.44	0.86	1.39	1.92	2.33	2.52	2.52	2.52	2.59	3.31	5.3	9.04	14.77	22.33	31.13	40.34	48.97	56.37	62.61
30/5/84	280.74	10.0989	0	0	0.2	0.53	0.98	1.51	2	2.33	2.42	2.42	2.42	2.64	3.76	6.3	10.69	17.03	25.03	34.02	43.04	51.1	58.15	64.08
30/5/102	280.92	10.1036	0	0	0.16	0.44	0.83	1.31	1.76	2.07	2.14	2.14	2.14	2.22	3.05	5.24	9.27	15.34	23.26	32.4	41.76	50.21	57.61	63.85
31/1/1	283.51	10.1723	0	0	0.16	0.48	0.95	1.55	2.17	2.67	2.95	2.98	2.98	3.04	3.71	5.54	9.01	14.37	21.48	29.81	38.54	46.7	53.7	59.64
31/1/17	283.67	10.1765	0	0	0.2	0.56	1.06	1.68	2.3	2.78	3	3	3	3.09	3.96	6.22	10.38	16.67	24.91	34.45	44.15	52.71	60.06	66.08
31/1/44 avg	283.94	10.1837	0	0	0.15	0.49	1.01	1.66	2.33	2.88	3.2	3.26	3.26	3.35	4.14	6.21	10.11	16.11	24.08	33.45	43.1	51.7	59.15	65.31
31/1/58	284.08	10.1874	0	0	0.13	0.43	0.89	1.48	2.09	2.59	2.85	2.85	2.85	2.89	3.5	5.43	9.26	15.35	23.6	33.39	43.49	52.41	60.05	66.26
31/1/83	284.33	10.194	0	0	0.18	0.54	1.07	1.74	2.43	3.01	3.36	3.45	3.45	3.64	4.58	6.88	11.07	17.42	25.77	35.48	45.37	54.06	61.49	67.52
31/1/105	284.55	10.1998	0	0	0.11	0.39	0.82	1.39	1.99	2.5	2.79	2.83	2.83	2.91	3.68	5.73	9.62	15.63	23.65	33.09	42.83	51.52	59.07	65.32
31/1/118	284.68	10.2033	0	0	0.17	0.51	1.01	1.65	2.32	2.89	3.23	3.31	3.31	3.39	4.17	6.22	10.06	15.96	23.78	32.96	42.44	50.96	58.43	64.67
31/1/138	284.88	10.2086	0	0	0.19	0.54	1.04	1.65	2.26	2.74	2.97	2.97	2.97	3.04	3.81	5.89	9.8	15.81	23.77	33.1	42.72	51.33	58.83	65.05
31/2/9	285.09	10.2141	0	0.06	0.25	0.57	1.03	1.59	2.15	2.57	2.73	2.73	2.73	2.82	3.69	5.98	10.2	16.6	24.98	34.68	44.55	53.24	60.69	66.76
31/2/29	285.29	10.2194	0	0	0.16	0.5	1	1.6	2.19	2.62	2.79	2.79	2.79	2.87	3.67	5.84	9.88	16.04	24.16	33.63	43.33	51.97	59.46	65.65
31/2/48	285.48	10.2245	0	0	0.17	0.51	1.01	1.65	2.31	2.84	3.14	3.19	3.19	3.41	4.45	6.89	11.21	17.6	25.81	35.18	44.63	52.99	60.2	66.15
31/2/73	285.73	10.2311	0	0	0.24	0.65	1.23	1.94	2.62	3.11	3.28	3.28	3.28	3.48	4.71	7.54	12.44	19.49	28.3	38.03	47.52	55.67	62.52	68.05
31/2/88 avg	285.88	10.2351	0	0.03	0.23	0.62	1.17	1.83	2.46	2.89	3.03	3.03	3.03	3.33	4.7	7.73	12.87	20.18	29.19	39	48.29	56.26	62.9	68.22
31/2/110	286.1	10.2409	0	0	0.26	0.66	1.23	1.91	2.58	3.09	3.34	3.34	3.34	3.59	4.75	7.42	12.06	18.79	27.27	36.74	46.08	54.2	61.1	66.75
31/2/134	286.34	10.2473	0	0.04	0.24	0.6	1.13	1.79	2.46	3	3.28	3.3	3.3	3.43	4.37	6.67	10.81	16.99	25	34.21	43.59	51.95	59.23	65.3
31/3/1	286.51	10.2518	0	0	0.19	0.53	1.02	1.62	2.21	2.65	2.83	2.83	2.83	3.02	4.11	6.65	11.12	17.68	26.08	35.65	45.32	53.87	61.23	67.27
31/3/23	286.73	10.2576	0	0.15	0.44	0.85	1.39	2.03	2.64	3.12	3.38	3.44	3.47	3.8	4.91	7.33	11.49	17.58	25.44	34.51	43.81	52.16	59.45	65.52
31/3/38	286.88	10.2616	0	0.01	0.19	0.56	1.1	1.74	2.36	2.84	3.09	3.13	3.14	3.46	4.62	7.17	11.54	17.9	26.03	35.3	44.68	52.99	60.17	66.09
31/3/57	287.04	10.2658	0	0	0.22	0.58	1.07	1.66	2.22	2.63	2.82	2.82	2.84	3.21	4.45	7.08	11.5	17.86	25.94	35.16	44.52	52.85	60.06	66
31/3/82	287.32	10.2732	0	0.14	0.41	0.81	1.34	1.96	2.54	2.97	3.17	3.19	3.25	3.72	5.08	7.82	12.29	18.57	26.42	35.29	44.29	52.38	59.46	65.39
31/3/102	287.52	10.2785	0	0.01	0.16	0.47	0.92	1.46	1.99	2.39	2.59	2.6	2.61	2.89	3.97	6.37	10.51	16.57	24.38	33.41	42.71	51.09	58.44	64.58
31/3/117	287.67	10.2825	0	0	0.16	0.44	0.84	1.33	1.81	2.16	2.3	2.3	2.3	2.52	3.59	6.05	10.37	16.75	25	34.53	44.26	52.92	60.4	66.54
31/3/141	287.91	10.2889	0	0	0.15	0.48	0.97	1.54	2.05	2.36	2.39	2.39	2.39	2.71	4.09	7.08	12.1	19.22	28.04	37.78	47.32	55.56	62.5	68.1
31/4/8	288.08	10.2934	0	0	0.14	0.44	0.88	1.39	1.85	2.15	2.21	2.21	2.23	2.68	4.21	7.37	12.53	19.71	28.49	38.08	47.43	55.54	62.4	67.98
31/4/30	288.3	10.2992	0	0	0.15	0.47	0.94	1.47	1.94	2.24	2.29	2.29	2.32	2.81	4.4	7.63	12.85	20.06	28.82	38.36	47.65	55.7	62.52	68.07
31/4/55 avg	288.55	10.3058	0	0.11	0.35	0.73	1.23	1.8	2.31	2.62	2.66	2.66	2.69	3.17	4.76	7.98	13.13	20.18	28.65	37.79	46.65	54.36	60.94	66.4
31/4/70	288.7	10.3098	0	0.01	0.17	0.49	0.95	1.47	1.91	2.12	2.13	2.13	2.17	2.85	4.85	8.72	14.75	22.8	32.25	42.09	50.94	58.65	65.05	70.17

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
31/4/89	288.89	10.3148	0	0	0.12	0.39	0.79	1.25	1.63	1.8	1.81	1.81	1.84	2.43	4.3	8.01	13.88	21.82	31.25	41.15	50.07	57.83	64.25	69.39
31/4/110	289.1	10.3204	0	0.01	0.17	0.5	0.97	1.51	1.98	2.26	2.28	2.28	2.33	3.06	5.06	8.87	14.78	22.67	31.94	41.63	50.36	57.99	64.35	69.48
31/4/134	289.34	10.3267	0	0.01	0.17	0.49	0.93	1.41	1.79	1.95	1.96	1.96	2	2.67	4.63	8.41	14.3	22.19	31.46	41.11	49.76	57.28	63.54	68.61
31/5/0	289.5	10.331	0	0	0.18	0.56	1.1	1.71	2.23	2.51	2.52	2.52	2.53	2.95	4.57	7.92	13.34	20.76	29.62	39.03	47.94	55.51	61.84	67.01
31/5/23	289.73	10.3371	0	0	0.15	0.46	0.91	1.43	1.89	2.17	2.19	2.19	2.19	2.49	3.81	6.69	11.54	18.44	27.03	36.55	45.9	53.99	60.84	66.43
31/5/43	289.93	10.3424	0	0	0.14	0.43	0.85	1.37	1.86	2.18	2.23	2.23	2.23	2.51	3.83	6.73	11.59	18.42	26.8	35.95	44.86	52.64	59.31	64.89
31/5/62	290.12	10.3474	0	0	0.16	0.5	1	1.59	2.13	2.49	2.58	2.58	2.6	3.05	4.56	7.66	12.68	19.62	28.03	37.14	45.96	53.62	60.17	65.62
31/5/83	290.33	10.353	0	0	0.19	0.51	0.95	1.48	1.97	2.29	2.34	2.34	2.34	2.65	4.02	7.01	11.99	18.94	27.38	36.47	45.21	52.77	59.22	64.6
31/5/101	290.51	10.3577	0	0.01	0.15	0.45	0.88	1.39	1.86	2.19	2.3	2.3	2.32	2.74	4.15	7.09	11.93	18.75	27.18	36.5	45.68	53.7	60.55	66.18
31/5/120	290.7	10.3628	0	0	0.09	0.31	0.65	1.09	1.55	1.91	2.07	2.07	2.07	2.16	3.05	5.31	9.45	15.71	23.91	33.41	43.06	51.55	58.82	64.78
31cc/0	290.74	10.3638	0	0	0.14	0.44	0.88	1.39	1.85	2.14	2.21	2.21	2.24	2.72	4.21	7.22	12.1	18.9	27.31	36.7	46.09	54.4	61.58	67.52
32/1/1	293.11	10.4266	0	0	0.12	0.37	0.75	1.23	1.71	2.08	2.23	2.23	2.23	2.32	3.15	5.24	9.04	14.74	22.14	30.64	39.39	47.46	54.33	60.13
32/1/23	293.33	10.4325	0	0	0.13	0.4	0.79	1.23	1.61	1.84	1.88	1.88	2.04	2.82	4.71	8.17	13.46	20.55	29.05	38.3	47.4	55.38	62.2	67.79
32/1/41	293.51	10.4372	0	0	0.13	0.4	0.79	1.21	1.56	1.74	1.75	1.75	1.84	2.54	4.33	7.65	12.76	19.63	27.88	36.9	45.83	53.75	60.61	66.33
32/1/61	293.71	10.4425	0	0.03	0.18	0.48	0.89	1.34	1.71	1.91	1.92	1.92	2.1	2.95	4.96	8.55	13.93	20.99	29.28	38.14	46.74	54.3	60.82	66.26
32/1/83	293.93	10.4484	0	0.05	0.24	0.58	1.06	1.59	2.04	2.31	2.37	2.37	2.47	3.17	4.98	8.37	13.6	20.6	28.94	37.94	46.74	54.5	61.22	66.86
32/1/102 avg	294.12	10.4534	0	0.03	0.19	0.51	0.94	1.43	1.85	2.09	2.12	2.12	2.16	2.74	4.38	7.57	12.61	19.48	27.83	37	46.07	54.1	61.05	66.83
32/1/121	294.31	10.4584	0	0.03	0.18	0.48	0.89	1.35	1.74	1.98	2.01	2.01	2.04	2.5	3.94	6.83	11.53	18.09	26.22	35.29	44.38	52.45	59.45	65.28
32/1/141	294.51	10.4637	0	0	0.15	0.41	0.77	1.22	1.65	1.96	2.09	2.09	2.11	2.48	3.69	6.22	10.46	16.53	24.23	33.05	42.1	50.32	57.6	63.78
32/2/11	294.71	10.469	0	0	0.13	0.41	0.8	1.24	1.62	1.84	1.85	1.85	1.87	2.27	3.62	6.41	11.03	17.57	25.79	35.1	44.55	53.03	60.44	66.63
32/2/30	294.9	10.4741	0	0	0.12	0.31	0.57	0.87	1.13	1.27	1.28	1.28	1.29	1.59	2.81	5.46	9.95	16.44	24.71	34.18	43.83	52.45	59.93	66.11
32/2/52	295.12	10.4799	0	0	0.13	0.35	0.66	1.04	1.4	1.64	1.7	1.7	1.7	1.88	2.85	5.11	9.1	15.02	22.72	31.66	41.04	49.82	57.31	63.58
32/2/73	295.33	10.4855	0	0	0.14	0.44	0.88	1.4	1.89	2.24	2.39	2.39	2.41	2.73	3.86	6.29	10.44	16.49	24.28	33.26	42.46	50.73	57.99	64.1
32/2/93	295.53	10.4908	0	0	0.16	0.43	0.8	1.25	1.66	1.94	2.01	2.01	2.01	2.29	3.47	6.08	10.54	16.99	25.15	34.37	43.62	51.79	58.84	64.7
32/2/113	295.73	10.4961	0	0.01	0.17	0.5	0.96	1.47	1.9	2.13	2.14	2.14	2.16	2.65	4.21	7.33	12.33	19.17	27.41	36.32	44.98	52.57	59.12	64.64
32/2/133	295.93	10.5014	0	0.03	0.2	0.52	0.99	1.58	2.16	2.6	2.79	2.79	2.79	2.94	3.97	6.44	10.82	17.29	25.61	35.09	44.63	53.02	60.22	66.16
32/3/1	296.11	10.5061	0	0	0.15	0.39	0.72	1.12	1.47	1.67	1.68	1.68	1.68	1.86	3.04	5.78	10.56	17.56	26.48	36.54	46.5	55.08	62.28	68.04
32/3/40	296.5	10.5165	0	0.01	0.2	0.61	1.2	1.9	2.56	3.04	3.24	3.24	3.25	3.55	4.77	7.45	12	18.55	26.8	36.05	45.25	53.34	60.31	66.11
32/3/62	296.72	10.5223	0	0	0.15	0.47	0.95	1.51	2.04	2.43	2.6	2.6	2.6	2.77	3.7	5.9	9.83	15.7	23.34	32.2	41.33	49.62	56.98	63.26
32/3/83	296.93	10.5279	0	0	0.19	0.53	1.02	1.62	2.22	2.7	2.96	3.01	3.02	3.25	4.21	6.42	10.34	16.19	23.82	32.7	41.83	50.06	57.32	63.48
32/3/102 avg	297.12	10.5329	0	0.07	0.27	0.62	1.11	1.71	2.31	2.74	2.89	2.89	2.9	3.19	4.46	7.31	12.17	19.18	27.99	37.79	47.37	55.56	62.39	67.87
32/3/123	297.33	10.5385	0	0.13	0.4	0.8	1.34	1.99	2.62	3.1	3.35	3.4	3.48	4.01	5.57	8.72	13.87	21.08	29.94	39.6	48.9	56.78	63.31	68.54
32/3/140	297.5	10.543	0	0	0.23	0.6	1.12	1.75	2.36	2.82	3.05	3.07	3.09	3.49	4.82	7.65	12.4	19.19	27.68	37.13	46.4	54.38	61.1	66.56
32/4/10	297.7	10.5483	0	0	0.15	0.43	0.83	1.32	1.79	2.13	2.25	2.25	2.26	2.59	3.9	6.78	11.71	18.85	27.88	38.01	47.98	56.48	63.52	69.09
32/4/30	297.9	10.5536	0	0	0.19	0.51	0.96	1.51	2.05	2.46	2.66	2.66	2.68	3.06	4.37	7.18	11.96	18.86	27.59	37.43	47.2	55.63	62.7	68.38
32/4/48	298.08	10.5583	0	0	0.16	0.44	0.84	1.33	1.81	2.16	2.3	2.3	2.31	2.65	3.89	6.58	11.17	17.81	26.24	35.75	45.19	53.35	60.24	65.84
32/4/68	298.28	10.5636	0	0	0.18	0.54	1.06	1.72	2.39	2.91	3.19	3.27	3.36	3.9	5.44	8.54	13.59	20.64	29.31	38.81	48.03	55.91	62.5	67.81

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
32/4/92	298.52	10.57	0	0.11	0.35	0.7	1.17	1.73	2.26	2.64	2.81	2.82	2.91	3.51	5.17	8.45	13.71	20.97	29.79	39.32	48.45	56.21	62.66	67.87
32/4/110	298.7	10.5748	0	0.09	0.34	0.73	1.28	1.94	2.57	3.04	3.25	3.25	3.28	3.75	5.25	8.35	13.44	20.52	29.14	38.47	47.46	55.18	61.69	67.03
32/4/133	298.93	10.5809	0	0.01	0.16	0.47	0.92	1.45	1.95	2.3	2.46	2.49	2.61	3.22	4.84	7.97	12.94	19.78	28.09	37.15	45.99	53.71	60.33	65.83
32/5/1	299.11	10.5856	0	0	0.22	0.57	1.05	1.62	2.15	2.51	2.63	2.63	2.66	3.14	4.68	7.8	12.86	19.87	28.39	37.66	46.66	54.46	61.09	66.56
32/5/28	299.38	10.5928	0	0	0.2	0.52	0.96	1.49	1.99	2.34	2.47	2.47	2.5	3.01	4.57	7.73	12.87	20.03	28.8	38.39	47.73	55.8	62.62	68.16
32/5/40 avg	299.5	10.596	0	0.08	0.33	0.7	1.21	1.82	2.4	2.83	3.03	3.04	3.06	3.43	4.69	7.34	11.78	18.07	25.93	34.73	43.54	51.39	58.27	64.06
32cc/2	299.67	10.6005	0	0	0.11	0.35	0.7	1.15	1.6	1.93	2.06	2.06	2.06	2.3	3.38	5.82	10.04	16.18	24	32.86	41.77	49.7	56.62	62.45
33/1/1	302.71	10.681	0	0	0.16	0.44	0.83	1.3	1.77	2.12	2.27	2.27	2.27	2.45	3.41	5.67	9.65	15.5	23	31.55	40.28	48.23	55.18	61.12
33/1/27	302.97	10.6879	0	0	0.15	0.43	0.83	1.33	1.83	2.21	2.37	2.37	2.38	2.74	4.05	6.88	11.68	18.56	27.18	36.77	46.21	54.4	61.35	67.03
33/1/40	303.1	10.6914	0	0.06	0.24	0.55	0.98	1.45	1.87	2.14	2.19	2.19	2.19	2.47	3.72	6.51	11.28	18.13	26.71	36.23	45.56	53.63	60.47	66.08
33/1/59	303.29	10.6964	0	0	0.14	0.4	0.78	1.24	1.69	2.02	2.14	2.14	2.15	2.51	3.83	6.69	11.53	18.46	27.14	36.76	46.19	54.32	61.18	66.77
33/1/83	303.53	10.7028	0	0	0.18	0.48	0.91	1.43	1.93	2.28	2.4	2.4	2.4	2.62	3.77	6.42	11.04	17.77	26.3	35.87	45.34	53.57	60.56	66.28
33/1/107	303.77	10.7091	0	0	0.15	0.41	0.77	1.2	1.6	1.85	1.86	1.86	1.86	1.97	3	5.53	10.03	16.67	25.16	34.74	44.26	52.57	59.65	65.47
33/1/121	303.91	10.7128	0	0	0.21	0.55	1.01	1.56	2.06	2.39	2.44	2.44	2.44	2.56	3.62	6.2	10.74	17.37	25.76	35.13	44.37	52.43	59.33	65.05
33/1/143	304.13	10.7187	0	0.05	0.24	0.56	1.01	1.52	1.99	2.31	2.41	2.41	2.42	2.8	4.19	7.16	12.13	19.18	27.94	37.61	47.06	55.19	62.02	67.55
33/2/9	304.29	10.7229	0	0	0.13	0.4	0.79	1.28	1.76	2.1	2.19	2.19	2.19	2.29	3.23	5.65	10.04	16.57	24.97	34.49	44	52.35	59.52	65.46
33/2/27	304.47	10.7277	0	0	0.15	0.43	0.83	1.32	1.79	2.12	2.21	2.21	2.21	2.46	3.65	6.34	11	17.76	26.33	35.97	45.56	53.93	61.05	66.86
33/2/46	304.66	10.7327	0	0	0.18	0.5	0.95	1.5	2.04	2.45	2.65	2.67	2.69	3.1	4.41	7.18	11.82	18.45	26.79	36.14	45.46	53.66	60.72	66.55
33/2/82	305.02	10.7422	0	0	0.15	0.47	0.94	1.48	1.97	2.3	2.39	2.39	2.4	2.71	3.93	6.58	11.06	17.48	25.55	34.61	43.66	51.68	58.64	64.48
33/2/95	305.15	10.7457	0	0.1	0.33	0.68	1.16	1.73	2.27	2.66	2.83	2.83	2.85	3.2	4.42	7	11.32	17.48	25.22	33.95	42.78	50.72	57.73	63.69
33/2/114	305.34	10.7507	0	0.08	0.32	0.71	1.25	1.86	2.44	2.87	3.1	3.18	3.31	3.85	5.27	8.05	12.54	18.83	26.66	35.46	44.34	52.31	59.31	65.22
33/2/135	305.55	10.7563	0	0.01	0.17	0.51	1	1.58	2.14	2.54	2.7	2.7	2.7	2.92	4.01	6.49	10.78	17	24.9	33.87	42.95	51.09	58.23	64.25
33/3/1 avg	305.71	10.7605	0	0	0.14	0.42	0.82	1.28	1.68	1.87	1.88	1.88	1.88	2.2	3.63	6.69	11.79	18.94	27.71	37.28	46.59	54.64	61.45	67.03
33/3/23	305.93	10.7664	0	0.05	0.26	0.62	1.13	1.7	2.22	2.58	2.73	2.73	2.78	3.26	4.66	7.46	12.01	18.38	26.29	35.13	43.98	51.86	58.73	64.5
33/3/41	306.11	10.7711	0	0	0.25	0.63	1.16	1.79	2.39	2.84	3.05	3.06	3.07	3.38	4.53	7.04	11.33	17.55	25.5	34.59	43.84	52.12	59.34	65.38
33/3/57	306.27	10.7754	0	0.01	0.16	0.46	0.89	1.39	1.85	2.15	2.21	2.21	2.21	2.32	3.3	5.68	9.95	16.3	24.54	34.04	43.7	52.25	59.61	65.68
33/3/84	306.54	10.7825	0	0	0.19	0.5	0.93	1.45	1.95	2.32	2.48	2.48	2.5	2.84	4.05	6.64	11.04	17.39	25.46	34.63	43.89	52.11	59.23	65.15
33/3/105	306.75	10.7881	0	0	0.09	0.3	0.62	1.03	1.42	1.67	1.69	1.69	1.69	1.89	3.05	5.71	10.3	16.92	25.23	34.49	43.67	51.75	58.71	64.53
33/3/116	306.86	10.791	0	0	0.19	0.5	0.93	1.45	1.94	2.28	2.38	2.38	2.39	2.74	4.08	6.97	11.81	18.69	27.24	36.73	46.1	54.28	61.27	67.03
33/3/138	307.08	10.7968	0	0.13	0.39	0.77	1.27	1.86	2.42	2.83	3.02	3.02	3.04	3.38	4.58	7.17	11.58	17.95	26.04	35.22	44.48	52.71	59.85	65.8
33/4/10	307.3	10.8027	0	0	0.14	0.4	0.78	1.25	1.7	2	2.05	2.05	2.05	2.22	3.38	6.08	10.77	17.55	26.05	35.49	44.74	52.77	59.6	65.23
33/4/29	307.49	10.8077	0	0	0.17	0.54	1.08	1.71	2.29	2.68	2.79	2.79	2.79	3.08	4.38	7.25	12.11	19.03	27.62	37.08	46.32	54.33	61.14	66.75
33/4/50	307.7	10.8133	0	0	0.18	0.56	1.11	1.76	2.36	2.77	2.9	2.9	2.9	3.18	4.45	7.27	12.06	18.91	27.46	36.94	46.26	54.38	61.3	66.99
33/4/73	307.93	10.8193	0	0	0.19	0.51	0.96	1.51	2.04	2.41	2.51	2.51	2.51	2.62	3.63	6.15	10.68	17.37	25.92	35.56	45.12	53.45	60.54	66.37
33/4/94	308.14	10.8249	0	0	0.13	0.39	0.77	1.25	1.73	2.1	2.25	2.25	2.25	2.43	3.47	5.95	10.37	16.93	25.37	34.98	44.6	53.03	60.24	66.16
33/4/110	308.3	10.8292	0	0	0.18	0.48	0.9	1.41	1.9	2.26	2.39	2.39	2.39	2.51	3.47	5.83	10.1	16.52	24.93	34.7	44.67	53.48	61.04	67.21
33/4/133	308.53	10.8352	0	0	0.16	0.45	0.86	1.36	1.84	2.18	2.28	2.28	2.28	2.37	3.26	5.6	9.89	16.33	24.65	34.11	43.58	51.89	59.03	64.95

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
33/5/1	308.71	10.84	0	0.01	0.17	0.5	0.98	1.54	2.05	2.38	2.44	2.44	2.44	2.67	3.93	6.77	11.61	18.49	26.99	36.27	45.29	53.11	59.78	65.33
33/5/29	308.99	10.8474	0	0	0.15	0.49	0.99	1.58	2.12	2.49	2.59	2.59	2.6	2.94	4.33	7.33	12.35	19.42	28.11	37.59	46.78	54.69	61.37	66.85
33/5/41	309.11	10.8516	0	0	0.16	0.44	0.84	1.33	1.79	2.09	2.13	2.13	2.13	2.23	3.21	5.7	10.17	16.77	25.18	34.62	43.97	52.13	59.11	64.9
33/5/58	309.28	10.8543	0	0	0.15	0.42	0.8	1.26	1.7	1.99	2.02	2.02	2.02	2.13	3.16	5.73	10.3	17	25.46	34.85	44.04	52.02	58.84	64.52
33/5/84 avg	309.54	10.8583	0	0	0.17	0.47	0.88	1.37	1.83	2.14	2.21	2.21	2.21	2.33	3.34	5.8	10.17	16.58	24.73	33.9	43.02	51.04	57.95	63.73
33/5/104	309.74	10.8615	0	0	0.2	0.55	1.04	1.64	2.22	2.65	2.8	2.8	2.8	2.91	3.95	6.53	11.16	18	26.72	36.51	46.17	54.5	61.53	67.26
34/1/1	312.31	10.9018	0	0	0.15	0.42	0.81	1.29	1.73	2.01	2.03	2.03	2.03	2.11	3	5.4	9.77	16.25	24.49	33.72	42.83	50.79	57.63	63.36
34/1/24	312.54	10.9054	0	0	0.12	0.4	0.81	1.29	1.72	1.96	1.97	1.97	2	2.54	4.28	7.78	13.39	21.05	30.21	39.94	49.18	57.05	63.62	68.96
34/1/37	312.67	10.9075	0	0	0.2	0.52	0.96	1.49	1.96	2.24	2.26	2.26	2.28	2.79	4.52	8.03	13.67	21.4	30.65	40.47	49.62	57.49	64.07	69.41
34/1/57	312.87	10.9106	0	0	0.18	0.47	0.87	1.35	1.77	2	2.01	2.01	2.01	2.37	3.94	7.32	12.91	20.67	30.02	39.96	49.33	57.23	63.76	69.04
34/1/77	313.07	10.9138	0	0.02	0.22	0.62	1.18	1.82	2.37	2.68	2.7	2.7	2.7	3.02	4.58	7.96	13.57	21.35	30.7	40.55	49.49	57.23	63.72	69.01
34/1/101	313.31	10.9175	0	0	0.14	0.44	0.88	1.38	1.79	1.97	1.98	1.98	1.99	2.45	4.26	7.99	13.98	22.08	31.55	41.24	49.79	57.14	63.26	68.27
34/1/123	313.53	10.921	0	0.02	0.21	0.58	1.1	1.68	2.18	2.48	2.51	2.51	2.63	3.55	5.91	10.27	16.87	25.48	35.28	45.09	53.58	60.74	66.57	71.24
34/1/141 avg	313.71	10.9238	0	0.01	0.17	0.47	0.91	1.41	1.84	2.05	2.06	2.06	2.06	2.38	3.95	7.36	13.01	20.83	30.18	39.97	48.9	56.49	62.79	67.92
34/2/10	313.9	10.9268	0	0	0.16	0.43	0.82	1.29	1.71	1.94	1.95	1.95	1.96	2.36	3.96	7.33	12.84	20.42	29.49	39.1	48.16	55.84	62.26	67.52
34/2/29	314.09	10.9298	0	0.02	0.2	0.57	1.09	1.68	2.2	2.52	2.54	2.54	2.54	2.88	4.38	7.6	12.94	20.37	29.34	38.94	48.07	55.84	62.36	67.7
34/2/49	314.29	10.9329	0	0	0.19	0.52	0.98	1.54	2.06	2.42	2.53	2.53	2.57	3.18	4.93	8.38	13.86	21.31	30.21	39.7	48.75	56.51	63.05	68.41
34/2/65	314.45	10.9354	0	0.15	0.44	0.85	1.4	2.03	2.61	3	3.12	3.12	3.17	3.83	5.69	9.29	14.92	22.47	31.34	40.57	48.89	56.2	62.39	67.51
34/2/89	314.69	10.9392	0	0	0.15	0.42	0.81	1.28	1.7	1.95	1.96	1.96	1.97	2.38	3.95	7.25	12.67	20.2	29.31	39.07	48.34	56.17	62.67	67.94
34/2/110	314.9	10.9425	0	0	0.13	0.37	0.72	1.15	1.55	1.79	1.8	1.8	1.8	2.1	3.53	6.71	12.09	19.71	29.06	39.15	48.72	56.73	63.31	68.59
34/2/133	315.13	10.9461	0	0	0.14	0.41	0.8	1.29	1.75	2.06	2.1	2.1	2.1	2.22	3.34	6.07	10.89	17.91	26.73	36.45	45.84	53.83	60.51	65.95
34/3/0	315.3	10.9496	0	0	0.15	0.48	0.96	1.52	2.02	2.32	2.34	2.34	2.34	2.51	3.75	6.63	11.58	18.67	27.45	37.04	46.29	54.2	60.84	66.28
34/3/22	315.52	10.9569	0	0.07	0.29	0.66	1.19	1.84	2.48	2.98	3.22	3.22	3.22	3.43	4.53	7.11	11.66	18.35	26.87	36.45	45.92	54.11	61.05	66.73
34/3/41	315.71	10.9631	0	0	0.1	0.32	0.66	1.09	1.51	1.81	1.88	1.88	1.88	2.01	3.11	5.76	10.46	17.36	26.12	35.91	45.5	53.71	60.59	66.17
34/3/76	316.06	10.9746	0	0.07	0.28	0.64	1.15	1.77	2.38	2.83	3.02	3.02	3.02	3.23	4.42	7.2	12.06	19.14	28.08	38.02	47.72	55.99	62.88	68.42
34/3/97	316.27	10.9815	0	0	0.12	0.39	0.79	1.3	1.81	2.18	2.29	2.29	2.29	2.38	3.29	5.73	10.23	17.01	25.75	35.63	45.35	53.65	60.59	66.21
34/3/118 avg	316.48	10.9884	0	0	0.08	0.29	0.6	0.99	1.38	1.64	1.66	1.66	1.66	1.73	2.57	4.92	9.33	16.03	24.73	34.6	44.33	52.66	59.64	65.31
34/3/137	316.67	10.9947	0	0	0.05	0.2	0.47	0.83	1.19	1.43	1.44	1.44	1.44	1.46	2.05	4.11	8.22	14.67	23.23	33.07	42.85	51.24	58.29	64.04
34/4/8	316.88	11.0016	0	0	0.07	0.24	0.52	0.87	1.2	1.39	1.4	1.4	1.4	1.53	2.74	5.68	10.89	18.5	28.05	38.5	48.45	56.73	63.48	68.84
34/4/30	317.1	11.0088	0	0	0.14	0.41	0.8	1.28	1.74	2.05	2.1	2.1	2.1	2.25	3.46	6.34	11.41	18.79	28.06	38.28	48.14	56.48	63.38	68.9
34/4/50	317.3	11.0154	0	0	0.17	0.46	0.87	1.37	1.84	2.16	2.23	2.23	2.23	2.44	3.63	6.36	11.1	17.96	26.59	36.18	45.57	53.66	60.49	66.08
34/4/70	317.5	11.022	0	0	0.22	0.59	1.1	1.72	2.32	2.76	2.93	2.93	2.93	3.14	4.34	7.14	12.04	19.17	28.15	38.11	47.79	56.03	62.89	68.41
34/4/88	317.68	11.0279	0	0	0.15	0.42	0.81	1.28	1.72	2.01	2.03	2.03	2.03	2.17	3.37	6.21	11.18	18.39	27.38	37.22	46.65	54.62	61.25	66.63
34/4/110	317.9	11.0351	0	0	0.15	0.44	0.86	1.38	1.89	2.27	2.41	2.41	2.41	2.57	3.66	6.29	10.96	17.84	26.59	36.39	46	54.22	61.11	66.69
34/4/133	318.13	11.0427	0	0	0.08	0.28	0.59	0.99	1.38	1.64	1.66	1.66	1.66	1.69	2.32	4.41	8.52	14.94	23.43	33.17	42.82	51.09	58.03	63.72
34/5/5	318.35	11.0499	0	0	0.12	0.37	0.75	1.23	1.7	2.03	2.07	2.07	2.07	2.12	2.89	5.29	9.89	16.96	26.17	36.57	46.71	55.24	62.26	67.87
34/5/30	318.6	11.0582	0	0.14	0.4	0.76	1.23	1.77	2.26	2.56	2.58	2.58	2.58	2.65	3.55	6.09	10.78	17.81	26.8	36.81	46.49	54.64	61.35	66.75

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25	6.5	6.75	7	7.25	7.5	7.75	8	8.25
35/1/1	321.91	11.167	0	0	0.05	0.21	0.5	0.88	1.28	1.57	1.61	1.61	1.61	1.62	2.18	4.19	8.19	14.47	22.78	32.3	41.72	49.8	56.59	62.19
35/1/23	322.13	11.1742	0	0	0.15	0.43	0.84	1.35	1.84	2.17	2.23	2.23	2.23	2.44	3.75	6.79	12.08	19.77	29.42	40.02	50.14	58.52	65.27	70.54
35/1/43	322.33	11.1808	0	0	0.06	0.23	0.52	0.9	1.27	1.52	1.54	1.54	1.54	1.66	2.78	5.62	10.73	18.32	27.98	38.7	48.98	57.48	64.33	69.68
35/1/64 avg	322.54	11.1877	0	0	0.09	0.31	0.68	1.15	1.63	1.99	2.11	2.11	2.11	2.29	3.47	6.3	11.33	18.73	28.14	38.62	48.75	57.19	64.05	69.41
35/1/82	322.72	11.1936	0	0	0.13	0.39	0.77	1.25	1.72	2.05	2.13	2.13	2.13	2.31	3.51	6.34	11.32	18.61	27.83	38.08	48	56.31	63.11	68.48
35/1/100	322.9	11.1996	0	0	0.16	0.46	0.89	1.43	1.96	2.35	2.48	2.48	2.48	2.62	3.72	6.39	11.16	18.23	27.28	37.46	47.43	55.88	62.87	68.44
35/1/119	323.09	11.2058	0	0	0.12	0.38	0.77	1.27	1.76	2.11	2.2	2.2	2.2	2.29	3.23	5.74	10.36	17.3	26.27	36.41	46.38	54.86	61.9	67.54
35/1/141	323.31	11.213	0	0	0.09	0.32	0.68	1.15	1.61	1.92	1.94	1.94	1.94	2.02	2.97	5.62	10.54	17.96	27.5	38.16	48.44	56.97	63.86	69.25
35/2/8	323.48	11.2186	0	0	0.12	0.37	0.75	1.22	1.66	1.94	1.96	1.96	1.96	2.06	3.07	5.71	10.48	17.51	26.36	36.08	45.41	53.3	59.87	65.23
35/2/32	323.72	11.2265	0	0	0.22	0.59	1.1	1.71	2.28	2.66	2.73	2.73	2.73	2.86	4.02	6.83	11.75	18.85	27.66	37.25	46.45	54.28	60.85	66.24
35/2/51	323.91	11.2328	0	0	0.17	0.45	0.84	1.3	1.72	1.97	1.98	1.98	1.98	2.29	3.7	6.78	11.93	19.17	28.01	37.54	46.65	54.43	60.96	66.31
35/2/90	324.3	11.2456	0	0	0.14	0.41	0.8	1.29	1.75	2.05	2.07	2.07	2.07	2.19	3.33	6.14	11.13	18.44	27.64	37.76	47.46	55.57	62.21	67.49
35/2/110	324.5	11.2522	0	0	0.13	0.38	0.75	1.2	1.61	1.85	1.86	1.86	1.86	2	3.23	6.22	11.48	19.1	28.59	38.92	48.74	56.91	63.56	68.83
35/2/130	324.7	11.2587	0	0	0.18	0.49	0.92	1.45	1.94	2.27	2.33	2.33	2.33	2.45	3.54	6.2	10.92	17.85	26.64	36.45	46.05	54.26	61.12	66.66
35/3/1	324.91	11.2657	0	0	0.09	0.32	0.68	1.15	1.61	1.93	1.98	1.98	1.98	2.08	3.08	5.67	10.37	17.37	26.33	36.4	46.29	54.73	61.74	67.37
35/3/22	325.12	11.2726	0	0	0.12	0.35	0.68	1.1	1.5	1.76	1.78	1.78	1.78	1.9	3.01	5.73	10.59	17.78	26.95	37.24	47.32	55.86	62.91	68.51
35/3/43 avg	325.33	11.2795	0	0	0.07	0.23	0.5	0.85	1.18	1.38	1.39	1.39	1.39	1.47	2.34	4.81	9.4	16.33	25.25	35.26	45.04	53.36	60.27	65.87
35/3/67	325.57	11.2874	0	0	0.09	0.27	0.54	0.88	1.2	1.38	1.39	1.39	1.39	1.44	2.2	4.5	8.88	15.62	24.45	34.51	44.45	52.96	60.08	65.86
35/3/81	325.71	11.292	0	0	0.06	0.22	0.49	0.83	1.17	1.4	1.41	1.41	1.41	1.49	2.39	4.78	9.2	15.88	24.54	34.39	44.15	52.57	59.68	65.5
35/3/104	325.94	11.2995	0	0	0.06	0.21	0.46	0.78	1.08	1.25	1.26	1.26	1.26	1.34	2.26	4.8	9.52	16.65	25.84	36.16	46.21	54.73	61.79	67.47
35/3/117	326.07	11.3038	0	0	0.02	0.14	0.38	0.7	1.02	1.23	1.24	1.24	1.24	1.31	2.18	4.61	9.13	15.95	24.72	34.55	44.17	52.43	59.39	65.12
35/3/138	326.28	11.3107	0	0	0.13	0.38	0.75	1.22	1.66	1.93	1.95	1.95	1.95	2.17	3.53	6.65	12.01	19.68	29.18	39.51	49.36	57.59	64.3	69.6
35/4/10	326.5	11.3179	0	0	0.08	0.25	0.53	0.88	1.2	1.36	1.37	1.37	1.37	1.49	2.63	5.47	10.51	17.88	27.1	37.17	46.79	54.88	61.56	66.95
35/4/30	326.7	11.3245	0	0	0.11	0.36	0.72	1.13	1.47	1.6	1.6	1.6	1.6	1.73	2.92	5.79	10.82	18.09	27.11	36.92	46.29	54.25	60.9	66.35
35/4/48	326.88	11.3304	0	0	0.12	0.34	0.66	1.05	1.4	1.59	1.6	1.6	1.6	1.75	3.02	5.97	11.08	18.42	27.5	37.36	46.8	54.8	61.46	66.86
35/4/69	327.09	11.3373	0	0	0.01	0.15	0.42	0.77	1.1	1.27	1.28	1.28	1.28	1.41	2.63	5.59	10.8	18.34	27.7	37.85	47.51	55.64	62.34	67.73
35/4/88	327.28	11.3436	0	0	0.05	0.2	0.47	0.81	1.14	1.34	1.35	1.35	1.35	1.5	2.73	5.62	10.66	17.96	27.11	37.22	47.06	55.47	62.49	68.13
35/4/110 avg	327.5	11.3508	0	0	0.1	0.3	0.6	0.98	1.32	1.53	1.54	1.54	1.54	1.76	3.02	5.87	10.72	17.68	26.32	35.83	45.13	53.22	60.12	65.83
35/4/134	327.74	11.3587	0	0	0.14	0.4	0.77	1.23	1.69	2.02	2.13	2.13	2.13	2.32	3.41	5.96	10.45	17.06	25.51	35.09	44.67	53.06	60.24	66.15
35/5/1	327.91	11.3643	0	0	0.18	0.52	1.01	1.61	2.21	2.65	2.83	2.83	2.83	2.9	3.68	5.82	9.81	15.88	23.85	33.1	42.57	51	58.33	64.42
35/5/16	328.06	11.3692	0	0	0.11	0.35	0.72	1.19	1.67	2.03	2.17	2.17	2.17	2.23	2.94	4.92	8.66	14.43	22.12	31.2	40.81	49.81	57.41	63.7
35/5/37	328.27	11.3761	0	0	0.14	0.4	0.78	1.25	1.73	2.09	2.24	2.24	2.24	2.29	2.91	4.77	8.37	14.01	21.6	30.61	40.19	49.21	56.89	63.3
35/5/57	328.47	11.3827	0	0	0.01	0.11	0.29	0.54	0.83	1.08	1.19	1.19	1.19	1.28	2.09	4.17	8.01	13.87	21.61	30.63	40.05	48.8	56.21	62.37
35/5/82	328.72	11.3909	0	0	0	0	0	0	0	0	0	0	0	0	0.26	1.94	5.46	11.52	20.12	30.57	41.39	50.87	58.92	65.4

Appendix B Table 11 (cont.): Quarter phi textural data 8.5-13.75 phi (File on CD: App B Table 11 8 to 14 phi).

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
14/1/0 avg	120.3	5.1273	61.19	65.84	69.71	72.95	75.63	77.94	80.06	82.12	84.36	86.95	89.73	92.61	95.41	97.6	98.93	99.58	99.85	99.95	99.98	99.99	99.99	99.99
14/1/21 avg	120.51	5.1326	59.39	64.03	67.96	71.3	74.13	76.61	78.93	81.19	83.6	86.27	89.07	91.93	94.71	96.97	98.46	99.3	99.71	99.89	99.97	99.99	100	100
14/1/39	120.69	5.1372	60.5	65.12	68.96	72.17	74.84	77.14	79.28	81.34	83.6	86.23	89.06	92.02	94.93	97.26	98.73	99.49	99.83	99.96	100	100.01	100.01	100.01
14/1/60	120.9	5.1425	63.72	68.27	71.88	74.77	77.11	79.12	80.99	82.86	84.98	87.49	90.19	93	95.72	97.82	99.05	99.63	99.86	99.94	99.96	99.97	99.97	99.97
14/1/81	121.11	5.1479	64.55	68.88	72.32	75.08	77.31	79.23	81.03	82.84	84.86	87.19	89.7	92.32	94.91	97.05	98.48	99.3	99.71	99.89	99.96	99.98	99.99	99.99
14/1/96	121.26	5.1517	63.48	68	71.63	74.56	76.94	78.97	80.85	82.71	84.75	87.1	89.63	92.27	94.87	97.03	98.48	99.3	99.71	99.89	99.96	99.98	99.99	99.99
14/1/119	121.49	5.1576	63.24	67.84	71.56	74.56	76.97	78.98	80.82	82.6	84.57	86.87	89.38	92.04	94.69	96.9	98.4	99.26	99.69	99.88	99.96	99.99	100	100
14/1/139	121.69	5.1626	62.4	66.76	70.35	73.29	75.67	77.66	79.46	81.16	83.13	85.45	88.02	90.78	93.59	96.02	97.78	98.87	99.48	99.78	99.91	99.97	99.99	100
14/2/10	121.9	5.168	61.37	66.03	69.9	73.1	75.72	77.93	79.95	81.86	83.96	86.45	89.18	92.08	94.96	97.28	98.74	99.49	99.82	99.95	99.99	100	100	100
14/2/29	122.09	5.1728	59.76	64.35	68.18	71.39	74.06	76.36	78.5	80.56	82.83	85.5	88.41	91.49	94.53	96.99	98.56	99.38	99.75	99.9	99.95	99.96	99.96	99.96
14/2/46	122.26	5.1771	61.79	66.37	70.15	73.29	75.89	78.14	80.22	82.26	84.45	86.91	89.51	92.19	94.81	96.98	98.44	99.28	99.7	99.89	99.97	100	100.01	100.01
14/2/71	122.51	5.1835	61.14	65.94	69.93	73.23	75.93	78.23	80.33	82.34	84.52	87.04	89.74	92.55	95.29	97.47	98.83	99.53	99.84	99.96	100	100.01	100.01	100.01
14/2/91	122.71	5.1886	60.48	65.31	69.32	72.61	75.29	77.56	79.61	81.55	83.62	85.95	88.45	91.07	93.69	95.97	97.66	98.75	99.39	99.73	99.89	99.96	99.99	100
14/2/112	122.92	5.1939	58.78	63.87	68.07	71.5	74.27	76.58	78.66	80.64	82.81	85.35	88.13	91.08	94.03	96.5	98.18	99.15	99.64	99.86	99.95	99.98	99.99	99.99
14/2/130	123.1	5.1979	62.26	66.89	70.64	73.67	76.09	78.11	79.94	81.71	83.74	86.13	88.76	91.55	94.34	96.68	98.27	99.19	99.65	99.86	99.95	99.98	99.99	99.99
14/3/0	123.3	5.2009	59.73	64.84	68.99	72.3	74.91	77.05	78.98	80.83	82.94	85.45	88.21	91.15	94.09	96.55	98.22	99.18	99.66	99.87	99.96	99.99	100	100
14/3/23	123.53	5.2044	62.58	67.46	71.39	74.51	76.97	78.99	80.82	82.58	84.54	86.84	89.36	92.03	94.68	96.9	98.4	99.26	99.69	99.88	99.96	99.99	100	100
14/3/39	123.69	5.2069	60.39	65.48	69.56	72.79	75.32	77.4	79.28	81.09	83.11	85.49	88.12	90.92	93.74	96.16	97.89	98.95	99.53	99.81	99.93	99.98	100	100.01
14/3/58	123.88	5.2098	61.69	66.45	70.28	73.34	75.78	77.82	79.69	81.51	83.54	85.9	88.48	91.21	93.94	96.28	97.94	98.96	99.51	99.78	99.9	99.95	99.97	99.98
14/3/81	124.11	5.2132	60	64.72	68.59	71.76	74.34	76.52	78.52	80.46	82.6	85.08	87.79	90.66	93.54	96.01	97.78	98.88	99.48	99.78	99.91	99.97	99.99	100
14/3/100	124.3	5.2161	62.35	66.9	70.63	73.67	76.13	78.2	80.09	81.9	83.89	86.19	88.71	91.38	94.06	96.36	98	99.01	99.56	99.83	99.94	99.99	100.01	100.02
14/3/120	124.5	5.2192	62.21	66.76	70.49	73.53	75.99	78.06	79.93	81.71	83.64	85.86	88.29	90.87	93.49	95.79	97.51	98.64	99.3	99.66	99.83	99.91	99.94	99.95
14/3/138	124.68	5.2219	61.73	66.45	70.28	73.35	75.78	77.78	79.57	81.26	83.14	85.35	87.82	90.48	93.2	95.61	97.42	98.61	99.31	99.69	99.87	99.95	99.98	99.99
14/4/10	124.9	5.2252	60.37	65.27	69.22	72.36	74.85	76.91	78.78	80.58	82.61	84.98	87.59	90.36	93.16	95.61	97.44	98.63	99.33	99.7	99.87	99.95	99.98	99.99
14/4/30	125.1	5.2283	61.27	66.27	70.36	73.64	76.24	78.38	80.29	82.09	84.06	86.35	88.85	91.49	94.13	96.39	98	98.99	99.53	99.79	99.9	99.95	99.97	99.98
14/4/50	125.3	5.2313	59.51	64.99	69.39	72.82	75.44	77.54	79.38	81.11	83.07	85.41	88.02	90.82	93.64	96.08	97.82	98.9	99.49	99.78	99.91	99.96	99.98	99.99
14/4/68	125.48	5.234	58.46	63.98	68.37	71.79	74.42	76.54	78.45	80.24	82.41	85.12	88.17	91.44	94.68	97.24	98.79	99.55	99.86	99.97	100	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
14/4/91	125.71	5.2375	58.58	64.19	68.63	72.08	74.72	76.85	78.77	80.58	82.72	85.39	88.39	91.61	94.79	97.29	98.8	99.54	99.84	99.95	99.98	99.99	99.99	99.99
14/4/111	125.91	5.2406	60.58	65.95	70.14	73.35	75.79	77.76	79.54	81.29	83.31	85.75	88.45	91.33	94.2	96.6	98.23	99.17	99.65	99.86	99.95	99.98	99.99	99.99
14/4/130	126.1	5.2435	57.9	63.52	68.03	71.6	74.4	76.7	78.8	80.81	83.11	85.91	88.97	92.18	95.29	97.66	99.02	99.64	99.88	99.96	99.98	99.99	99.99	99.99
14/5/0	126.3	5.2465	60.98	66.04	70.05	73.19	75.64	77.66	79.51	81.33	83.4	85.85	88.54	91.38	94.21	96.58	98.2	99.15	99.63	99.85	99.94	99.97	99.98	99.98
14/5/26	126.56	5.2504	63.5	68.29	72.09	75.08	77.41	79.32	81.06	82.77	84.71	87.03	89.58	92.28	94.95	97.14	98.57	99.35	99.72	99.87	99.93	99.95	99.96	99.96
14/5/40	126.7	5.2526	61.95	66.78	70.59	73.61	75.99	77.98	79.79	81.61	83.76	86.41	89.34	92.44	95.46	97.76	99.07	99.66	99.88	99.95	99.97	99.97	99.97	99.97
14/5/60	126.9	5.2556	63.61	68.3	72.1	75.16	77.59	79.6	81.42	83.18	85.14	87.44	89.95	92.59	95.2	97.32	98.69	99.42	99.76	99.9	99.95	99.97	99.98	99.98
14/5/82	127.12	5.2589	59.61	64.37	68.29	71.5	74.1	76.29	78.28	80.19	82.33	84.83	87.57	90.49	93.43	95.96	97.77	98.89	99.5	99.8	99.93	99.99	100.01	100.02
14/5/100	127.3	5.2617	62.18	66.84	70.68	73.82	76.37	78.51	80.46	82.3	84.34	86.77	89.44	92.27	95.08	97.34	98.76	99.49	99.81	99.93	99.97	99.98	99.98	99.98
14/5/121	127.51	5.2649	62.47	67.15	70.98	74.09	76.6	78.7	80.61	82.41	84.41	86.8	89.45	92.27	95.07	97.33	98.75	99.48	99.8	99.93	99.97	99.98	99.98	99.98
14/5/140	127.7	5.2678	63.73	68.13	71.69	74.57	76.9	78.86	80.64	82.36	84.26	86.48	88.92	91.53	94.16	96.42	98.03	99.01	99.54	99.8	99.91	99.96	99.98	99.99
14/6/10	127.9	5.2708	61.61	66.14	69.85	72.86	75.3	77.36	79.23	81.01	82.97	85.25	87.76	90.45	93.19	95.61	97.42	98.61	99.31	99.68	99.85	99.93	99.96	99.97
14/6/30	128.1	5.2738	64.12	68.63	72.3	75.26	77.63	79.59	81.35	83.01	84.83	86.96	89.31	91.82	94.36	96.54	98.09	99.04	99.55	99.8	99.91	99.96	99.98	99.99
14/6/49	128.29	5.2767	62.95	67.57	71.33	74.37	76.81	78.84	80.68	82.44	84.39	86.68	89.19	91.86	94.54	96.79	98.33	99.22	99.67	99.87	99.96	99.99	100	100
14/6/69	128.49	5.2798	63.2	67.73	71.44	74.45	76.88	78.92	80.77	82.54	84.48	86.72	89.16	91.74	94.32	96.53	98.1	99.06	99.58	99.84	99.95	100	100.02	100.03
14/6/92	128.72	5.2832	63.26	67.7	71.27	74.14	76.45	78.41	80.23	82.05	84.09	86.48	89.09	91.84	94.57	96.85	98.39	99.27	99.71	99.91	99.99	100.02	100.03	100.03
14/6/112	128.92	5.2863	60.36	65.14	69.11	72.38	75.05	77.3	79.35	81.34	83.53	86.08	88.85	91.76	94.63	96.98	98.52	99.36	99.76	99.93	99.99	100.01	100.02	100.02
14/6/130	129.1	5.289	61.76	66.53	70.43	73.58	76.12	78.24	80.17	82.03	84.11	86.52	89.13	91.86	94.56	96.81	98.33	99.2	99.64	99.83	99.91	99.94	99.95	99.95
14/7/0	129.3	5.2921	63.77	68.2	71.77	74.64	76.95	78.91	80.71	82.46	84.38	86.57	88.94	91.44	93.95	96.14	97.76	98.81	99.42	99.75	99.9	99.97	100	100.01
14/7/20	129.5	5.2951	61.91	66.54	70.27	73.27	75.68	77.71	79.58	81.39	83.47	85.88	88.49	91.24	93.98	96.32	97.97	98.98	99.52	99.79	99.9	99.95	99.97	99.98
14cc/10	129.69	5.298	61.39	66.09	69.87	72.89	75.31	77.35	79.23	81.06	83.18	85.64	88.3	91.1	93.88	96.25	97.93	98.96	99.52	99.8	99.92	99.97	99.99	100
15/1/0	129.9	5.3012	60.72	65.74	69.73	72.86	75.31	77.35	79.22	81.11	83.26	85.79	88.54	91.43	94.29	96.67	98.28	99.2	99.66	99.86	99.95	99.98	99.99	99.99
15/1/22	130.12	5.3045	61.95	66.64	70.41	73.41	75.79	77.78	79.57	81.32	83.38	85.94	88.82	91.91	94.97	97.38	98.84	99.55	99.84	99.94	99.97	99.98	99.98	99.98
15/1/39	130.29	5.3071	62.53	67.16	70.9	73.9	76.28	78.25	80.05	81.81	83.8	86.17	88.78	91.57	94.36	96.7	98.29	99.2	99.66	99.86	99.95	99.98	99.99	99.99
15/1/60	130.5	5.3103	61.8	66.5	70.26	73.26	75.64	77.63	79.46	81.26	83.3	85.73	88.42	91.29	94.17	96.59	98.24	99.19	99.67	99.88	99.97	100	100.01	100.01
15/1/79	130.69	5.3132	62.69	67.29	70.94	73.84	76.13	78.06	79.82	81.58	83.68	86.31	89.25	92.39	95.46	97.8	99.12	99.71	99.93	100	100.02	100.02	100.02	100.02
15/1/99	130.89	5.3162	63.54	67.9	71.34	74.07	76.24	78.08	79.78	81.51	83.6	86.22	89.16	92.31	95.4	97.76	99.1	99.7	99.92	99.99	100.01	100.01	100.01	100.01
15/1/120	131.1	5.3194	61.5	66.19	69.94	72.94	75.31	77.31	79.12	80.93	83.09	85.8	88.84	92.09	95.28	97.71	99.08	99.69	99.91	99.98	100	100	100	100
15/1/140	131.3	5.3224	60.36	65.02	68.82	71.91	74.38	76.46	78.34	80.19	82.37	85.08	88.13	91.42	94.68	97.26	98.8	99.54	99.84	99.95	99.98	99.99	99.99	99.99
15/2/11	131.51	5.3256	59.56	64.29	68.14	71.26	73.75	75.86	77.69	79.45	81.64	84.53	87.89	91.57	95.19	97.85	99.22	99.76	99.92	99.96	99.97	99.97	99.97	99.97
15/2/30	131.7	5.3285	60.78	65.52	69.27	72.23	74.55	76.5	78.27	80.05	82.23	85.01	88.17	91.58	94.94	97.52	98.99	99.65	99.9	99.98	100	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
15/2/51	131.91	5.3317	62.79	67.17	70.6	73.3	75.46	77.2	78.76	80.44	82.57	85.4	88.65	92.17	95.59	98.06	99.31	99.79	99.93	99.97	99.98	99.98	99.98	99.98
15/2/71	132.11	5.3347	61.2	65.67	69.28	72.2	74.54	76.53	78.34	80.15	82.31	85	88.04	91.33	94.6	97.19	98.76	99.53	99.85	99.96	99.99	100	100	100
15/2/93	132.33	5.3381	62.16	66.62	70.21	73.11	75.43	77.39	79.17	80.92	83.02	85.67	88.68	91.93	95.13	97.6	99.03	99.68	99.93	100.01	100.03	100.04	100.04	100.04
15/2/113	132.53	5.3411	62.64	67.01	70.49	73.27	75.48	77.34	79.04	80.74	82.82	85.48	88.52	91.81	95.06	97.57	99.01	99.66	99.91	99.99	100.01	100.02	100.02	100.02
15/2/134 avg	132.74	5.3443	62.28	66.8	70.35	73.17	75.39	77.28	78.93	80.57	82.69	85.54	88.84	92.42	95.87	98.29	99.44	99.84	99.95	99.97	99.98	99.98	99.98	99.98
15/3/0	132.9	5.3467	58.28	63	66.9	70.11	72.7	74.91	76.83	78.67	80.94	83.93	87.41	91.22	94.98	97.75	99.19	99.75	99.93	99.98	99.99	99.99	99.99	99.99
15/3/17	133.07	5.3493	59.93	64.47	68.18	71.2	73.63	75.69	77.55	79.37	81.54	84.29	87.43	90.86	94.29	97.02	98.69	99.51	99.85	99.97	100	100.01	100.01	100.01
15/3/39	133.29	5.3526	60.48	64.97	68.7	71.79	74.3	76.43	78.35	80.21	82.39	85.12	88.22	91.57	94.88	97.45	98.94	99.62	99.88	99.96	99.98	99.99	99.99	99.99
15/3/56	133.46	5.3552	60.68	65.2	68.93	72.01	74.5	76.61	78.52	80.38	82.56	85.29	88.37	91.69	94.97	97.51	98.98	99.65	99.91	99.99	100.01	100.02	100.02	100.02
15/3/78	133.68	5.3586	59.93	64.5	68.21	71.23	73.66	75.74	77.56	79.32	81.52	84.43	87.82	91.54	95.19	97.87	99.25	99.79	99.95	99.99	100	100	100	100
15/3/99	133.89	5.3617	59.65	64.37	68.22	71.33	73.82	75.92	77.81	79.68	81.9	84.67	87.8	91.18	94.54	97.19	98.78	99.55	99.86	99.97	100	100.01	100.01	100.01
15/3/120	134.1	5.3649	60.71	65.17	68.79	71.7	74.03	75.99	77.8	79.63	81.74	84.27	87.09	90.13	93.2	95.85	97.74	98.9	99.53	99.83	99.96	100.01	100.03	100.04
15/3/140	134.3	5.368	60.19	64.71	68.4	71.39	73.79	75.82	77.65	79.45	81.61	84.35	87.49	90.91	94.33	97.05	98.7	99.5	99.83	99.95	99.98	99.99	99.99	99.99
15/4/10	134.5	5.371	57.14	62.01	66.08	69.45	72.18	74.47	76.59	78.59	80.94	83.89	87.25	90.88	94.47	97.25	98.86	99.6	99.88	99.97	99.99	100	100	100
15/4/30	134.7	5.374	58.68	63.41	67.29	70.46	73.01	75.16	77.11	79.01	81.27	84.1	87.32	90.81	94.29	97.04	98.7	99.51	99.84	99.95	99.98	99.99	99.99	99.99
15/4/50	134.9	5.3771	59.26	63.94	67.73	70.8	73.26	75.36	77.2	79.03	81.33	84.34	87.8	91.56	95.23	97.9	99.26	99.79	99.95	99.99	100	100	100	100
15/4/70	135.1	5.3801	58.97	63.63	67.44	70.53	73.02	75.13	77.03	78.92	81.15	83.91	87.05	90.46	93.88	96.67	98.45	99.38	99.79	99.95	100.01	100.02	100.02	100.02
15/4/90	135.3	5.3832	58.31	62.99	66.89	70.12	72.76	74.98	77.04	78.99	81.28	84.13	87.34	90.82	94.28	97.03	98.7	99.51	99.84	99.96	99.99	100	100	100
15/4/110	135.5	5.3862	62.46	66.85	70.31	73.06	75.26	77.15	78.91	80.73	82.94	85.7	88.78	92.05	95.24	97.67	99.05	99.67	99.9	99.97	99.99	99.99	99.99	99.99
15/4/130	135.7	5.3892	59.3	64.11	68	71.13	73.62	75.72	77.62	79.53	81.8	84.62	87.79	91.19	94.55	97.2	98.79	99.56	99.87	99.98	100.01	100.02	100.02	100.02
15/5/0	135.9	5.3923	59.91	64.59	68.37	71.41	73.85	75.92	77.81	79.7	81.95	84.74	87.88	91.25	94.58	97.2	98.78	99.54	99.85	99.96	99.99	100	100	100
15/5/16	136.06	5.3947	61.39	65.9	69.52	72.42	74.73	76.69	78.48	80.28	82.44	85.14	88.19	91.47	94.72	97.28	98.82	99.56	99.86	99.97	100	100.01	100.01	100.01
15/5/42	136.32	5.3986	60.46	65.08	68.75	71.69	74.03	76.04	77.82	79.61	81.89	84.91	88.37	92.1	95.68	98.2	99.42	99.86	99.98	100.01	100.02	100.02	100.02	100.02
15/5/61	136.51	5.4015	58.9	63.69	67.57	70.71	73.23	75.37	77.32	79.25	81.53	84.37	87.57	91.01	94.42	97.11	98.74	99.53	99.86	99.98	100.01	100.02	100.02	100.02
15/5/102	136.92	5.4078	58.98	63.53	67.25	70.29	72.76	74.87	76.8	78.74	81.05	83.93	87.2	90.72	94.21	96.97	98.64	99.45	99.78	99.9	99.93	99.94	99.94	99.94
15/5/123	137.13	5.4109	58.42	62.86	66.54	69.56	72.03	74.14	76.1	78.02	80.2	82.79	85.69	88.82	92.02	94.85	96.98	98.38	99.2	99.64	99.84	99.93	99.97	99.98
15/5/142	137.32	5.4138	56.17	61	65.09	68.51	71.32	73.7	75.91	78.08	80.53	83.45	86.68	90.12	93.53	96.34	98.19	99.21	99.69	99.89	99.97	99.99	100	100
15/6/12	137.52	5.4169	55.89	61.1	65.42	68.94	71.73	74.06	76.07	77.99	80.37	83.5	87.13	91.09	94.97	97.79	99.23	99.78	99.94	99.98	99.99	99.99	99.99	99.99
15/6/31	137.71	5.4197	55.22	60.33	64.62	68.15	70.99	73.35	75.52	77.65	80.11	83.12	86.49	90.1	93.69	96.59	98.42	99.37	99.79	99.95	100.01	100.02	100.02	100.02
15/6/51	137.91	5.4228	55.68	60.58	64.63	67.93	70.57	72.8	74.71	76.54	78.86	81.99	85.71	89.87	94.04	97.21	98.95	99.68	99.93	100	100.01	100.01	100.01	100.01
15/6/65	138.05	5.4249	57.32	62.29	66.38	69.69	72.31	74.5	76.36	78.12	80.35	83.36	86.92	90.87	94.79	97.68	99.19	99.78	99.96	100.01	100.02	100.02	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
15/6/87	138.27	5.4282	57.89	62.93	67.01	70.26	72.79	74.87	76.7	78.47	80.64	83.45	86.72	90.32	93.94	96.84	98.61	99.47	99.83	99.96	100	100.01	100.01	100.01
15/6/126	138.47	5.4313	59.24	64.13	68.07	71.21	73.67	75.7	77.5	79.28	81.47	84.29	87.54	91.08	94.6	97.33	98.9	99.62	99.89	99.98	100	100.01	100.01	100.01
15/6/107	138.66	5.4342	59.53	64.4	68.31	71.41	73.81	75.79	77.46	79.05	81.12	83.97	87.38	91.18	94.96	97.75	99.19	99.76	99.93	99.97	99.98	99.98	99.98	99.98
15/7/0	138.9	5.4378	59.21	64.04	67.94	71.05	73.5	75.53	77.39	79.27	81.46	84.11	87.07	90.25	93.44	96.13	97.98	99.05	99.59	99.83	99.93	99.96	99.97	99.97
15/7/17	139.07	5.4404	59.13	63.85	67.63	70.63	73.01	75	76.85	78.73	80.91	83.54	86.49	89.66	92.87	95.63	97.6	98.81	99.47	99.79	99.92	99.98	100	100.01
15cc/9	139.22	5.4427	58.66	63.53	67.47	70.64	73.16	75.29	77.14	78.92	81.16	84.13	87.59	91.38	95.1	97.82	99.22	99.77	99.94	99.98	99.99	99.99	99.99	99.99
16/1/0	139.5	5.4469	56.32	61.11	65.12	68.45	71.17	73.48	75.63	77.76	80.2	83.13	86.4	89.89	93.37	96.24	98.14	99.19	99.69	99.9	99.98	100	100.01	100.01
16/1/25	139.75	5.4507	57.5	62.22	66.22	69.56	72.28	74.57	76.68	78.75	81.11	83.97	87.16	90.58	93.97	96.72	98.47	99.39	99.8	99.96	100.02	100.03	100.03	100.03
16/1/43	139.93	5.4535	58.7	63.18	66.94	70.05	72.59	74.73	76.69	78.6	80.82	83.51	86.54	89.81	93.12	95.93	97.87	99.01	99.59	99.85	99.96	100	100.01	100.01
16/1/67	140.17	5.4571	58.04	62.91	66.95	70.27	72.94	75.16	77.22	79.17	81.45	84.32	87.58	91.11	94.6	97.31	98.88	99.6	99.88	99.97	99.99	100	100	100
16/1/84	140.34	5.4597	59.86	64.38	68.09	71.1	73.51	75.55	77.38	79.18	81.32	84.01	87.09	90.46	93.86	96.64	98.42	99.36	99.78	99.94	100	100.01	100.01	100.01
16/1/104	140.54	5.4627	58.06	62.89	66.91	70.21	72.86	75.07	77.11	79.03	81.27	84.08	87.28	90.75	94.21	96.97	98.66	99.49	99.83	99.95	99.98	99.99	99.99	99.99
16/1/123	140.73	5.4656	59.66	64.36	68.19	71.28	73.73	75.8	77.59	79.3	81.46	84.34	87.72	91.44	95.11	97.81	99.21	99.76	99.93	99.97	99.98	99.98	99.98	99.98
16/1/142	140.92	5.4685	56.89	62.04	66.32	69.8	72.57	74.85	76.91	78.82	81.06	83.89	87.11	90.62	94.13	96.93	98.64	99.48	99.83	99.95	99.98	99.99	99.99	99.99
16/2/13	141.13	5.4717	57.4	62.46	66.63	70	72.67	74.86	76.84	78.75	80.94	83.61	86.62	89.88	93.17	95.96	97.89	99.02	99.59	99.85	99.96	99.99	100	100
16/2/36	141.36	5.4752	57.22	62.21	66.34	69.71	72.4	74.65	76.58	78.38	80.61	83.59	87.1	90.98	94.83	97.67	99.15	99.73	99.91	99.96	99.97	99.97	99.97	99.97
16/2/54	141.54	5.4779	59.27	63.99	67.88	71.05	73.59	75.7	77.65	79.48	81.62	84.33	87.45	90.87	94.3	97.04	98.71	99.52	99.85	99.97	100	100.01	100.01	100.01
16/2/79	141.79	5.4817	60.95	65.31	68.87	71.75	74.06	76.01	77.81	79.64	81.76	84.33	87.23	90.36	93.51	96.18	98.01	99.08	99.62	99.86	99.96	99.99	100	100
16/2/92	141.92	5.4837	59.4	64.11	67.98	71.13	73.65	75.76	77.65	79.49	81.7	84.51	87.73	91.23	94.69	97.37	98.91	99.61	99.87	99.95	99.97	99.98	99.98	99.98
16/2/112	142.12	5.4867	60.31	64.91	68.67	71.71	74.14	76.18	78.01	79.79	81.91	84.6	87.69	91.06	94.42	97.1	98.73	99.52	99.84	99.95	99.98	99.99	99.99	99.99
16/2/132	142.32	5.4897	58.58	63.39	67.35	70.56	73.11	75.22	77.15	79.02	81.17	83.8	86.77	89.99	93.25	96.01	97.92	99.03	99.6	99.85	99.96	99.99	100	100
16/3/0	142.5	5.4925	58.55	63.55	67.68	71.03	73.69	75.88	77.87	79.71	81.85	84.56	87.66	91.04	94.43	97.13	98.75	99.53	99.85	99.96	99.99	100	100	100
16/3/25	142.75	5.4963	59.13	64.1	68.19	71.51	74.13	76.28	78.24	80.06	82.19	84.92	88.05	91.47	94.87	97.49	98.99	99.66	99.91	99.99	100.01	100.02	100.02	100.02
16/3/43	142.93	5.499	59.23	64.18	68.21	71.44	73.97	76.03	77.91	79.66	81.74	84.41	87.51	90.92	94.35	97.08	98.72	99.51	99.83	99.94	99.97	99.98	99.98	99.98
16/3/65	143.15	5.5023	59.99	64.84	68.76	71.88	74.31	76.29	78.1	79.79	81.85	84.51	87.59	90.97	94.37	97.08	98.72	99.52	99.85	99.96	99.99	100	100	100
16/3/82	143.32	5.5049	59.3	64.28	68.32	71.54	74.05	76.08	77.92	79.62	81.67	84.33	87.42	90.82	94.26	97.01	98.68	99.5	99.84	99.96	99.99	100	100	100
16/3/103	143.53	5.5081	58.12	63.36	67.61	70.98	73.59	75.7	77.58	79.37	81.44	83.99	86.9	90.06	93.28	96.02	97.91	99.01	99.57	99.82	99.93	99.97	99.98	99.98
16/3/124	143.74	5.5116	60.11	65.29	69.43	72.69	75.2	77.23	79.08	80.81	82.86	85.5	88.53	91.82	95.09	97.6	99.03	99.67	99.91	99.99	100.01	100.01	100.01	100.01
16/3/134	143.84	5.5145	61.3	65.93	69.63	72.56	74.86	76.78	78.49	80.19	82.24	84.82	87.77	90.99	94.23	96.87	98.54	99.41	99.79	99.93	99.98	99.99	99.99	99.99
16/4/7	144.07	5.5211	60.11	65.07	69.05	72.2	74.67	76.71	78.53	80.3	82.42	85.09	88.12	91.4	94.67	97.25	98.8	99.55	99.85	99.96	99.99	100	100	100
16/4/26	144.26	5.5266	58.7	63.92	68.16	71.55	74.21	76.37	78.32	80.13	82.25	84.92	87.96	91.27	94.59	97.21	98.78	99.53	99.83	99.94	99.97	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
16/4/46	144.46	5.5324	56.43	61.68	66.04	69.58	72.4	74.72	76.8	78.78	81.03	83.74	86.76	90.01	93.3	96.07	97.96	99.05	99.6	99.84	99.94	99.97	99.98	99.98
16/4/67	144.67	5.5385	59.21	64.19	68.34	71.73	74.44	76.67	78.67	80.5	82.57	85.13	88.03	91.19	94.38	96.97	98.6	99.43	99.79	99.93	99.98	99.99	99.99	99.99
16/4/93	144.93	5.546	61.94	66.7	70.54	73.61	76.03	78.02	79.83	81.59	83.6	86.03	88.74	91.65	94.56	96.95	98.51	99.35	99.74	99.9	99.96	99.98	99.99	99.99
16/4/113	145.13	5.5518	62.1	66.75	70.5	73.49	75.84	77.77	79.52	81.22	83.19	85.58	88.25	91.13	94.04	96.5	98.18	99.15	99.64	99.86	99.95	99.98	99.99	99.99
16/4/132	145.32	5.5573	62.47	67.26	71.15	74.25	76.68	78.67	80.45	82.14	84.05	86.34	88.89	91.63	94.39	96.71	98.29	99.2	99.66	99.86	99.94	99.97	99.98	99.98
16/5/0	145.5	5.5626	61.63	66.77	70.91	74.18	76.7	78.73	80.56	82.33	84.35	86.8	89.5	92.37	95.21	97.47	98.86	99.56	99.86	99.98	100.02	100.03	100.03	100.03
16/5/14	145.64	5.5666	64.2	68.81	72.46	75.31	77.52	79.33	80.99	82.65	84.59	86.97	89.62	92.44	95.24	97.48	98.87	99.57	99.87	99.99	100.03	100.04	100.04	100.04
16/5/43	145.93	5.575	62.56	67.24	70.98	73.93	76.24	78.16	79.89	81.58	83.59	86.11	88.95	92.01	95.04	97.43	98.87	99.57	99.86	99.96	99.99	100	100	100
16/5/63	146.13	5.5808	64.75	69.36	73	75.84	78.04	79.86	81.54	83.23	85.18	87.53	90.11	92.82	95.48	97.59	98.89	99.55	99.83	99.94	99.97	99.98	99.98	99.98
16/5/86	146.36	5.5875	65.49	70	73.65	76.55	78.8	80.63	82.26	83.82	85.59	87.73	90.12	92.68	95.24	97.34	98.71	99.45	99.79	99.93	99.98	100	100.01	100.01
16/5/102	146.52	5.5921	66.11	70.22	73.58	76.28	78.42	80.18	81.76	83.26	84.95	86.98	89.26	91.73	94.25	96.44	98.02	99	99.54	99.81	99.93	99.98	100	100.01
16/5/121	146.71	5.5976	63.22	67.72	71.33	74.2	76.48	78.4	80.15	81.91	83.98	86.52	89.34	92.34	95.28	97.58	98.94	99.59	99.85	99.94	99.97	99.98	99.98	99.98
16/5/142	146.92	5.6037	61.04	65.73	69.55	72.63	75.09	77.14	79.02	80.86	82.94	85.42	88.16	91.08	94	96.46	98.15	99.13	99.63	99.85	99.94	99.97	99.98	99.98
16/6/6	147.06	5.6077	59.38	64.28	68.33	71.64	74.29	76.49	78.5	80.39	82.55	85.22	88.22	91.45	94.67	97.22	98.76	99.51	99.82	99.93	99.96	99.97	99.97	99.97
16/6/26	147.26	5.6135	57.11	62.54	67.02	70.62	73.46	75.78	77.88	79.84	82.11	84.9	88.02	91.35	94.65	97.24	98.79	99.54	99.85	99.96	99.99	100	100	100
16/6/47	147.47	5.6196	63.14	67.73	71.4	74.28	76.53	78.38	80.07	81.73	83.67	86.01	88.63	91.43	94.25	96.62	98.24	99.17	99.64	99.85	99.94	99.97	99.98	99.98
16/6/64	147.64	5.6245	61.89	66.73	70.65	73.78	76.24	78.25	80.08	81.78	83.75	86.22	89.02	92.05	95.08	97.47	98.9	99.59	99.87	99.97	100	100.01	100.01	100.01
16/6/93	147.93	5.6329	64.05	68.49	72.1	75.02	77.35	79.29	81.05	82.75	84.66	86.94	89.47	92.18	94.89	97.12	98.58	99.38	99.76	99.92	99.98	100	100.01	100.01
16/6/115	148.15	5.6393	63.01	67.45	71.12	74.12	76.52	78.51	80.31	82.04	83.99	86.34	88.96	91.78	94.62	96.97	98.51	99.35	99.75	99.91	99.97	99.99	100	100
16/6/133	148.33	5.6445	63.29	67.59	71.14	74.02	76.33	78.24	79.94	81.52	83.29	85.41	87.82	90.46	93.19	95.63	97.46	98.65	99.34	99.71	99.88	99.96	99.99	100
16/7/0	148.5	5.6494	62.49	66.99	70.68	73.67	76.06	78.05	79.86	81.61	83.58	85.94	88.57	91.39	94.23	96.62	98.25	99.18	99.65	99.86	99.95	99.98	99.99	99.99
16/7/17	148.67	5.6544	62.07	66.64	70.33	73.3	75.65	77.62	79.38	81.11	83.16	85.72	88.62	91.76	94.89	97.36	98.84	99.55	99.84	99.94	99.97	99.98	99.98	99.98
16cc/8	148.77	5.6573	62.32	66.92	70.71	73.79	76.25	78.28	80.11	81.85	83.79	86.11	88.69	91.47	94.27	96.63	98.25	99.19	99.67	99.88	99.97	100	100.01	100.01
17/1/0	149.1	5.6668	62.37	66.83	70.47	73.42	75.8	77.79	79.64	81.4	83.46	86.01	88.87	91.95	95	97.41	98.86	99.56	99.85	99.95	99.98	99.99	99.99	99.99
17/1/26	149.36	5.6743	61.77	66.39	70.21	73.3	75.77	77.82	79.66	81.41	83.36	85.66	88.22	90.97	93.75	96.15	97.87	98.93	99.51	99.79	99.91	99.96	99.98	99.99
17/1/42	149.52	5.679	62.29	67	70.87	73.98	76.44	78.46	80.27	82	83.94	86.26	88.83	91.59	94.36	96.69	98.28	99.2	99.67	99.88	99.97	100	100.01	100.01
17/1/82	149.92	5.6906	59.66	64.66	68.7	71.93	74.49	76.63	78.56	80.45	82.68	85.44	88.53	91.83	95.06	97.55	98.98	99.63	99.88	99.96	99.98	99.99	99.99	99.99
17/1/101	150.11	5.6961	59.68	64.63	68.71	72	74.61	76.75	78.68	80.46	82.5	85.04	87.93	91.08	94.26	96.86	98.52	99.39	99.78	99.93	99.98	99.99	99.99	99.99
17/1/121	150.31	5.7019	59.81	64.92	69.17	72.6	75.29	77.46	79.37	81.14	83.12	85.5	88.17	91.06	93.98	96.45	98.15	99.14	99.64	99.86	99.95	99.98	99.99	99.99
17/1/141	150.51	5.7076	57.94	63	67.26	70.75	73.55	75.87	77.95	79.92	82.1	84.68	87.53	90.58	93.64	96.22	98	99.04	99.57	99.81	99.91	99.94	99.95	99.95
17/2/7	150.67	5.7123	62.95	67.24	70.71	73.52	75.77	77.68	79.42	81.13	83.16	85.7	88.59	91.72	94.84	97.31	98.81	99.54	99.84	99.95	99.98	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
17/2/27	150.87	5.7181	64.8	68.85	72.18	74.9	77.11	78.98	80.7	82.37	84.23	86.42	88.85	91.45	94.08	96.35	97.98	98.98	99.53	99.8	99.91	99.96	99.98	99.99
17/2/47	151.07	5.7239	62.46	66.92	70.55	73.48	75.83	77.81	79.6	81.34	83.39	85.93	88.8	91.89	94.95	97.37	98.83	99.54	99.83	99.93	99.96	99.97	99.97	99.97
17/2/73	151.33	5.7314	61.03	65.6	69.37	72.44	74.91	76.98	78.86	80.68	82.72	85.13	87.81	90.68	93.57	96.06	97.84	98.93	99.52	99.81	99.93	99.98	100	100.01
17/2/92	151.52	5.7369	59.9	64.63	68.53	71.7	74.24	76.35	78.28	80.15	82.27	84.81	87.64	90.67	93.72	96.29	98.06	99.09	99.62	99.86	99.96	99.99	100	100
17/2/115	151.75	5.7436	60.53	65.15	68.93	71.98	74.41	76.44	78.29	80.09	82.14	84.59	87.33	90.27	93.25	95.83	97.69	98.84	99.47	99.78	99.91	99.97	99.99	100
17/2/136	151.96	5.7496	64.07	68.24	71.58	74.25	76.38	78.18	79.85	81.51	83.41	85.69	88.24	90.98	93.76	96.16	97.88	98.94	99.52	99.8	99.92	99.97	99.99	100
17/3/0	152.1	5.7537	59.25	64.4	68.51	71.75	74.27	76.34	78.19	79.99	82.16	84.93	88.08	91.48	94.84	97.44	98.94	99.62	99.88	99.96	99.98	99.99	99.99	99.99
17/3/15	152.25	5.758	60.12	65.15	69.28	72.59	75.21	77.35	79.27	81.09	83.12	85.54	88.23	91.11	94	96.44	98.12	99.1	99.6	99.83	99.93	99.96	99.97	99.97
17/3/37	152.47	5.7644	61.44	66.17	70.1	73.3	75.88	78.02	79.93	81.72	83.68	85.96	88.48	91.17	93.88	96.22	97.9	98.94	99.51	99.79	99.91	99.96	99.98	99.99
17/3/65	152.75	5.7725	62.25	66.87	70.61	73.61	76.01	78.03	79.89	81.67	83.69	86.15	88.9	91.85	94.78	97.16	98.67	99.46	99.81	99.94	99.99	100	100	100
17/3/81	152.91	5.7772	61.03	65.57	69.35	72.46	75	77.16	79.15	81.07	83.26	85.78	88.5	91.36	94.19	96.56	98.19	99.14	99.63	99.85	99.95	99.98	99.99	99.99
17/3/102	153.12	5.7832	59.6	64.35	68.21	71.36	73.92	76.12	78.16	80.21	82.58	85.45	88.6	91.91	95.12	97.57	98.98	99.63	99.88	99.96	99.98	99.99	99.99	99.99
17/3/116	153.26	5.7873	61.82	65.98	69.46	72.37	74.8	76.91	78.88	80.81	82.93	85.37	88.03	90.85	93.67	96.1	97.84	98.92	99.51	99.8	99.93	99.99	100.01	100.02
17/3/135	153.45	5.7928	59.88	64.34	68.18	71.45	74.18	76.52	78.64	80.64	82.79	85.24	87.9	90.72	93.55	95.99	97.75	98.85	99.46	99.76	99.89	99.95	99.97	99.98
17/4/6	153.66	5.7989	59.42	63.99	67.89	71.16	73.87	76.17	78.24	80.18	82.27	84.66	87.28	90.07	92.9	95.4	97.28	98.52	99.25	99.64	99.83	99.92	99.95	99.96
17/4/37	153.97	5.8079	58	63	67.19	70.61	73.37	75.66	77.73	79.65	81.81	84.42	87.35	90.52	93.71	96.38	98.17	99.18	99.67	99.88	99.96	99.99	100	100
17/4/53	154.13	5.8125	59.01	64.01	68.15	71.5	74.18	76.39	78.38	80.26	82.35	84.81	87.53	90.44	93.38	95.92	97.74	98.86	99.47	99.77	99.9	99.96	99.98	99.99
17/4/72	154.32	5.818	59.22	64.01	67.95	71.13	73.68	75.81	77.74	79.59	81.65	84.07	86.77	89.67	92.62	95.23	97.19	98.48	99.24	99.65	99.84	99.93	99.97	99.98
17/4/94	154.54	5.8244	61.25	65.88	69.7	72.82	75.33	77.43	79.34	81.19	83.25	85.68	88.36	91.22	94.08	96.5	98.16	99.13	99.62	99.84	99.93	99.96	99.97	99.97
17/4/117	154.77	5.831	57.54	62.55	66.74	70.19	72.98	75.31	77.42	79.44	81.69	84.34	87.27	90.39	93.52	96.16	97.98	99.04	99.58	99.82	99.92	99.95	99.96	99.96
17/4/135	154.95	5.8362	59.05	63.88	67.89	71.17	73.82	76.05	78.08	80.02	82.17	84.68	87.44	90.38	93.34	95.89	97.72	98.85	99.47	99.77	99.9	99.96	99.98	99.99
17/5/0	155.1	5.8406	58.45	63.62	67.85	71.26	73.97	76.2	78.23	80.13	82.31	85.02	88.07	91.37	94.65	97.24	98.8	99.56	99.87	99.98	100.01	100.02	100.02	100.02
17/5/14	155.24	5.8446	60.53	65.32	69.26	72.45	74.99	77.1	79.01	80.85	82.92	85.38	88.11	91.03	93.96	96.43	98.13	99.12	99.63	99.86	99.96	99.99	100	100
17/5/38	155.48	5.8516	61.01	65.73	69.64	72.84	75.42	77.57	79.5	81.33	83.34	85.69	88.28	91.04	93.83	96.23	97.94	98.99	99.56	99.84	99.96	100.01	100.03	100.04
17/5/57	155.67	5.8571	59.26	63.96	67.87	71.09	73.71	75.93	77.97	79.9	82.15	84.86	87.87	91.09	94.3	96.9	98.55	99.41	99.79	99.94	99.99	100	100	100
17/5/84	155.94	5.8649	60.66	65.25	68.99	72.05	74.56	76.72	78.71	80.69	82.96	85.7	88.71	91.89	95	97.43	98.88	99.58	99.86	99.96	99.99	100	100	100
17/5/103	156.13	5.8704	59.09	63.65	67.49	70.72	73.41	75.73	77.86	79.92	82.26	84.95	87.85	90.9	93.92	96.44	98.16	99.15	99.65	99.87	99.96	99.99	100	100
17/5/117	156.27	5.8745	58.72	63.21	67.05	70.35	73.14	75.56	77.8	79.96	82.29	84.95	87.83	90.85	93.86	96.38	98.11	99.12	99.63	99.86	99.96	99.99	100	100
17/5/137	156.47	5.8803	56.09	60.81	64.93	68.48	71.48	74.06	76.39	78.57	80.88	83.49	86.33	89.34	92.39	95.08	97.1	98.43	99.21	99.63	99.83	99.92	99.96	99.98
17/6/11	156.71	5.8872	61.46	65.9	69.6	72.67	75.18	77.31	79.23	81.05	83.03	85.32	87.84	90.54	93.28	95.7	97.5	98.67	99.35	99.71	99.88	99.96	99.99	100
17/6/35	156.95	5.8942	62.19	66.53	70.08	72.98	75.35	77.38	79.26	81.11	83.17	85.57	88.21	91.01	93.82	96.22	97.93	98.98	99.55	99.82	99.94	99.99	100.01	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
17/6/52	157.12	5.8991	62.38	66.63	70.13	73.02	75.4	77.43	79.29	81.08	83.05	85.33	87.85	90.54	93.27	95.68	97.48	98.65	99.33	99.69	99.86	99.94	99.97	99.98
17/6/77	157.37	5.9063	61.31	65.65	69.35	72.5	75.14	77.4	79.44	81.37	83.43	85.79	88.36	91.09	93.84	96.21	97.91	98.96	99.53	99.81	99.93	99.98	100	100.01
17/6/92	157.52	5.9107	62.35	66.6	70.17	73.15	75.61	77.7	79.59	81.37	83.3	85.52	87.98	90.62	93.31	95.69	97.48	98.65	99.33	99.69	99.86	99.94	99.97	99.98
17/6/116	157.76	5.9176	58.36	63.12	67.06	70.3	72.93	75.14	77.19	79.14	81.42	84.25	87.44	90.89	94.32	97.04	98.69	99.49	99.82	99.94	99.97	99.98	99.98	99.98
17/6/133	157.93	5.9225	59.56	64.03	67.74	70.8	73.31	75.45	77.41	79.31	81.41	83.87	86.6	89.54	92.54	95.2	97.19	98.5	99.27	99.68	99.87	99.96	100	100.01
17/7/0	158.1	5.9275	60.02	64.46	68.13	71.16	73.65	75.78	77.75	79.68	81.83	84.36	87.16	90.16	93.19	95.8	97.67	98.82	99.45	99.76	99.89	99.95	99.97	99.98
17/7/17	158.27	5.9324	60.45	64.79	68.41	71.4	73.86	75.96	77.88	79.73	81.78	84.18	86.84	89.71	92.64	95.23	97.17	98.44	99.19	99.59	99.78	99.87	99.9	99.91
17cc/6	158.52	5.9396	58.64	63.1	66.89	70.11	72.81	75.13	77.27	79.33	81.69	84.42	87.38	90.51	93.63	96.25	98.05	99.1	99.64	99.88	99.98	100.01	100.02	100.02
18/1/0	158.7	5.9448	56.42	61.29	65.41	68.89	71.79	74.28	76.58	78.83	81.3	84.17	87.29	90.58	93.84	96.51	98.26	99.22	99.68	99.87	99.94	99.96	99.97	99.97
18/1/25	158.95	5.9521	58.27	62.53	66.29	69.6	72.46	74.96	77.26	79.44	81.76	84.38	87.21	90.21	93.22	95.81	97.67	98.82	99.45	99.76	99.89	99.95	99.97	99.98
18/1/43	159.13	5.9573	58.33	62.7	66.5	69.8	72.62	75.08	77.36	79.56	81.93	84.64	87.57	90.66	93.73	96.31	98.08	99.11	99.63	99.86	99.96	99.99	100	100
18/1/65	159.35	5.9637	61.16	65.1	68.53	71.5	74.05	76.27	78.3	80.21	82.24	84.54	87.05	89.73	92.46	94.93	96.86	98.2	99.05	99.54	99.79	99.91	99.97	99.99
18/1/79	159.49	5.9677	62.09	65.9	69.15	71.93	74.3	76.37	78.29	80.13	82.12	84.4	86.92	89.62	92.38	94.88	96.83	98.19	99.05	99.54	99.8	99.92	99.98	100
18/1/102	159.72	5.9744	58.73	63.1	66.8	69.94	72.58	74.85	76.97	78.99	81.27	84.04	87.15	90.52	93.9	96.67	98.44	99.37	99.78	99.94	100	100.01	100.01	100.01
18/1/116	159.86	5.9784	57.1	61.62	65.46	68.7	71.4	73.71	75.83	77.88	80.17	82.88	85.91	89.18	92.5	95.38	97.45	98.72	99.42	99.76	99.91	99.97	99.99	100
18/1/141	160.11	5.9857	61.49	65.52	68.98	71.94	74.43	76.57	78.49	80.27	82.18	84.39	86.85	89.52	92.29	94.81	96.79	98.17	99.04	99.54	99.8	99.92	99.98	100
18/2/13	160.33	5.9921	57.78	62.3	66.28	69.73	72.6	75.02	77.2	79.25	81.5	84.19	87.19	90.43	93.7	96.42	98.22	99.21	99.68	99.87	99.94	99.96	99.97	99.97
18/2/34	160.54	5.9981	59.21	63.58	67.45	70.83	73.67	76.07	78.2	80.16	82.27	84.75	87.53	90.55	93.62	96.24	98.05	99.1	99.64	99.88	99.98	100.01	100.02	100.02
18/2/53	160.73	6.0036	57.64	62.42	66.54	70.05	72.93	75.32	77.45	79.37	81.53	84.22	87.31	90.72	94.18	96.96	98.66	99.49	99.83	99.95	99.98	99.99	99.99	99.99
18/2/79	160.99	6.0112	54.1	58.99	63.33	67.11	70.28	72.94	75.3	77.47	79.82	82.61	85.75	89.17	92.67	95.66	97.73	98.95	99.57	99.85	99.97	100.01	100.02	100.02
18/2/96	161.16	6.0161	59.02	63.28	67.09	70.43	73.25	75.63	77.71	79.58	81.57	83.89	86.51	89.38	92.36	95.04	97.08	98.43	99.23	99.66	99.86	99.95	99.99	100.01
18/2/112	161.32	6.0207	57.39	61.93	65.92	69.38	72.29	74.75	76.95	79	81.23	83.85	86.78	89.95	93.18	95.94	97.86	98.99	99.57	99.83	99.94	99.98	99.99	99.99
18/2/133	161.53	6.0268	57.54	62.3	66.47	70.07	73.07	75.59	77.83	79.91	82.15	84.78	87.69	90.81	93.95	96.56	98.29	99.25	99.71	99.9	99.97	99.99	100	100
18/3/0	161.7	6.0317	57.11	61.57	65.49	68.88	71.73	74.13	76.24	78.15	80.18	82.55	85.22	88.16	91.22	94.04	96.27	97.84	98.84	99.42	99.72	99.86	99.93	99.96
18/3/14 2nd run	161.84	6.0358	59.51	64.43	68.65	72.21	75.12	77.53	79.65	81.55	83.59	86.02	88.73	91.68	94.66	97.1	98.64	99.44	99.79	99.93	99.98	99.99	99.99	99.99
18/3/42 2nd run	162.12	6.0439	61.73	66.24	70.19	73.6	76.44	78.81	80.88	82.75	84.69	86.9	89.32	91.91	94.54	96.77	98.31	99.21	99.67	99.88	99.97	100	100.01	100.01
18/3/56 2nd run	162.26	6.0479	59.87	64.59	68.71	72.26	75.21	77.67	79.83	81.75	83.79	86.18	88.84	91.73	94.66	97.07	98.62	99.44	99.81	99.96	100.01	100.02	100.02	100.02
18/3/85	162.55	6.0563	60.6	65.49	69.54	72.85	75.51	77.7	79.68	81.51	83.59	86.13	88.96	92.01	95.05	97.45	98.89	99.58	99.86	99.96	99.99	100	100	100
18/3/117	162.87	6.0656	59.27	64.19	68.43	72.07	75.11	77.67	79.96	82.09	84.32	86.84	89.53	92.34	95.11	97.34	98.74	99.47	99.8	99.93	99.98	99.99	99.99	99.99
18/3/135	163.05	6.0708	59.56	64.53	68.78	72.39	75.38	77.89	80.12	82.16	84.32	86.82	89.53	92.41	95.26	97.52	98.89	99.56	99.84	99.94	99.97	99.98	99.98	99.98
18/4/13	163.33	6.0789	62.53	67.18	71.03	74.23	76.85	79.05	81.04	82.94	84.97	87.3	89.81	92.45	95.07	97.22	98.62	99.39	99.76	99.91	99.97	99.99	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
18/4/36	163.56	6.0856	61.36	65.97	69.87	73.17	75.91	78.24	80.35	82.32	84.45	86.94	89.64	92.5	95.33	97.57	98.92	99.58	99.86	99.96	99.99	100	100	100
18/4/56	163.73	6.0905	61.87	66.33	70.06	73.2	75.81	78.05	80.12	82.11	84.28	86.82	89.57	92.47	95.32	97.56	98.91	99.57	99.84	99.94	99.97	99.98	99.98	99.98
18/4/73	163.93	6.0963	60.35	64.95	68.88	72.24	75.07	77.49	79.67	81.7	83.86	86.35	89.06	91.94	94.81	97.15	98.65	99.44	99.8	99.94	99.99	100	100	100
18/4/93	164.13	6.1021	62.78	67.23	70.99	74.17	76.81	79.06	81.09	83	85.05	87.44	90.04	92.8	95.53	97.68	98.98	99.61	99.87	99.97	100	100.01	100.01	100.01
18/4/111 2nd run	164.31	6.1073	65.25	69.43	72.9	75.82	78.25	80.34	82.25	84.09	86.04	88.25	90.61	93.07	95.5	97.48	98.77	99.47	99.8	99.94	100	100.02	100.03	100.03
18/4/132 avg	164.52	6.1134	63.07	67.42	71.08	74.2	76.82	79.06	81.12	83.08	85.16	87.5	89.99	92.6	95.17	97.27	98.64	99.4	99.76	99.91	99.97	99.99	100	100
18/5/0 avg	164.7	6.1186	79.22	83.93	87.81	90.92	93.35	95.28	96.84	98.09	98.88	99.33	99.73	99.94	100.02	100.02	100.02	100.02	100.02	100.02	100.02	100.02	100.02	100.02
18/5/26 avg	164.96	6.1261	78.58	83.4	87.38	90.59	93.11	95.11	96.71	97.98	98.81	99.28	99.69	99.91	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
18/5/43	165.13	6.1311	59.17	63.73	67.71	71.2	74.18	76.75	79.08	81.26	83.54	86.1	88.84	91.71	94.56	96.9	98.44	99.29	99.7	99.88	99.95	99.97	99.98	99.98
18/5/65	165.35	6.1374	61.47	66.03	69.86	73.11	75.82	78.15	80.29	82.36	84.58	87.11	89.79	92.58	95.31	97.48	98.83	99.52	99.82	99.94	99.98	99.99	99.99	99.99
18/5/80	165.5	6.1418	59.93	64.67	68.66	72.03	74.84	77.25	79.45	81.57	83.83	86.4	89.14	91.99	94.8	97.09	98.58	99.39	99.78	99.94	100	100.02	100.03	100.03
18/5/104	165.74	6.1487	63.55	67.89	71.49	74.5	76.99	79.11	81.04	82.87	84.88	87.17	89.63	92.21	94.78	96.93	98.4	99.25	99.68	99.88	99.96	99.99	100	100
18/5/125	165.95	6.1548	62.54	66.84	70.43	73.47	76.04	78.28	80.35	82.35	84.48	86.88	89.43	92.09	94.72	96.91	98.39	99.25	99.69	99.89	99.97	100	100.01	100.01
18/5/141	166.11	6.1594	63.69	67.84	71.26	74.13	76.54	78.62	80.55	82.42	84.48	86.82	89.34	91.98	94.61	96.82	98.33	99.21	99.66	99.87	99.96	99.99	100	100
18/6/6	166.26	6.1638	64.47	68.68	72.09	74.95	77.35	79.45	81.43	83.4	85.53	87.94	90.48	93.1	95.64	97.65	98.9	99.54	99.82	99.93	99.97	99.98	99.98	99.98
18/6/26	166.46	6.1696	63.16	67.29	70.72	73.66	76.18	78.4	80.48	82.53	84.71	87.15	89.73	92.4	95.02	97.16	98.57	99.35	99.73	99.89	99.96	99.98	99.99	99.99
18/6/46	166.66	6.1754	66.19	70.02	73.13	75.77	78.04	80.07	82.02	83.99	86.1	88.46	90.92	93.44	95.87	97.79	98.98	99.59	99.86	99.97	100	100.01	100.01	100.01
18/6/66	166.86	6.1812	66.35	70.22	73.36	76.03	78.32	80.37	82.32	84.28	86.37	88.69	91.1	93.56	95.93	97.8	98.96	99.55	99.81	99.91	99.94	99.95	99.95	99.95
18/6/86	167.06	6.187	64.12	68.11	71.43	74.31	76.81	79.04	81.15	83.25	85.47	87.93	90.49	93.1	95.63	97.63	98.88	99.52	99.81	99.92	99.96	99.97	99.97	99.97
18/6/104	167.24	6.1922	63.89	67.84	71.19	74.13	76.7	78.98	81.11	83.18	85.34	87.72	90.21	92.78	95.29	97.33	98.66	99.39	99.74	99.89	99.95	99.97	99.98	99.98
18/6/124	167.44	6.198	65.56	69.45	72.69	75.48	77.9	80.05	82.07	84.04	86.11	88.39	90.77	93.22	95.61	97.54	98.79	99.47	99.79	99.93	99.98	100	100.01	100.01
18cc/7(2nd attempt)	167.57	6.2017	64.56	68.61	71.98	74.86	77.33	79.51	81.55	83.55	85.68	88.09	90.63	93.26	95.82	97.82	99.02	99.61	99.86	99.95	99.98	99.99	99.99	99.99
19/1/0	168.3	6.2229	58.21	62.03	65.27	68.07	70.5	72.65	74.61	76.42	78.6	81.03	83.66	86.46	89.35	92.1	94.46	96.33	97.7	98.65	99.26	99.63	99.84	99.95
19/1/22	168.52	6.2292	67.1	70.94	74.08	76.71	78.9	80.8	82.57	84.31	86.21	88.38	90.71	93.15	95.55	97.51	98.78	99.47	99.79	99.92	99.97	99.99	100	100
19/1/41	168.71	6.2347	62.45	66.7	70.32	73.44	76.1	78.4	80.51	82.51	84.61	86.96	89.47	92.09	94.7	96.88	98.37	99.23	99.67	99.87	99.96	99.99	100	100
19/1/62	168.92	6.2408	66.15	69.98	73.17	75.89	78.21	80.25	82.16	84.04	86.04	88.29	90.67	93.14	95.56	97.52	98.79	99.47	99.79	99.92	99.97	99.99	100	100
19/1/83	169.13	6.2469	64.05	68.05	71.43	74.34	76.82	78.99	81.01	82.98	85.08	87.45	89.97	92.59	95.17	97.28	98.65	99.4	99.76	99.91	99.97	99.99	100	100
19/1/104	169.34	6.253	61.73	65.9	69.48	72.61	75.31	77.69	79.9	82.04	84.31	86.84	89.51	92.27	94.97	97.17	98.6	99.38	99.75	99.9	99.96	99.98	99.99	99.99
19/1/121	169.51	6.2579	61.92	66.08	69.65	72.77	75.46	77.84	80.05	82.2	84.5	87.11	89.87	92.73	95.51	97.68	98.98	99.61	99.87	99.96	99.99	100	100	100
19/1/142	169.72	6.264	59.9	64.2	67.93	71.23	74.12	76.7	79.12	81.48	83.93	86.6	89.37	92.19	94.92	97.13	98.57	99.36	99.74	99.9	99.97	99.99	100	100
19/2/5	169.85	6.2678	62.88	67.08	70.61	73.66	76.3	78.64	80.83	82.97	85.19	87.61	90.11	92.66	95.14	97.18	98.55	99.33	99.72	99.9	99.98	100.01	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
19/2/26	170.06	6.2738	62.99	67.04	70.5	73.53	76.17	78.51	80.71	82.85	85.09	87.55	90.11	92.73	95.28	97.35	98.69	99.42	99.77	99.92	99.98	100	100.01	100.01
19/2/52	170.32	6.2814	63.01	67	70.47	73.55	76.25	78.64	80.84	82.93	85.09	87.44	89.89	92.42	94.91	96.99	98.41	99.24	99.67	99.87	99.96	99.99	100	100
19/2/72	170.52	6.2872	66.29	70.22	73.54	76.4	78.86	81.01	82.99	84.88	86.84	89	91.25	93.57	95.83	97.66	98.84	99.48	99.78	99.91	99.96	99.98	99.99	99.99
19/2/93	170.73	6.2933	65.87	69.85	73.12	75.88	78.21	80.24	82.14	83.99	85.97	88.2	90.57	93.03	95.45	97.43	98.72	99.42	99.76	99.9	99.96	99.98	99.99	99.99
19/2/114	170.94	6.2993	66.46	70.42	73.67	76.41	78.72	80.74	82.64	84.5	86.48	88.69	91.01	93.4	95.73	97.62	98.83	99.49	99.8	99.93	99.98	100	100.01	100.01
19/2/135	171.15	6.3054	64.87	68.93	72.27	75.09	77.47	79.55	81.5	83.41	85.46	87.78	90.24	92.79	95.3	97.34	98.67	99.4	99.75	99.9	99.96	99.98	99.99	99.99
19/3/0	171.3	6.3098	62.91	67.19	70.76	73.79	76.36	78.61	80.71	82.76	84.96	87.48	90.16	92.94	95.64	97.75	99.01	99.63	99.89	99.98	100.01	100.02	100.02	100.02
19/3/27	171.57	6.3176	66.41	70.3	73.4	75.95	78.09	79.98	81.8	83.64	85.64	87.9	90.29	92.76	95.18	97.18	98.54	99.32	99.72	99.9	99.98	100.01	100.02	100.02
19/3/42	171.72	6.3219	67.34	71.13	74.21	76.79	78.96	80.87	82.68	84.49	86.44	88.64	90.96	93.36	95.71	97.61	98.83	99.49	99.8	99.93	99.98	100	100.01	100.01
19/3/62	171.92	6.3277	63.77	67.79	71.17	74.07	76.56	78.76	80.83	82.85	84.99	87.36	89.85	92.41	94.92	97	98.42	99.24	99.66	99.85	99.93	99.96	99.97	99.97
19/3/83	172.13	6.3338	64.82	68.87	72.25	75.13	77.58	79.74	81.76	83.73	85.8	88.08	90.45	92.87	95.23	97.18	98.5	99.27	99.66	99.84	99.92	99.95	99.96	99.96
19/3/102	172.32	6.3393	65.4	69.46	72.77	75.51	77.78	79.75	81.58	83.38	85.39	87.76	90.33	93.03	95.68	97.76	99	99.6	99.85	99.94	99.97	99.98	99.98	99.98
19/3/117	172.47	6.3436	65.68	69.68	72.94	75.65	77.92	79.89	81.74	83.56	85.52	87.75	90.12	92.59	95.03	97.07	98.45	99.25	99.66	99.85	99.93	99.96	99.97	99.97
19/3/136	172.66	6.3491	66.41	70.41	73.6	76.22	78.4	80.31	82.13	83.98	86.02	88.35	90.81	93.35	95.81	97.75	98.96	99.58	99.85	99.96	100	100.01	100.01	100.01
19/4/6	172.86	6.3549	68	71.82	74.92	77.5	79.67	81.57	83.36	85.13	87.02	89.13	91.35	93.64	95.86	97.66	98.85	99.51	99.83	99.96	100.01	100.03	100.04	100.04
19/4/27	173.07	6.361	65.48	69.31	72.52	75.29	77.66	79.75	81.71	83.63	85.67	87.97	90.4	92.92	95.39	97.41	98.73	99.45	99.79	99.93	99.99	100.01	100.02	100.02
19/4/47	173.27	6.3668	66.33	70.26	73.5	76.24	78.55	80.58	82.48	84.35	86.34	88.57	90.91	93.32	95.67	97.58	98.82	99.5	99.82	99.95	100	100.02	100.03	100.03
19/4/72	173.52	6.3741	68.71	72.41	75.37	77.81	79.84	81.61	83.29	84.98	86.82	88.92	91.16	93.48	95.74	97.58	98.79	99.45	99.77	99.9	99.95	99.97	99.98	99.98
19/4/92	173.72	6.3798	64.96	68.89	72.19	75.01	77.42	79.54	81.51	83.41	85.46	87.74	90.14	92.62	95.07	97.11	98.5	99.31	99.72	99.91	99.99	100.02	100.03	100.03
19/4/113	173.93	6.3859	63.54	67.68	71.18	74.21	76.84	79.17	81.34	83.43	85.59	87.93	90.35	92.81	95.21	97.19	98.54	99.32	99.72	99.9	99.98	100.01	100.02	100.02
19/4/134	174.14	6.392	63.06	67.19	70.69	73.72	76.35	78.69	80.9	83.07	85.34	87.81	90.36	92.94	95.43	97.44	98.74	99.45	99.79	99.93	99.99	100.01	100.02	100.02
19/5/0	174.3	6.3966	62.07	66.35	69.93	72.99	75.62	77.97	80.19	82.4	84.77	87.43	90.2	93.02	95.72	97.81	99.06	99.67	99.92	100.01	100.04	100.05	100.05	100.05
19/5/24	174.54	6.4036	64.43	68.56	71.89	74.67	77.02	79.11	81.12	83.17	85.39	87.89	90.49	93.14	95.68	97.68	98.92	99.55	99.83	99.94	99.98	99.99	99.99	99.99
19/5/42	174.72	6.4088	68.31	72.08	75.01	77.38	79.35	81.11	82.83	84.63	86.62	88.88	91.26	93.68	96	97.83	98.97	99.56	99.82	99.92	99.95	99.96	99.96	99.96
19/5/56	174.86	6.4129	67.06	71.15	74.38	77.02	79.21	81.13	82.97	84.84	86.87	89.14	91.49	93.87	96.15	97.94	99.05	99.62	99.87	99.97	100	100.01	100.01	100.01
19/5/96	175.26	6.4244	68.17	72.15	75.24	77.74	79.81	81.64	83.4	85.22	87.2	89.41	91.71	94.03	96.25	97.99	99.07	99.62	99.87	99.97	100	100.01	100.01	100.01
19/5/117	175.47	6.4305	65.83	70.04	73.39	76.14	78.45	80.5	82.45	84.42	86.51	88.81	91.17	93.55	95.83	97.66	98.84	99.48	99.79	99.92	99.97	99.99	100	100
19/5/141	175.71	6.4375	64.81	69.12	72.61	75.53	77.99	80.15	82.19	84.23	86.38	88.75	91.18	93.63	95.97	97.81	98.96	99.55	99.82	99.93	99.97	99.98	99.98	99.98
19/6/6	175.86	6.4418	66.9	70.88	74.07	76.73	78.97	80.95	82.83	84.73	86.77	89.04	91.39	93.77	96.06	97.87	99	99.58	99.84	99.95	99.99	100	100	100
19/6/26	176.06	6.4476	67.84	71.74	74.85	77.41	79.55	81.43	83.22	85.01	86.93	89.08	91.33	93.63	95.87	97.68	98.85	99.49	99.8	99.93	99.98	100	100.01	100.01
19/6/52	176.32	6.4551	65.32	69.53	72.97	75.85	78.26	80.36	82.31	84.22	86.24	88.49	90.84	93.26	95.61	97.52	98.77	99.46	99.79	99.93	99.99	100.01	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
19/6/67	176.47	6.4595	65.88	70.06	73.44	76.24	78.56	80.56	82.41	84.22	86.16	88.35	90.68	93.1	95.49	97.44	98.72	99.42	99.76	99.9	99.96	99.98	99.99	99.99
19/6/84	176.64	6.4644	66.8	70.94	74.24	76.94	79.16	81.06	82.84	84.6	86.52	88.72	91.06	93.48	95.85	97.74	98.93	99.55	99.83	99.94	99.98	99.99	99.99	99.99
19/6/112	176.92	6.4725	65.1	69.3	72.75	75.64	78.05	80.13	82.06	83.94	85.94	88.19	90.57	93.03	95.45	97.42	98.71	99.42	99.76	99.9	99.96	99.98	99.99	99.99
19/6/134	177.14	6.4789	63.35	67.81	71.5	74.61	77.22	79.47	81.55	83.56	85.7	88.12	90.67	93.31	95.87	97.87	99.07	99.65	99.89	99.98	100.01	100.02	100.02	100.02
19/7/0	177.3	6.4835	66.53	70.54	73.77	76.44	78.66	80.58	82.37	84.14	86.06	88.26	90.62	93.09	95.53	97.52	98.8	99.49	99.82	99.95	100	100.02	100.03	100.03
19/7/22	177.52	6.4899	63.67	68.06	71.63	74.61	77.11	79.28	81.3	83.29	85.41	87.78	90.28	92.85	95.36	97.4	98.72	99.43	99.77	99.91	99.97	99.99	100	100
19cc/0	177.82	6.4986	64.53	68.75	72.2	75.1	77.52	79.62	81.56	83.45	85.47	87.76	90.2	92.74	95.25	97.3	98.64	99.38	99.74	99.89	99.95	99.97	99.98	99.98
20/1/0	177.9	6.5009	64.37	68.9	72.6	75.66	78.17	80.3	82.23	84.08	86.04	88.26	90.62	93.08	95.5	97.48	98.76	99.46	99.79	99.93	99.99	100.01	100.02	100.02
20/1/15	178.05	6.5052	66.84	71.11	74.46	77.15	79.3	81.11	82.79	84.47	86.34	88.53	90.9	93.38	95.81	97.75	98.96	99.58	99.85	99.96	99.99	100	100	100
20/1/37	178.27	6.5116	64.13	68.93	72.76	75.84	78.28	80.29	82.1	83.84	85.76	88.02	90.47	93.05	95.6	97.64	98.9	99.54	99.82	99.93	99.97	99.98	99.98	99.98
20/1/58	178.48	6.5177	64.45	69.15	72.88	75.87	78.26	80.26	82.09	83.89	85.87	88.17	90.64	93.21	95.73	97.73	98.97	99.6	99.87	99.98	100.01	100.02	100.02	100.02
20/1/78	178.68	6.5235	62.71	67.62	71.58	74.79	77.35	79.46	81.37	83.17	85.16	87.56	90.2	93.02	95.79	97.92	99.13	99.68	99.89	99.96	99.98	99.98	99.98	99.98
20/1/97	178.87	6.529	65.8	70.33	73.87	76.67	78.88	80.7	82.36	83.99	85.81	87.96	90.32	92.82	95.32	97.37	98.7	99.42	99.76	99.9	99.95	99.97	99.98	99.98
20/1/118	179.08	6.5351	64.53	69.26	72.99	75.96	78.31	80.26	82.04	83.79	85.73	88.01	90.48	93.07	95.62	97.65	98.91	99.55	99.83	99.94	99.98	99.99	99.99	99.99
20/1/137	179.27	6.5406	63.98	68.72	72.48	75.49	77.9	79.91	81.76	83.59	85.61	87.95	90.46	93.07	95.62	97.65	98.9	99.54	99.82	99.93	99.97	99.98	99.98	99.98
20/2/5	179.45	6.5458	66.11	70.55	73.99	76.71	78.87	80.69	82.39	84.11	86.04	88.29	90.72	93.25	95.72	97.69	98.91	99.54	99.82	99.93	99.97	99.98	99.98	99.98
20/2/27	179.67	6.5522	65.49	70.02	73.55	76.35	78.58	80.46	82.21	83.96	85.91	88.18	90.62	93.17	95.66	97.65	98.89	99.53	99.82	99.93	99.97	99.98	99.98	99.98
20/2/46	179.86	6.5577	65.97	70.47	73.95	76.71	78.91	80.77	82.52	84.3	86.29	88.61	91.08	93.63	96.09	98	99.13	99.68	99.91	99.99	100.02	100.03	100.03	100.03
20/2/77	180.17	6.5666	65.7	70.14	73.61	76.39	78.65	80.59	82.43	84.29	86.33	88.65	91.08	93.57	95.97	97.86	99.03	99.62	99.88	99.98	100.01	100.02	100.02	100.02
20/2/93	180.33	6.5713	66.41	70.6	73.89	76.55	78.73	80.62	82.42	84.25	86.26	88.55	90.97	93.46	95.87	97.78	98.96	99.56	99.83	99.94	99.97	99.98	99.98	99.98
20/2/106	180.46	6.575	67.13	71.15	74.33	76.95	79.14	81.07	82.92	84.8	86.83	89.09	91.43	93.8	96.06	97.85	98.98	99.57	99.84	99.95	99.98	99.99	99.99	99.99
20/2/133	180.73	6.5829	63.39	67.88	71.54	74.59	77.14	79.36	81.45	83.52	85.73	88.19	90.73	93.31	95.79	97.74	98.95	99.57	99.84	99.95	99.99	100	100	100
20/3/1	180.91	6.5881	62.64	67.14	70.82	73.9	76.48	78.73	80.85	82.95	85.2	87.71	90.33	93	95.57	97.61	98.88	99.54	99.83	99.95	99.99	100	100	100
20/3/24	181.14	6.5947	61.54	66.21	70.08	73.36	76.13	78.54	80.77	82.92	85.16	87.62	90.17	92.77	95.29	97.34	98.68	99.42	99.78	99.93	99.99	100.01	100.02	100.02
20/3/42	181.32	6.6	62.69	67.26	71.01	74.16	76.81	79.11	81.26	83.38	85.62	88.1	90.66	93.26	95.76	97.73	98.95	99.58	99.86	99.97	100.01	100.02	100.02	100.02
20/3/67	181.57	6.6072	66.22	70.44	73.86	76.7	79.07	81.12	83.02	84.87	86.82	88.98	91.24	93.55	95.8	97.63	98.82	99.48	99.8	99.93	99.98	100	100.01	100.01
20/3/82 avg	181.72	6.6115	64.38	68.7	72.21	75.13	77.56	79.68	81.65	83.62	85.73	88.11	90.62	93.2	95.7	97.68	98.92	99.56	99.84	99.95	99.99	100	100	100
20/3/96	181.86	6.6156	63.4	67.92	71.63	74.73	77.3	79.51	81.54	83.52	85.63	88.01	90.52	93.11	95.63	97.64	98.9	99.55	99.84	99.96	100	100.01	100.01	100.01
20/3/116	182.06	6.6214	61.3	66.04	70.01	73.36	76.15	78.53	80.69	82.74	84.92	87.41	90.07	92.85	95.57	97.7	98.97	99.58	99.83	99.92	99.95	99.96	99.96	99.96
20/3/133	182.23	6.6263	62.69	67.26	71.07	74.28	76.96	79.26	81.36	83.37	85.51	87.95	90.54	93.23	95.84	97.88	99.09	99.68	99.92	100.01	100.04	100.05	100.05	100.05
20/4/7	182.47	6.6333	61.58	66.08	69.83	73.02	75.73	78.11	80.32	82.48	84.75	87.26	89.88	92.56	95.16	97.27	98.64	99.39	99.75	99.9	99.96	99.98	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
20/4/28	182.68	6.6393	63.45	67.85	71.43	74.41	76.91	79.09	81.15	83.2	85.41	87.89	90.48	93.12	95.66	97.67	98.92	99.56	99.85	99.96	100	100.01	100.01	100.01
20/4/48	182.88	6.6451	63.33	67.72	71.29	74.28	76.81	79.04	81.16	83.28	85.54	88.05	90.63	93.24	95.74	97.7	98.92	99.54	99.82	99.93	99.97	99.98	99.98	99.98
20/4/68	183.08	6.6509	62.04	66.59	70.3	73.41	76.05	78.38	80.58	82.76	85.06	87.58	90.18	92.81	95.34	97.37	98.69	99.41	99.76	99.91	99.97	99.99	100	100
20/4/86	183.26	6.6561	62.44	66.96	70.68	73.81	76.46	78.79	80.97	83.1	85.34	87.79	90.33	92.91	95.4	97.41	98.72	99.44	99.78	99.93	99.99	100.01	100.02	100.02
20/4/105	183.45	6.6616	65.32	69.54	72.96	75.81	78.2	80.29	82.25	84.18	86.23	88.5	90.87	93.3	95.66	97.56	98.79	99.46	99.78	99.91	99.96	99.98	99.99	99.99
20/4/132	183.72	6.6695	63.47	67.92	71.56	74.61	77.15	79.35	81.4	83.41	85.56	87.97	90.5	93.1	95.62	97.62	98.87	99.52	99.81	99.93	99.97	99.98	99.98	99.98
20/5/1 avg	183.91	6.675	66.01	70.17	73.49	76.2	78.44	80.38	82.22	84.06	86.08	88.42	90.9	93.46	95.95	97.88	99.05	99.63	99.87	99.96	99.99	100	100	100
20/5/25	184.15	6.6819	62.78	67.38	71.17	74.34	76.98	79.25	81.33	83.33	85.44	87.79	90.26	92.81	95.3	97.33	98.66	99.39	99.74	99.89	99.95	99.97	99.98	99.98
20/5/42 2nd attempt	184.32	6.6868	67.08	71.1	74.28	76.88	79.02	80.87	82.63	84.41	86.36	88.6	90.99	93.46	95.87	97.78	98.97	99.58	99.85	99.96	99.99	100	100	100
20/5/61	184.51	6.6923	65.91	70.05	73.36	76.08	78.33	80.27	82.1	83.94	85.95	88.25	90.7	93.24	95.71	97.68	98.91	99.54	99.82	99.93	99.97	99.98	99.98	99.98
20/5/82	184.72	6.6984	66.58	70.66	73.88	76.49	78.62	80.45	82.19	83.95	85.91	88.19	90.63	93.18	95.67	97.66	98.91	99.55	99.84	99.95	99.99	100	100	100
20/5/101	184.91	6.7039	67.22	71.3	74.47	77.01	79.08	80.87	82.58	84.33	86.28	88.54	90.94	93.43	95.85	97.77	98.96	99.57	99.84	99.95	99.99	100	100	100
20/5/117	185.07	6.7086	67.86	71.65	74.59	76.96	78.93	80.66	82.33	84.1	86.13	88.52	91.08	93.72	96.26	98.17	99.25	99.74	99.92	99.98	100	100	100	100
20/5/137	185.27	6.7144	65.27	69.41	72.71	75.44	77.72	79.73	81.64	83.59	85.75	88.25	90.89	93.6	96.18	98.13	99.23	99.72	99.91	99.97	99.99	99.99	99.99	99.99
20/6/7	185.47	6.7201	66.64	70.52	73.62	76.2	78.38	80.31	82.17	84.06	86.12	88.45	90.9	93.42	95.85	97.77	98.96	99.57	99.84	99.95	99.98	99.99	99.99	99.99
20/6/34	185.74	6.728	65.89	69.86	73.08	75.78	78.07	80.09	82.01	83.95	86.04	88.39	90.86	93.39	95.83	97.76	98.96	99.57	99.84	99.95	99.99	100	100	100
20/6/52	185.92	6.7332	65.68	69.72	73	75.74	78.05	80.08	82.01	83.94	86.03	88.39	90.86	93.39	95.84	97.77	98.97	99.59	99.86	99.97	100.01	100.02	100.02	100.02
20/6/68	186.08	6.7378	66.85	70.77	73.9	76.49	78.67	80.59	82.42	84.26	86.25	88.49	90.85	93.28	95.64	97.55	98.79	99.47	99.79	99.92	99.97	99.99	100	100
20/6/92	186.32	6.7448	65.89	69.85	73.05	75.73	78	80.01	81.94	83.89	86	88.37	90.85	93.38	95.82	97.75	98.95	99.57	99.85	99.96	100	100.01	100.01	100.01
20/6/111	186.51	6.7503	64.12	68.39	71.87	74.79	77.26	79.42	81.46	83.49	85.67	88.1	90.63	93.21	95.7	97.67	98.9	99.53	99.81	99.92	99.96	99.97	99.97	99.97
20/6/132	186.72	6.7563	62.74	67.13	70.75	73.81	76.41	78.7	80.85	82.97	85.21	87.68	90.24	92.85	95.37	97.4	98.72	99.44	99.78	99.92	99.98	100	100.01	100.01
20/7/0	186.9	6.7616	61.3	65.8	69.54	72.72	75.43	77.81	80.05	82.27	84.67	87.39	90.23	93.13	95.9	97.99	99.17	99.7	99.9	99.97	99.99	100	100	100
20/7/17	187.07	6.7665	63.09	67.3	70.71	73.58	76.02	78.21	80.32	82.49	84.88	87.6	90.44	93.32	96.04	98.07	99.21	99.72	99.91	99.97	99.99	99.99	99.99	99.99
20CC/7	187.22	6.7708	61.4	65.88	69.6	72.75	75.44	77.82	80.07	82.31	84.72	87.42	90.21	93.05	95.75	97.83	99.06	99.65	99.89	99.98	100.01	100.02	100.02	100.02
21/1/1 avg	187.51	6.7792	60.54	65.01	68.73	71.91	74.64	77.07	79.38	81.69	84.19	87.02	89.97	92.97	95.82	97.96	99.17	99.71	99.91	99.98	100	100	100	100
21/1/26	187.76	6.7865	59.72	64.29	68.08	71.31	74.07	76.52	78.85	81.2	83.75	86.65	89.68	92.76	95.69	97.89	99.13	99.69	99.9	99.97	99.99	100	100	100
21/1/43	187.93	6.7914	63.43	67.6	70.96	73.77	76.17	78.32	80.41	82.56	84.9	87.52	90.23	92.97	95.59	97.64	98.9	99.54	99.82	99.93	99.97	99.98	99.98	99.98
21/1/58	188.08	6.7957	61.09	65.55	69.18	72.22	74.8	77.11	79.33	81.6	84.1	86.96	89.94	92.97	95.84	97.99	99.19	99.73	99.93	100	100.02	100.02	100.02	100.02
21/1/82	188.32	6.8027	63.48	67.71	71.08	73.87	76.23	78.34	80.41	82.57	84.95	87.63	90.4	93.19	95.83	97.85	99.04	99.61	99.85	99.94	99.97	99.98	99.98	99.98
21/1/102	188.52	6.8085	65.1	69.1	72.25	74.84	77.04	79.03	81.02	83.13	85.46	88.08	90.78	93.48	96.02	97.96	99.1	99.65	99.88	99.96	99.98	99.99	99.99	99.99
21/1/117	188.67	6.8128	61.91	66.32	69.91	72.93	75.5	77.8	80.01	82.26	84.68	87.36	90.11	92.88	95.52	97.59	98.87	99.53	99.82	99.94	99.98	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
21/1/142	188.92	6.8201	60.73	65.31	69.14	72.42	75.22	77.68	79.99	82.24	84.6	87.18	89.85	92.56	95.17	97.28	98.65	99.4	99.76	99.91	99.97	99.99	100	100
21/2/8	189.08	6.8247	64.16	68.2	71.46	74.2	76.54	78.66	80.73	82.86	85.17	87.74	90.4	93.09	95.65	97.66	98.9	99.54	99.82	99.93	99.97	99.98	99.98	99.98
21/2/33	189.33	6.8319	63.74	67.97	71.41	74.3	76.75	78.93	81.02	83.14	85.41	87.94	90.55	93.2	95.73	97.72	98.95	99.58	99.86	99.97	100.01	100.02	100.02	100.02
21/2/46 avg	189.46	6.8357	63.49	67.7	71.14	74.05	76.53	78.74	80.85	82.97	85.25	87.8	90.43	93.1	95.66	97.67	98.92	99.55	99.83	99.94	99.98	99.99	99.99	99.99
21/2/75	189.75	6.8441	64.31	68.4	71.67	74.4	76.71	78.78	80.8	82.9	85.2	87.8	90.51	93.25	95.86	97.86	99.05	99.62	99.86	99.95	99.98	99.99	99.99	99.99
21/2/93	189.93	6.8493	63.99	68.2	71.55	74.3	76.59	78.62	80.58	82.6	84.84	87.39	90.07	92.82	95.47	97.56	98.86	99.52	99.81	99.93	99.97	99.98	99.98	99.98
21/2/117	190.17	6.8563	64.21	68.4	71.75	74.51	76.82	78.86	80.82	82.83	85.04	87.55	90.2	92.91	95.53	97.6	98.88	99.54	99.83	99.94	99.98	99.99	99.99	99.99
21/2/142	190.42	6.8635	62.95	67.3	70.88	73.89	76.43	78.66	80.76	82.85	85.09	87.61	90.24	92.93	95.52	97.57	98.85	99.51	99.8	99.92	99.96	99.97	99.97	99.97
21/3/1	190.51	6.8661	62.99	67.35	70.95	74	76.59	78.86	80.98	83.05	85.23	87.65	90.18	92.78	95.3	97.34	98.67	99.39	99.73	99.87	99.93	99.95	99.96	99.96
21/3/16	190.66	6.8705	62.02	66.41	70.06	73.17	75.81	78.13	80.31	82.47	84.77	87.35	90.04	92.79	95.44	97.54	98.85	99.52	99.82	99.94	99.98	99.99	99.99	99.99
21/3/37	190.87	6.8765	62.27	66.62	70.25	73.34	75.97	78.27	80.42	82.51	84.75	87.3	90.01	92.82	95.55	97.69	98.97	99.59	99.85	99.94	99.97	99.98	99.98	99.98
21/3/62	191.12	6.8838	61.9	66.33	70.01	73.12	75.75	78.04	80.18	82.27	84.5	87	89.64	92.36	95.02	97.19	98.6	99.38	99.75	99.91	99.97	99.99	100	100
21/3/82	191.32	6.8896	61.71	66.22	69.99	73.19	75.89	78.23	80.4	82.5	84.71	87.18	89.78	92.46	95.08	97.21	98.6	99.36	99.73	99.88	99.94	99.96	99.97	99.97
21/3/102 avg	191.52	6.8954	65.16	69.24	72.47	75.12	77.34	79.31	81.22	83.18	85.35	87.82	90.41	93.06	95.62	97.64	98.89	99.53	99.82	99.93	99.96	99.97	99.97	99.97
21/3/121	191.71	6.9009	61.97	66.43	70.1	73.18	75.79	78.08	80.24	82.38	84.69	87.31	90.07	92.9	95.62	97.73	98.99	99.6	99.85	99.94	99.97	99.98	99.98	99.98
21/3/136	191.86	6.9052	64.83	68.98	72.28	75	77.28	79.31	81.27	83.28	85.48	87.96	90.55	93.18	95.71	97.7	98.93	99.56	99.84	99.95	99.99	100	100	100
21/4/7	192.07	6.9113	64.67	68.72	71.94	74.6	76.85	78.87	80.84	82.88	85.12	87.66	90.31	93.01	95.6	97.64	98.9	99.55	99.84	99.95	99.99	100	100	100
21/4/36	192.36	6.9197	62.7	67.17	70.79	73.79	76.29	78.47	80.53	82.59	84.83	87.37	90.04	92.78	95.43	97.53	98.84	99.51	99.81	99.93	99.97	99.98	99.98	99.98
21/4/52	192.52	6.9243	67.87	71.5	74.29	76.55	78.44	80.15	81.87	83.74	85.88	88.37	91	93.68	96.23	98.14	99.22	99.71	99.9	99.96	99.98	99.98	99.98	99.98
21/4/73	192.73	6.9304	67.12	71.07	74.11	76.56	78.58	80.37	82.14	84.01	86.12	88.54	91.08	93.67	96.13	98.02	99.13	99.66	99.88	99.96	99.98	99.99	99.99	99.99
21/4/96	192.96	6.9371	65.93	69.9	72.98	75.46	77.52	79.32	81.07	82.96	85.16	87.79	90.6	93.5	96.25	98.26	99.33	99.78	99.93	99.97	99.98	99.98	99.98	99.98
21/4/112	193.12	6.9417	62.84	67.29	70.85	73.77	76.17	78.26	80.22	82.2	84.44	87.09	89.94	92.9	95.75	97.91	99.13	99.68	99.89	99.96	99.98	99.98	99.98	99.98
21/4/133	193.33	6.9478	63.22	67.72	71.31	74.25	76.67	78.76	80.74	82.74	84.94	87.45	90.11	92.84	95.48	97.57	98.87	99.54	99.83	99.95	99.99	100	100	100
21/5/0 avg	193.5	6.9527	63.24	67.69	71.27	74.19	76.58	78.65	80.58	82.5	84.67	87.24	90.02	92.91	95.72	97.88	99.12	99.69	99.91	99.99	100.01	100.02	100.02	100.02
21/5/22	193.72	6.9591	64	68.19	71.55	74.32	76.64	78.69	80.65	82.66	84.91	87.54	90.34	93.22	95.98	98.05	99.22	99.74	99.94	100	100.02	100.02	100.02	100.02
21/5/42	193.92	6.9649	60.62	65.18	68.94	72.1	74.76	77.08	79.26	81.41	83.76	86.47	89.36	92.36	95.27	97.54	98.9	99.56	99.84	99.94	99.97	99.98	99.98	99.98
21/5/62	194.12	6.9707	65.3	69.33	72.52	75.14	77.34	79.31	81.23	83.22	85.41	87.89	90.49	93.14	95.68	97.68	98.91	99.54	99.82	99.93	99.97	99.98	99.98	99.98
21/5/84	194.34	6.977	62.51	66.97	70.62	73.67	76.23	78.45	80.53	82.57	84.79	87.34	90.05	92.86	95.59	97.72	99	99.62	99.88	99.97	100	100.01	100.01	100.01
21/5/102	194.52	6.9822	63.42	67.89	71.53	74.55	77.06	79.23	81.25	83.24	85.37	87.76	90.27	92.85	95.36	97.39	98.71	99.43	99.77	99.91	99.97	99.99	100	100
21/5/122	194.72	6.988	66.99	70.9	73.99	76.52	78.62	80.47	82.25	84.07	86.09	88.4	90.85	93.37	95.82	97.76	98.96	99.58	99.85	99.96	100	100.01	100.01	100.01
21/5/140	194.9	6.9932	65.62	69.78	73.09	75.79	78.01	79.94	81.75	83.56	85.58	87.95	90.51	93.19	95.8	97.84	99.06	99.65	99.89	99.98	100.01	100.02	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
21/6/7	195.07	6.9982	66.57	70.71	73.95	76.55	78.66	80.47	82.15	83.84	85.76	88.06	90.57	93.22	95.81	97.84	99.05	99.63	99.87	99.96	99.98	99.99	99.99	99.99
21/6/33	195.33	7.0057	65.72	69.83	73.1	75.77	77.96	79.85	81.6	83.34	85.33	87.73	90.36	93.15	95.88	97.97	99.16	99.7	99.91	99.98	100	100	100	100
21/6/49 avg	195.49	7.0103	63.77	68.29	71.97	75.01	77.53	79.68	81.67	83.59	85.65	87.98	90.46	93.03	95.54	97.55	98.83	99.51	99.82	99.94	99.99	100.01	100.01	100.01
21/6/66	195.66	7.0153	64.23	68.55	72.07	75	77.45	79.57	81.55	83.5	85.58	87.92	90.38	92.92	95.4	97.41	98.72	99.44	99.78	99.92	99.98	100	100.01	100.01
21/6/87	195.87	7.0213	64.34	68.58	72.04	74.93	77.34	79.42	81.35	83.24	85.28	87.6	90.08	92.67	95.22	97.3	98.67	99.42	99.78	99.93	99.99	100.01	100.02	100.02
21/6/107	196.07	7.0271	66.71	70.71	73.9	76.52	78.69	80.58	82.36	84.14	86.08	88.29	90.65	93.11	95.52	97.49	98.77	99.47	99.8	99.94	100	100.02	100.03	100.03
21/6/134	196.34	7.035	64.59	68.78	72.17	74.97	77.29	79.3	81.18	83.05	85.09	87.44	89.96	92.59	95.18	97.29	98.66	99.41	99.77	99.92	99.98	100	100.01	100.01
21/7/0	196.5	7.0396	65.05	69.01	72.28	75.06	77.43	79.53	81.51	83.46	85.53	87.82	90.23	92.71	95.13	97.14	98.5	99.28	99.68	99.86	99.94	99.97	99.98	99.98
21/7/22	196.72	7.046	64.7	68.82	72.18	75.01	77.4	79.49	81.46	83.41	85.5	87.85	90.33	92.89	95.39	97.41	98.72	99.43	99.77	99.91	99.97	99.99	100	100
21CC/6	197	7.0541	64.18	68.48	72.04	75.04	77.55	79.71	81.69	83.6	85.63	87.91	90.33	92.85	95.33	97.36	98.68	99.4	99.74	99.88	99.94	99.96	99.97	99.97
22/1/1	197.11	7.0573	65.01	69.23	72.6	75.37	77.65	79.63	81.47	83.31	85.38	87.84	90.5	93.28	95.98	98.03	99.19	99.71	99.9	99.96	99.98	99.98	99.98	99.98
22/1/16	197.26	7.0616	63.19	67.66	71.3	74.3	76.77	78.88	80.84	82.73	84.81	87.27	89.94	92.76	95.53	97.7	99	99.62	99.88	99.97	100	100.01	100.01	100.01
22/1/38 avg	197.48	7.068	65.31	69.52	72.86	75.57	77.79	79.71	81.51	83.31	85.33	87.72	90.3	93.01	95.66	97.73	98.98	99.59	99.86	99.95	99.99	100	100	100
22/1/58	197.68	7.0738	65.76	69.86	73.07	75.66	77.79	79.67	81.46	83.32	85.45	87.96	90.65	93.43	96.1	98.11	99.23	99.73	99.92	99.98	100	100	100	100
22/1/84	197.94	7.0813	65.43	69.53	72.79	75.47	77.7	79.65	81.51	83.39	85.45	87.8	90.29	92.87	95.39	97.43	98.75	99.47	99.81	99.95	100.01	100.03	100.04	100.04
22/1/104	198.14	7.0871	64.74	69.02	72.44	75.23	77.53	79.51	81.35	83.18	85.22	87.63	90.24	92.99	95.68	97.79	99.05	99.66	99.91	100	100.03	100.04	100.04	100.04
22/1/122	198.32	7.0923	64.71	69.03	72.44	75.2	77.45	79.4	81.22	83.06	85.16	87.66	90.37	93.2	95.94	98.01	99.18	99.7	99.89	99.95	99.97	99.97	99.97	99.97
22/1/142	198.52	7.0981	62.56	66.97	70.55	73.52	76	78.16	80.18	82.18	84.39	86.97	89.74	92.63	95.45	97.65	98.96	99.59	99.85	99.94	99.97	99.98	99.98	99.98
22/2/13	198.73	7.1042	62.9	67.21	70.8	73.86	76.46	78.74	80.86	82.93	85.11	87.53	90.07	92.68	95.23	97.3	98.65	99.39	99.74	99.89	99.95	99.97	99.98	99.98
22/2/32	198.92	7.1097	66.38	70.16	73.23	75.82	78.02	79.97	81.83	83.7	85.72	88.01	90.43	92.94	95.4	97.4	98.71	99.43	99.77	99.91	99.97	99.99	100	100
22/2/54	199.14	7.116	68.96	72.34	75.04	77.31	79.26	81.02	82.72	84.46	86.37	88.54	90.85	93.25	95.61	97.53	98.77	99.45	99.77	99.9	99.95	99.97	99.98	99.98
22/2/74	199.34	7.1218	66.94	70.83	73.98	76.61	78.82	80.75	82.57	84.37	86.3	88.49	90.81	93.22	95.59	97.52	98.78	99.47	99.8	99.94	99.99	100.01	100.02	100.02
22/2/93 avg	199.53	7.1273	66.4	70.41	73.58	76.18	78.34	80.24	82.07	83.93	85.96	88.26	90.7	93.2	95.64	97.59	98.83	99.49	99.79	99.92	99.96	99.98	99.99	99.99
22/2/112	199.72	7.1328	67.2	70.92	73.89	76.36	78.47	80.37	82.22	84.13	86.21	88.56	91.01	93.52	95.93	97.83	99	99.59	99.85	99.95	99.98	99.99	99.99	99.99
22/2/133	199.93	7.1389	66.3	70.05	73.14	75.79	78.09	80.16	82.14	84.12	86.21	88.51	90.9	93.33	95.68	97.58	98.8	99.46	99.78	99.91	99.96	99.98	99.99	99.99
22/3/1	200.11	7.1441	66.63	70.33	73.38	75.99	78.25	80.28	82.21	84.14	86.19	88.47	90.84	93.27	95.63	97.54	98.78	99.45	99.77	99.9	99.95	99.97	99.98	99.98
22/3/15	200.25	7.1482	66.87	70.68	73.78	76.41	78.66	80.66	82.56	84.46	86.48	88.73	91.07	93.46	95.78	97.65	98.85	99.5	99.81	99.94	99.99	100.01	100.02	100.02
22/3/42	200.52	7.156	63.9	68.23	71.77	74.74	77.25	79.46	81.54	83.6	85.78	88.18	90.66	93.18	95.61	97.56	98.81	99.48	99.8	99.93	99.98	100	100.01	100.01
22/3/56	200.66	7.1601	67.94	71.64	74.62	77.13	79.27	81.19	83.04	84.91	86.91	89.12	91.41	93.73	95.96	97.75	98.9	99.52	99.82	99.95	100	100.02	100.03	100.03
22/3/82	200.92	7.1676	67.85	71.5	74.43	76.9	79.03	80.94	82.78	84.64	86.64	88.86	91.17	93.53	95.82	97.66	98.85	99.49	99.79	99.92	99.97	99.99	100	100
22/3/95	201.05	7.1714	66.37	70.34	73.51	76.14	78.35	80.31	82.18	84.07	86.11	88.4	90.8	93.26	95.65	97.58	98.82	99.48	99.79	99.92	99.97	99.99	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
22/3/117	201.27	7.1777	67.55	71.39	74.42	76.91	79	80.86	82.66	84.51	86.54	88.83	91.23	93.68	96.04	97.89	99.03	99.61	99.86	99.96	99.99	100	100	100
22/3/132 avg	201.42	7.1821	65.85	69.94	73.19	75.86	78.1	80.06	81.95	83.86	85.93	88.27	90.72	93.24	95.67	97.62	98.86	99.52	99.82	99.95	99.99	100.01	100.02	100.02
22/4/7	201.67	7.1893	64.75	69.03	72.4	75.15	77.42	79.42	81.32	83.27	85.45	87.99	90.68	93.44	96.08	98.07	99.2	99.71	99.9	99.96	99.98	99.98	99.98	99.98
22/4/33	201.93	7.1968	66.6	70.73	73.95	76.56	78.72	80.63	82.47	84.36	86.41	88.7	91.07	93.48	95.79	97.64	98.83	99.48	99.79	99.92	99.97	99.99	100	100
22/4/73	202.33	7.2084	69.84	73.37	76.07	78.24	80.06	81.7	83.34	85.08	87.02	89.24	91.56	93.93	96.21	97.99	99.08	99.63	99.87	99.96	99.99	100	100	100
22/4/92	202.52	7.2139	68.79	72.2	74.86	77.06	78.94	80.66	82.38	84.2	86.23	88.54	90.98	93.47	95.87	97.77	98.95	99.56	99.83	99.94	99.98	99.99	99.99	99.99
22/4/113	202.73	7.22	72.02	75.03	77.36	79.3	80.98	82.53	84.09	85.76	87.61	89.72	91.93	94.19	96.36	98.07	99.11	99.64	99.87	99.96	99.99	100	100	100
22/4/133	202.93	7.2258	73.69	76.47	78.61	80.39	81.94	83.37	84.81	86.35	88.07	90.05	92.15	94.31	96.41	98.07	99.1	99.62	99.85	99.94	99.97	99.98	99.98	99.98
22CC/7	203.17	7.2328	59.3	64.25	68.29	71.64	74.42	76.82	79.06	81.25	83.64	86.39	89.3	92.31	95.22	97.5	98.88	99.56	99.85	99.96	99.99	100	100	100
23/1/1	206.71	7.3502	65.32	69.47	72.81	75.59	77.94	80.02	82.02	84.04	86.21	88.62	91.1	93.61	96.01	97.88	99.03	99.61	99.86	99.96	99.99	100	100	100
23/1/15	206.85	7.3549	67.83	71.52	74.44	76.85	78.89	80.71	82.48	84.32	86.34	88.64	91.06	93.54	95.93	97.82	98.99	99.59	99.86	99.97	100	100.01	100.01	100.01
23/1/43 avg	207.13	7.3643	67.73	71.55	74.55	77.01	79.08	80.91	82.69	84.5	86.49	88.73	91.09	93.5	95.83	97.69	98.88	99.52	99.82	99.94	99.99	100	100.01	100.01
23/1/58	207.28	7.3693	65.79	69.8	73.04	75.75	78.04	80.06	81.98	83.91	85.98	88.29	90.71	93.18	95.58	97.52	98.78	99.46	99.79	99.93	99.98	100	100.01	100.01
23/1/78	207.48	7.376	65.71	69.79	73.08	75.82	78.12	80.14	82.04	83.93	85.97	88.26	90.67	93.15	95.56	97.52	98.79	99.48	99.81	99.95	100	100.02	100.03	100.03
23/1/103	207.73	7.3844	66.78	70.72	73.85	76.42	78.56	80.44	82.23	84.04	86.01	88.25	90.63	93.09	95.49	97.44	98.72	99.42	99.76	99.9	99.96	99.98	99.99	99.99
23/1/118	207.88	7.3894	67.5	71.37	74.42	76.92	79	80.83	82.59	84.39	86.37	88.63	91.02	93.48	95.86	97.75	98.93	99.54	99.81	99.92	99.96	99.97	99.97	99.97
23/1/142	208.12	7.3974	70.08	73.77	76.61	78.89	80.77	82.43	84.04	85.7	87.54	89.64	91.85	94.11	96.29	98.01	99.08	99.63	99.87	99.96	99.99	100	100	100
23/2/6	208.26	7.4021	67.91	71.92	75.05	77.56	79.61	81.38	83.07	84.8	86.72	88.92	91.25	93.66	95.99	97.84	98.99	99.58	99.84	99.94	99.97	99.98	99.98	99.98
23/2/32	208.52	7.4108	69.07	72.96	75.98	78.4	80.38	82.1	83.74	85.41	87.26	89.37	91.61	93.91	96.14	97.91	99.02	99.59	99.85	99.95	99.98	99.99	99.99	99.99
23/2/53	208.73	7.4179	69.26	73.03	75.95	78.29	80.21	81.89	83.52	85.2	87.06	89.2	91.47	93.81	96.08	97.88	99	99.58	99.84	99.94	99.97	99.98	99.98	99.98
23/2/86	209.06	7.4289	69.38	73.25	76.26	78.68	80.65	82.35	83.97	85.61	87.42	89.5	91.71	93.99	96.21	97.97	99.06	99.62	99.87	99.97	100	100.01	100.01	100.01
23/2/107 avg	209.27	7.436	68.85	72.74	75.78	78.23	80.24	81.99	83.65	85.33	87.19	89.31	91.56	93.88	96.12	97.9	99.01	99.58	99.84	99.94	99.98	99.99	99.99	99.99
23/2/134	209.54	7.445	67.94	71.8	74.85	77.34	79.4	81.21	82.94	84.71	86.65	88.87	91.21	93.62	95.96	97.82	98.98	99.58	99.85	99.96	100	100.01	100.01	100.01
23/3/0	209.7	7.4504	68.25	72.07	75.09	77.56	79.62	81.43	83.16	84.93	86.87	89.07	91.38	93.75	96.05	97.87	99	99.59	99.85	99.95	99.98	99.99	99.99	99.99
23/3/15	209.85	7.4554	69.82	73.5	76.35	78.64	80.53	82.19	83.8	85.47	87.32	89.44	91.68	93.97	96.18	97.93	99.02	99.58	99.83	99.93	99.96	99.97	99.97	99.97
23/3/42	210.12	7.4644	68.3	72.17	75.16	77.55	79.49	81.17	82.79	84.47	86.36	88.57	90.94	93.41	95.82	97.74	98.94	99.56	99.84	99.95	99.99	100	100	100
23/3/63	210.33	7.4715	68	71.81	74.86	77.34	79.39	81.17	82.86	84.55	86.4	88.51	90.76	93.09	95.38	97.28	98.57	99.31	99.69	99.86	99.93	99.96	99.97	99.97
23/3/83	210.53	7.4782	66.51	70.91	74.32	76.99	79.11	80.92	82.64	84.4	86.37	88.65	91.07	93.55	95.94	97.82	98.99	99.59	99.86	99.97	100	100.01	100.01	100.01
23/3/102	210.72	7.4845	68.13	72.16	75.25	77.65	79.56	81.18	82.72	84.35	86.28	88.62	91.15	93.78	96.31	98.22	99.29	99.77	99.95	100.01	100.03	100.03	100.03	100.03
23/3/117	210.87	7.4896	65.84	70.33	73.84	76.59	78.77	80.62	82.34	84.08	86.09	88.48	91.05	93.7	96.24	98.15	99.23	99.71	99.89	99.95	99.97	99.97	99.97	99.97
23/3/136	211.06	7.4959	67.91	72.08	75.29	77.79	79.77	81.47	83.1	84.79	86.71	88.94	91.3	93.72	96.05	97.88	99.01	99.59	99.85	99.95	99.98	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
23/4/7 avg	211.27	7.503	67.08	71.21	74.46	77.05	79.13	80.91	82.59	84.3	86.21	88.43	90.79	93.25	95.65	97.58	98.82	99.48	99.79	99.92	99.97	99.98	99.99	99.99
23/4/32	211.52	7.5113	68.75	72.6	75.63	78.09	80.12	81.9	83.6	85.33	87.23	89.39	91.65	93.96	96.19	97.95	99.04	99.6	99.85	99.95	99.98	99.99	99.99	99.99
23/4/52	211.72	7.518	68.36	72.24	75.29	77.76	79.8	81.58	83.28	85.01	86.92	89.1	91.41	93.78	96.08	97.9	99.03	99.61	99.87	99.97	100	100.01	100.01	100.01
23/4/73	211.93	7.5251	68.42	72.31	75.35	77.8	79.82	81.59	83.3	85.05	86.98	89.18	91.49	93.85	96.13	97.92	99.03	99.6	99.85	99.95	99.98	99.99	99.99	99.99
23/4/93	212.13	7.5318	66.6	70.65	73.87	76.5	78.67	80.56	82.35	84.15	86.12	88.36	90.73	93.18	95.58	97.52	98.77	99.45	99.77	99.9	99.95	99.97	99.98	99.98
23/4/112	212.32	7.5381	68.29	72.1	75.11	77.57	79.62	81.42	83.15	84.9	86.8	88.95	91.22	93.56	95.83	97.67	98.86	99.5	99.8	99.93	99.98	100	100.01	100.01
23/4/133	212.53	7.5452	69.71	73.18	75.93	78.21	80.16	81.91	83.61	85.35	87.24	89.35	91.56	93.82	96	97.76	98.9	99.51	99.8	99.92	99.96	99.98	99.98	99.98
23/5/1	212.71	7.5512	67.14	70.88	73.97	76.62	78.92	80.98	82.94	84.88	86.92	89.14	91.42	93.72	95.93	97.71	98.86	99.49	99.79	99.92	99.97	99.99	100	100
23/5/24	212.94	7.5589	69	72.57	75.45	77.86	79.92	81.75	83.5	85.26	87.15	89.26	91.47	93.73	95.93	97.71	98.87	99.5	99.8	99.93	99.98	100	100.01	100.01
23/5/42	213.12	7.5649	69.07	72.75	75.71	78.16	80.22	82.02	83.72	85.41	87.23	89.29	91.46	93.7	95.89	97.67	98.83	99.46	99.76	99.89	99.94	99.96	99.97	99.97
23/5/83 avg	213.53	7.5787	68.69	72.42	75.41	77.88	79.95	81.74	83.43	85.1	86.91	88.98	91.19	93.49	95.76	97.61	98.81	99.47	99.79	99.92	99.97	99.99	100	100
23/5/102	213.72	7.585	68.84	72.46	75.4	77.86	79.93	81.73	83.42	85.09	86.89	88.94	91.14	93.44	95.72	97.59	98.81	99.48	99.8	99.93	99.98	100	100.01	100.01
23/5/122	213.92	7.5917	69.26	72.94	75.91	78.38	80.44	82.24	83.92	85.58	87.36	89.37	91.51	93.74	95.93	97.71	98.87	99.51	99.81	99.94	99.99	100.01	100.02	100.02
23/5/142	214.12	7.5984	67.08	71.11	74.34	76.99	79.16	81.02	82.75	84.45	86.31	88.44	90.73	93.13	95.5	97.44	98.72	99.43	99.77	99.91	99.97	99.99	100	100
23/6/7	214.27	7.6034	68.9	72.81	75.84	78.26	80.22	81.9	83.49	85.09	86.87	88.93	91.15	93.47	95.76	97.63	98.84	99.5	99.81	99.94	99.99	100.01	100.02	100.02
23/6/31	214.51	7.6115	69.55	73.28	76.22	78.6	80.55	82.23	83.81	85.39	87.13	89.14	91.31	93.58	95.82	97.65	98.84	99.49	99.8	99.93	99.98	100	100.01	100.01
23/6/52	214.72	7.6185	69.06	72.73	75.65	78.04	80.01	81.72	83.34	84.98	86.8	88.92	91.2	93.58	95.91	97.78	98.95	99.55	99.82	99.93	99.97	99.98	99.98	99.98
23/6/85	215.05	7.6296	68.88	72.63	75.62	78.07	80.08	81.82	83.46	85.1	86.91	89.02	91.29	93.66	95.99	97.85	99.01	99.61	99.88	99.99	100.02	100.03	100.03	100.03
23/6/111	215.31	7.6383	70.71	74.24	77	79.24	81.08	82.68	84.22	85.79	87.54	89.57	91.74	94	96.21	97.97	99.06	99.62	99.87	99.97	100	100.01	100.01	100.01
23/6/133	215.53	7.6456	71.22	74.55	77.19	79.37	81.2	82.82	84.36	85.92	87.63	89.58	91.67	93.85	96	97.75	98.89	99.51	99.81	99.94	99.98	100	100	100
23/7/1 avg	215.71	7.6517	69.27	72.9	75.85	78.33	80.44	82.29	84.03	85.77	87.62	89.69	91.87	94.1	96.26	97.98	99.05	99.61	99.86	99.96	99.99	100	100.01	100.01
23/7/23	215.93	7.659	69.97	73.46	76.22	78.5	80.41	82.1	83.73	85.4	87.24	89.35	91.59	93.91	96.16	97.94	99.05	99.62	99.87	99.97	100	100.01	100.01	100.01
23CC/7	216.22	7.6688	70.13	73.71	76.59	78.99	81	82.75	84.38	85.98	87.7	89.65	91.73	93.89	96.02	97.76	98.9	99.52	99.82	99.95	100	100.02	100.03	100.03
24/1/1	216.31	7.6718	66.12	70.25	73.73	76.73	79.28	81.48	83.47	85.34	87.25	89.33	91.5	93.73	95.91	97.69	98.85	99.49	99.8	99.93	99.98	100	100.01	100.01
24/1/27	216.57	7.6805	68.18	72.11	75.32	78.01	80.26	82.2	83.99	85.71	87.52	89.54	91.66	93.85	95.99	97.73	98.87	99.5	99.8	99.93	99.98	100	100.01	100.01
24/1/43	216.73	7.6858	67.59	71.4	74.56	77.26	79.56	81.57	83.43	85.22	87.1	89.19	91.38	93.65	95.87	97.68	98.86	99.51	99.82	99.95	100	100.02	100.03	100.03
24/1/64	216.94	7.6929	70.84	74.16	76.86	79.14	81.09	82.82	84.45	86.05	87.74	89.63	91.64	93.73	95.8	97.53	98.71	99.39	99.74	99.9	99.97	99.99	100	100
24/1/82	217.12	7.6989	70.93	74.24	76.96	79.27	81.24	82.97	84.57	86.11	87.74	89.57	91.54	93.62	95.7	97.45	98.65	99.35	99.71	99.87	99.94	99.96	99.97	99.97
24/1/104	217.34	7.7063	72.91	76.04	78.55	80.66	82.45	84.03	85.53	87.02	88.64	90.48	92.44	94.49	96.5	98.1	99.1	99.62	99.85	99.94	99.97	99.98	99.98	99.98
24/1/123	217.53	7.7126	75.11	77.88	80.09	81.96	83.56	84.98	86.34	87.71	89.2	90.92	92.77	94.71	96.62	98.16	99.13	99.63	99.85	99.94	99.97	99.98	99.98	99.98
24/1/142 avg	217.72	7.719	73.13	76.17	78.68	80.86	82.76	84.43	85.99	87.52	89.12	90.9	92.78	94.73	96.64	98.17	99.14	99.64	99.87	99.96	99.99	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
24/2/12	217.92	7.7257	72.42	75.58	78.18	80.42	82.35	84.05	85.64	87.19	88.82	90.65	92.58	94.59	96.56	98.14	99.13	99.65	99.88	99.97	100	100.01	100.01	100.01
24/2/28	218.08	7.7311	72.51	75.73	78.38	80.65	82.59	84.29	85.86	87.37	88.96	90.75	92.65	94.63	96.58	98.14	99.12	99.63	99.86	99.95	99.98	99.99	99.99	99.99
24/2/46	218.26	7.7371	71.79	75.13	77.91	80.31	82.35	84.12	85.73	87.26	88.86	90.66	92.57	94.57	96.54	98.12	99.12	99.64	99.87	99.96	99.99	100	100	100
24/2/72	218.52	7.7458	71.67	75.05	77.86	80.26	82.27	83.98	85.53	87	88.55	90.34	92.28	94.34	96.38	98.03	99.08	99.62	99.86	99.96	99.99	100	100	100
24/2/87	218.67	7.7508	70.29	73.94	77	79.61	81.78	83.61	85.24	86.76	88.35	90.17	92.14	94.23	96.31	97.99	99.06	99.62	99.87	99.97	100	100.01	100.01	100.01
24/2/107	218.87	7.7575	69.89	73.6	76.66	79.23	81.34	83.11	84.69	86.18	87.78	89.65	91.7	93.89	96.08	97.86	98.99	99.58	99.85	99.96	100	100.01	100.01	100.01
24/2/135	219.15	7.7669	70.09	73.82	76.85	79.36	81.42	83.15	84.72	86.2	87.79	89.63	91.64	93.78	95.92	97.69	98.85	99.49	99.8	99.93	99.98	100	100.01	100.01
24/3/1	219.31	7.7723	72.73	76.05	78.71	80.92	82.74	84.29	85.71	87.09	88.59	90.35	92.28	94.33	96.37	98.02	99.06	99.6	99.84	99.94	99.97	99.98	99.98	99.98
24/3/23	219.53	7.7796	74.5	77.55	79.99	82.04	83.75	85.23	86.61	87.99	89.5	91.26	93.15	95.13	97.05	98.53	99.38	99.78	99.93	99.98	99.99	99.99	99.99	99.99
24/3/42 avg	219.72	7.786	74.45	77.54	80.02	82.1	83.84	85.33	86.71	88.07	89.55	91.28	93.14	95.1	97.02	98.5	99.36	99.75	99.91	99.96	99.97	99.97	99.97	99.97
24/3/56	219.86	7.7907	73.97	77.09	79.59	81.68	83.43	84.94	86.35	87.73	89.23	90.97	92.85	94.84	96.79	98.33	99.26	99.72	99.91	99.98	100	100.01	100.01	100.01
24/3/82	220.12	7.7994	73.69	76.88	79.43	81.55	83.3	84.79	86.16	87.49	88.94	90.64	92.5	94.49	96.47	98.08	99.1	99.63	99.87	99.96	99.99	100	100	100
24/3/102	220.32	7.8061	74.91	77.89	80.25	82.21	83.85	85.27	86.6	87.92	89.36	91.03	92.84	94.75	96.65	98.18	99.15	99.65	99.88	99.97	100	100.01	100.01	100.01
24/3/116	220.46	7.8108	72.63	75.98	78.63	80.8	82.59	84.13	85.58	87.01	88.58	90.4	92.36	94.42	96.45	98.08	99.1	99.63	99.86	99.95	99.98	99.99	99.99	99.99
24/3/133	220.63	7.8165	71.13	74.71	77.58	79.95	81.91	83.6	85.16	86.68	88.3	90.14	92.11	94.16	96.19	97.85	98.94	99.54	99.83	99.95	99.99	100.01	100.01	100.01
24/4/7	220.87	7.8245	72.2	75.59	78.3	80.55	82.42	84.03	85.52	86.97	88.52	90.29	92.2	94.21	96.2	97.84	98.92	99.51	99.79	99.91	99.95	99.97	99.97	99.97
24/4/32	221.12	7.8329	72.62	75.92	78.57	80.78	82.63	84.23	85.73	87.2	88.78	90.59	92.52	94.54	96.52	98.11	99.11	99.63	99.86	99.95	99.98	99.99	99.99	99.99
24/4/47	221.27	7.8379	74.31	77.43	79.87	81.87	83.53	84.97	86.33	87.69	89.18	90.9	92.75	94.69	96.59	98.12	99.09	99.6	99.83	99.92	99.95	99.96	99.96	99.96
24/4/72	221.52	7.8463	72.35	75.57	78.15	80.3	82.1	83.68	85.16	86.62	88.21	90.03	91.99	94.06	96.11	97.8	98.91	99.53	99.83	99.96	100.01	100.03	100.04	100.04
24/4/86 avg	221.66	7.851	72.26	75.59	78.24	80.44	82.26	83.85	85.35	86.85	88.5	90.4	92.43	94.55	96.61	98.23	99.2	99.68	99.88	99.96	99.98	99.99	99.99	99.99
24/4/112	221.92	7.8597	72.53	75.81	78.37	80.46	82.21	83.75	85.23	86.74	88.4	90.3	92.32	94.41	96.45	98.08	99.1	99.63	99.86	99.95	99.98	99.99	99.99	99.99
24/4/133	222.13	7.8667	71.73	75.2	77.93	80.18	82.07	83.72	85.29	86.86	88.55	90.46	92.47	94.54	96.55	98.15	99.14	99.65	99.88	99.97	100	100.01	100.01	100.01
24/5/1	222.31	7.8728	70.58	74.14	76.95	79.28	81.23	82.95	84.59	86.26	88.07	90.12	92.27	94.47	96.59	98.24	99.22	99.7	99.9	99.97	99.99	100	100	100
24/5/15	222.45	7.8774	69.7	73.26	76.09	78.44	80.43	82.19	83.88	85.6	87.46	89.56	91.76	94.02	96.21	97.95	99.03	99.58	99.83	99.93	99.96	99.97	99.97	99.97
24/5/43	222.73	7.8868	69.63	73.19	76.07	78.48	80.5	82.27	83.94	85.61	87.42	89.48	91.67	93.94	96.15	97.92	99.02	99.59	99.85	99.95	99.98	99.99	99.99	99.99
24/5/63	222.93	7.8935	72.37	75.61	78.19	80.35	82.16	83.74	85.25	86.78	88.47	90.44	92.54	94.72	96.83	98.44	99.36	99.78	99.94	100	100.02	100.02	100.02	100.02
24/5/84	223.14	7.9006	73	76.22	78.78	80.92	82.71	84.27	85.76	87.26	88.91	90.82	92.84	94.93	96.95	98.49	99.37	99.77	99.92	99.97	99.98	99.98	99.98	99.98
24/5/103	223.33	7.9069	71.62	74.97	77.66	79.92	81.83	83.5	85.08	86.66	88.37	90.33	92.41	94.56	96.65	98.27	99.24	99.71	99.9	99.97	99.99	100	100	100
24/5/118	223.48	7.9119	71.04	74.46	77.19	79.47	81.39	83.08	84.69	86.31	88.08	90.1	92.23	94.43	96.56	98.22	99.21	99.69	99.89	99.96	99.98	99.99	99.99	99.99
24/5/142 avg	223.72	7.92	72.57	75.88	78.49	80.64	82.43	83.99	85.48	86.98	88.64	90.54	92.57	94.68	96.72	98.31	99.26	99.71	99.9	99.97	99.99	100	100	100
24/6/7	223.87	7.925	70.79	74.36	77.22	79.59	81.56	83.27	84.87	86.44	88.13	90.06	92.11	94.25	96.34	98.01	99.06	99.6	99.84	99.94	99.97	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
24/6/27	224.07	7.9317	72.95	76.24	78.82	80.95	82.74	84.32	85.83	87.35	88.99	90.84	92.78	94.77	96.7	98.23	99.18	99.67	99.89	99.98	100.01	100.02	100.02	100.02
24/6/47	224.27	7.9384	73.11	76.34	78.89	81	82.78	84.35	85.85	87.36	88.98	90.81	92.73	94.71	96.64	98.18	99.14	99.64	99.86	99.95	99.98	99.99	99.99	99.99
24/6/67	224.47	7.9451	71.5	74.89	77.57	79.79	81.66	83.31	84.88	86.46	88.16	90.09	92.14	94.27	96.35	98.02	99.07	99.61	99.86	99.96	99.99	100	100	100
24/6/86	224.66	7.9515	72.78	76.03	78.6	80.73	82.52	84.1	85.6	87.1	88.72	90.56	92.52	94.55	96.53	98.12	99.11	99.62	99.85	99.94	99.97	99.98	99.98	99.98
24/6/107	224.87	7.9585	73.01	76.24	78.82	80.98	82.8	84.4	85.92	87.45	89.09	90.95	92.91	94.92	96.87	98.38	99.28	99.72	99.9	99.97	99.99	100	100	100
24/6/132	225.12	7.9669	71.83	75.12	77.75	79.95	81.81	83.46	85.02	86.57	88.24	90.12	92.11	94.17	96.2	97.85	98.93	99.52	99.8	99.92	99.96	99.98	99.99	99.99
24CC/9	225.36	7.9749	70.58	74.06	76.88	79.26	81.28	83.06	84.73	86.36	88.09	90.01	92.03	94.12	96.17	97.84	98.93	99.53	99.82	99.94	99.99	100.01	100.02	100.02
25/1/1	225.91	7.9933	68.66	72.35	75.41	78.06	80.37	82.43	84.36	86.24	88.16	90.2	92.27	94.35	96.34	97.94	98.98	99.55	99.82	99.94	99.98	100	100.01	100.01
25/1/23	226.13	8.0007	71.83	75.2	77.94	80.26	82.23	83.95	85.55	87.11	88.74	90.55	92.46	94.43	96.36	97.94	98.97	99.54	99.81	99.93	99.97	99.99	99.99	99.99
25/1/42 avg	226.32	8.0071	71.98	75.37	78.1	80.39	82.32	84	85.56	87.08	88.69	90.49	92.39	94.37	96.31	97.91	98.95	99.53	99.81	99.93	99.97	99.99	99.99	99.99
25/1/63	226.53	8.0141	68.71	72.49	75.65	78.35	80.64	82.61	84.4	86.07	87.78	89.66	91.65	93.72	95.78	97.5	98.68	99.37	99.72	99.88	99.95	99.97	99.98	99.98
25/1/85	226.75	8.0215	69.66	73.33	76.35	78.91	81.07	82.94	84.65	86.28	87.96	89.82	91.78	93.82	95.85	97.55	98.72	99.4	99.75	99.91	99.98	100.01	100.02	100.02
25/1/103	226.93	8.0275	68.97	72.74	75.82	78.41	80.58	82.46	84.2	85.89	87.67	89.65	91.73	93.88	95.99	97.71	98.84	99.47	99.78	99.91	99.96	99.98	99.99	99.99
25/1/125	227.13	8.0342	67.95	71.9	75.15	77.89	80.18	82.15	83.95	85.67	87.47	89.47	91.58	93.77	95.92	97.68	98.84	99.48	99.79	99.92	99.97	99.99	100	100
25/1/144	227.34	8.0412	68.55	72.2	75.21	77.75	79.89	81.74	83.44	85.06	86.79	88.75	90.87	93.11	95.35	97.25	98.55	99.31	99.7	99.88	99.96	99.99	100	100
25/2/5	227.45	8.0449	67.72	71.5	74.65	77.34	79.63	81.62	83.44	85.17	86.96	88.95	91.06	93.26	95.45	97.29	98.56	99.31	99.7	99.88	99.96	99.99	100	100
25/2/32	227.72	8.054	68.87	72.54	75.58	78.17	80.37	82.29	84.06	85.76	87.54	89.52	91.61	93.78	95.91	97.66	98.81	99.45	99.76	99.89	99.94	99.96	99.97	99.97
25/2/53	227.93	8.061	69.22	72.86	75.85	78.37	80.49	82.33	84.03	85.68	87.46	89.46	91.57	93.76	95.92	97.69	98.85	99.49	99.8	99.93	99.98	100	100.01	100.01
25/2/72	228.12	8.0674	69.59	73.35	76.43	79.01	81.16	83	84.68	86.28	87.97	89.86	91.87	93.97	96.04	97.74	98.86	99.48	99.78	99.91	99.96	99.98	99.99	99.99
25/2/95	228.35	8.0751	70.12	73.75	76.72	79.21	81.3	83.11	84.76	86.33	87.97	89.8	91.74	93.77	95.79	97.49	98.66	99.35	99.7	99.86	99.93	99.95	99.96	99.96
25/2/112 avg	228.52	8.0808	71.46	74.93	77.75	80.13	82.13	83.85	85.44	86.97	88.57	90.36	92.27	94.26	96.23	97.85	98.92	99.51	99.79	99.92	99.96	99.98	99.99	99.99
25/2/134	228.74	8.0881	69.31	73.02	76.1	78.75	81	82.94	84.71	86.38	88.1	89.99	91.98	94.05	96.09	97.77	98.88	99.5	99.8	99.93	99.98	100	100.01	100.01
25/3/0	228.9	8.0935	68.25	72.06	75.23	77.95	80.27	82.28	84.11	85.83	87.59	89.51	91.53	93.62	95.69	97.43	98.63	99.34	99.71	99.88	99.96	99.99	100	100
25/3/23	229.13	8.1012	68.13	72.01	75.21	77.91	80.18	82.13	83.9	85.57	87.3	89.22	91.26	93.4	95.53	97.32	98.56	99.29	99.67	99.85	99.93	99.96	99.97	99.97
25/3/43	229.33	8.1079	68.92	72.65	75.72	78.32	80.52	82.42	84.16	85.81	87.53	89.43	91.44	93.54	95.62	97.37	98.58	99.29	99.66	99.83	99.91	99.94	99.95	99.95
25/3/63	229.53	8.1146	70.23	73.91	76.89	79.38	81.46	83.25	84.88	86.44	88.07	89.88	91.81	93.83	95.84	97.53	98.7	99.39	99.75	99.91	99.98	100.01	100.02	100.02
25/3/95	229.85	8.1253	70	73.64	76.64	79.19	81.35	83.21	84.91	86.52	88.19	90.04	92	94.05	96.08	97.75	98.86	99.48	99.78	99.91	99.96	99.98	99.99	99.99
25/3/118	230.08	8.133	69.89	73.46	76.42	78.94	81.07	82.9	84.56	86.13	87.78	89.64	91.65	93.77	95.88	97.63	98.8	99.46	99.78	99.92	99.98	100	100.01	100.01
25/3/137	230.27	8.1394	69.84	73.47	76.47	79.02	81.17	83.03	84.72	86.31	87.96	89.78	91.72	93.75	95.77	97.47	98.65	99.35	99.72	99.89	99.97	100	100.01	100.01
25/4/7	230.47	8.1461	69.38	73.02	76.02	78.57	80.71	82.55	84.23	85.83	87.52	89.43	91.48	93.64	95.79	97.57	98.76	99.43	99.76	99.9	99.96	99.98	99.99	99.99
25/4/32	230.72	8.1545	68.86	72.6	75.67	78.26	80.43	82.3	84.01	85.65	87.38	89.33	91.42	93.62	95.8	97.6	98.8	99.47	99.8	99.94	100	100.02	100.03	100.03

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
25/4/53 avg	230.93	8.1615	68.15	71.9	75.01	77.67	79.92	81.86	83.63	85.32	87.09	89.08	91.21	93.45	95.66	97.5	98.73	99.42	99.76	99.91	99.97	99.99	100	100
25/4/74	231.14	8.1685	69.77	73.45	76.46	78.99	81.12	82.95	84.63	86.24	87.93	89.83	91.85	93.96	96.04	97.75	98.88	99.51	99.81	99.94	99.99	100.01	100.02	100.02
25/4/93	231.33	8.1749	72.72	75.88	78.44	80.6	82.41	83.97	85.41	86.8	88.31	90.05	91.96	93.99	96.03	97.73	98.85	99.47	99.77	99.9	99.95	99.97	99.98	99.98
25/4/112	231.52	8.1813	68.08	71.83	74.95	77.61	79.86	81.8	83.57	85.26	87.03	89.03	91.17	93.42	95.65	97.5	98.73	99.42	99.76	99.9	99.96	99.98	99.99	99.99
25/4/133	231.73	8.1883	68.06	71.81	74.93	77.58	79.8	81.69	83.4	85.02	86.74	88.72	90.88	93.18	95.48	97.4	98.68	99.4	99.75	99.9	99.96	99.98	99.99	99.99
25/5/1	231.91	8.1943	67.48	71.4	74.66	77.43	79.75	81.73	83.53	85.23	87.01	89.02	91.17	93.43	95.67	97.52	98.75	99.44	99.78	99.92	99.98	100	100.01	100.01
25/5/16	232.06	8.1994	68.54	72.27	75.34	77.93	80.09	81.94	83.62	85.23	86.95	88.92	91.06	93.32	95.57	97.44	98.69	99.39	99.73	99.88	99.94	99.96	99.97	99.97
25/5/38	232.28	8.2067	69.61	73.37	76.44	79	81.12	82.93	84.58	86.16	87.84	89.74	91.77	93.89	95.98	97.7	98.84	99.47	99.77	99.9	99.95	99.97	99.98	99.98
25/5/62	232.52	8.2148	70.32	73.93	76.8	79.15	81.09	82.76	84.31	85.84	87.51	89.43	91.5	93.68	95.84	97.62	98.8	99.46	99.78	99.92	99.98	100	100.01	100.01
25/5/82	232.72	8.2215	69.38	73.12	76.15	78.67	80.77	82.57	84.23	85.83	87.54	89.47	91.54	93.7	95.84	97.61	98.79	99.45	99.78	99.92	99.98	100	100.01	100.01
25/5/102 avg	232.92	8.2282	71.42	74.87	77.6	79.83	81.68	83.29	84.79	86.28	87.91	89.77	91.78	93.88	95.97	97.69	98.83	99.47	99.79	99.93	99.98	100	100.01	100.01
25/5/117	233.07	8.2332	71.17	74.55	77.28	79.56	81.47	83.13	84.67	86.18	87.81	89.67	91.68	93.79	95.89	97.63	98.79	99.45	99.77	99.91	99.97	99.99	100	100
25/5/137	233.27	8.2399	71.13	74.67	77.49	79.82	81.77	83.46	85.04	86.59	88.25	90.12	92.1	94.16	96.18	97.83	98.92	99.52	99.81	99.93	99.98	100	100.01	100.01
25/6/7	233.47	8.2466	70.28	73.99	76.96	79.41	81.45	83.21	84.84	86.42	88.1	89.98	91.98	94.05	96.08	97.75	98.85	99.47	99.77	99.9	99.95	99.97	99.98	99.98
25/6/27	233.67	8.2533	71.93	75.36	78.1	80.37	82.27	83.92	85.46	86.96	88.56	90.35	92.25	94.23	96.18	97.79	98.87	99.48	99.78	99.91	99.96	99.98	99.99	99.99
25/6/48	233.88	8.2603	69.55	73.3	76.35	78.91	81.08	82.98	84.74	86.44	88.21	90.14	92.15	94.2	96.19	97.82	98.9	99.5	99.8	99.93	99.98	100	100.01	100.01
25/6/75	234.15	8.2694	71.34	74.85	77.66	79.98	81.93	83.63	85.21	86.74	88.36	90.16	92.06	94.03	95.97	97.6	98.73	99.4	99.75	99.91	99.98	100.01	100.02	100.02
25/6/93	234.33	8.2754	71.2	74.88	77.77	80.12	82.04	83.69	85.22	86.72	88.34	90.18	92.14	94.18	96.18	97.82	98.9	99.5	99.79	99.91	99.96	99.98	99.99	99.99
25/6/112	234.52	8.2818	70.85	74.63	77.61	80.03	82.01	83.71	85.28	86.81	88.45	90.29	92.24	94.26	96.23	97.85	98.92	99.51	99.8	99.92	99.97	99.99	100	100
25/6/133	234.73	8.2888	69.91	73.74	76.76	79.21	81.22	82.95	84.56	86.15	87.86	89.79	91.83	93.95	96.03	97.74	98.87	99.51	99.82	99.95	100	100.02	100.03	100.03
25/7/1	234.91	8.2948	71.16	74.86	77.75	80.06	81.93	83.53	85.02	86.49	88.08	89.89	91.83	93.86	95.87	97.55	98.7	99.38	99.73	99.89	99.96	99.98	99.99	99.99
25/7/17 avg	235.07	8.3002	69.03	72.99	76.17	78.78	80.91	82.71	84.34	85.9	87.57	89.47	91.51	93.65	95.77	97.54	98.73	99.41	99.76	99.91	99.98	100	100.01	100.01
25cc/10	235.26	8.3065	69.27	73.23	76.41	79.01	81.13	82.92	84.54	86.08	87.71	89.54	91.51	93.57	95.62	97.36	98.57	99.29	99.67	99.85	99.93	99.96	99.97	99.97
26/1/1	235.51	8.3149	71.53	75.23	78.24	80.73	82.78	84.51	86.06	87.5	89	90.67	92.45	94.31	96.16	97.72	98.79	99.42	99.74	99.89	99.95	99.97	99.98	99.98
26/1/23	235.73	8.3223	69.75	73.45	76.5	79.06	81.19	82.99	84.62	86.16	87.79	89.65	91.66	93.77	95.87	97.62	98.79	99.45	99.78	99.92	99.98	100	100.01	100.01
26/1/58	236.08	8.334	70.92	74.56	77.52	79.96	81.95	83.63	85.14	86.57	88.11	89.88	91.82	93.88	95.94	97.66	98.81	99.46	99.78	99.92	99.98	100	100.01	100.01
26/1/82	236.32	8.342	68.7	72.56	75.77	78.48	80.74	82.67	84.41	86.05	87.76	89.67	91.7	93.82	95.91	97.64	98.79	99.44	99.76	99.9	99.96	99.98	99.99	99.99
26/1/102	236.52	8.3487	68.81	72.52	75.6	78.21	80.41	82.3	84.01	85.62	87.31	89.21	91.24	93.38	95.51	97.32	98.58	99.33	99.73	99.91	99.99	100.02	100.03	100.03
26/1/117	236.67	8.3538	69.72	73.4	76.43	78.98	81.12	82.95	84.62	86.21	87.89	89.78	91.8	93.9	95.98	97.69	98.83	99.47	99.78	99.91	99.96	99.98	99.99	99.99
26/1/142	236.92	8.3621	69.45	73.19	76.29	78.93	81.16	83.09	84.85	86.53	88.26	90.16	92.15	94.19	96.19	97.83	98.91	99.52	99.82	99.95	100	100.02	100.03	100.03
26/2/13	237.13	8.3692	68.55	72.32	75.48	78.2	80.52	82.55	84.41	86.17	87.96	89.89	91.89	93.93	95.92	97.58	98.72	99.39	99.74	99.9	99.97	100	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
26/2/32 avg	237.32	8.3755	69.62	73.35	76.41	78.98	81.15	83.01	84.72	86.35	88.05	89.94	91.93	93.98	96	97.68	98.8	99.44	99.76	99.9	99.96	99.99	100	100
26/2/56	237.56	8.3836	69.24	72.98	76.09	78.72	80.94	82.85	84.59	86.24	87.97	89.89	91.91	94.01	96.07	97.76	98.88	99.5	99.8	99.93	99.98	100	100.01	100.01
26/2/93	237.93	8.396	69.84	73.69	76.82	79.42	81.57	83.4	85.06	86.62	88.24	90.04	91.95	93.94	95.91	97.56	98.7	99.38	99.73	99.89	99.96	99.98	99.99	99.99
26/2/112	238.12	8.4023	69.09	72.9	76.05	78.71	80.96	82.91	84.68	86.34	88.03	89.86	91.76	93.72	95.66	97.31	98.49	99.23	99.64	99.85	99.95	99.99	100.01	100.02
26/2/133	238.33	8.4094	71.57	75.21	78.14	80.55	82.54	84.24	85.78	87.24	88.77	90.48	92.29	94.18	96.06	97.65	98.74	99.39	99.73	99.89	99.96	99.99	100	100
26/3/1	238.51	8.4154	69.34	73.17	76.33	78.99	81.23	83.16	84.9	86.53	88.2	90.02	91.93	93.91	95.87	97.52	98.66	99.33	99.68	99.84	99.91	99.94	99.95	99.95
26/3/22	238.72	8.4224	71.35	74.93	77.84	80.27	82.29	84.03	85.61	87.12	88.7	90.47	92.35	94.31	96.25	97.85	98.91	99.5	99.79	99.92	99.97	99.99	100	100
26/3/43	238.93	8.4295	70.07	73.65	76.6	79.1	81.22	83.06	84.74	86.33	87.98	89.81	91.75	93.77	95.78	97.47	98.64	99.34	99.71	99.88	99.96	99.99	100	100
26/3/56	239.06	8.4338	71.26	74.87	77.78	80.2	82.23	83.98	85.59	87.12	88.71	90.46	92.3	94.21	96.1	97.68	98.77	99.41	99.74	99.89	99.96	99.98	99.99	99.99
26/3/82	239.32	8.4425	71.51	74.88	77.66	80.03	82.05	83.81	85.43	86.97	88.56	90.32	92.18	94.12	96.04	97.65	98.76	99.41	99.75	99.91	99.98	100	100.01	100.01
26/3/102	239.52	8.4492	70.94	74.24	76.96	79.28	81.29	83.07	84.73	86.34	88.02	89.87	91.82	93.84	95.83	97.5	98.66	99.35	99.71	99.88	99.95	99.98	99.99	99.99
26/3/117 avg	239.67	8.4543	71.16	74.43	77.14	79.49	81.53	83.35	85.05	86.69	88.38	90.21	92.11	94.07	95.99	97.61	98.72	99.37	99.72	99.88	99.95	99.97	99.98	99.98
26/3/133	239.83	8.4596	71.13	74.57	77.39	79.8	81.88	83.72	85.43	87.07	88.75	90.56	92.43	94.34	96.21	97.77	98.84	99.47	99.79	99.94	100	100.02	100.03	100.03
26/4/7	240.07	8.4677	71.98	75.16	77.77	80.01	81.95	83.69	85.33	86.93	88.6	90.42	92.32	94.26	96.16	97.74	98.82	99.45	99.77	99.92	99.98	100	100.01	100.01
26/4/32	240.32	8.476	74.92	77.73	80.02	81.97	83.66	85.17	86.6	87.99	89.45	91.07	92.78	94.56	96.32	97.8	98.82	99.42	99.73	99.87	99.93	99.95	99.96	99.96
26/4/52	240.52	8.4827	74.06	77.15	79.68	81.83	83.66	85.26	86.74	88.16	89.64	91.29	93.03	94.84	96.62	98.08	99.04	99.57	99.83	99.94	99.98	100	100.01	100.01
26/4/72	240.72	8.4894	72.66	76.02	78.78	81.1	83.05	84.72	86.25	87.7	89.21	90.91	92.71	94.59	96.45	97.98	98.99	99.55	99.82	99.94	99.98	100	100.01	100.01
26/4/92	240.92	8.4961	73.76	76.9	79.48	81.66	83.51	85.11	86.56	87.93	89.36	90.95	92.66	94.46	96.26	97.78	98.82	99.43	99.75	99.9	99.96	99.98	99.99	99.99
26/4/112	241.12	8.5028	73.45	76.64	79.26	81.48	83.37	85.03	86.55	88	89.49	91.12	92.83	94.6	96.36	97.83	98.84	99.44	99.75	99.89	99.95	99.97	99.98	99.98
26/4/132	241.32	8.5095	72.08	75.37	78.06	80.34	82.29	84.01	85.6	87.14	88.74	90.49	92.33	94.23	96.11	97.68	98.76	99.4	99.73	99.88	99.95	99.98	99.99	99.99
26/5/0	241.5	8.5156	73.73	76.9	79.47	81.65	83.51	85.15	86.67	88.13	89.64	91.28	92.99	94.75	96.48	97.92	98.9	99.47	99.77	99.91	99.97	99.99	100	100
26/5/15	241.65	8.5206	72.49	75.71	78.35	80.6	82.53	84.23	85.81	87.32	88.88	90.59	92.39	94.25	96.09	97.64	98.72	99.36	99.7	99.86	99.93	99.96	99.97	99.97
26/5/42 avg	241.92	8.5296	72.05	75.36	78.09	80.44	82.44	84.19	85.79	87.3	88.86	90.56	92.36	94.22	96.08	97.64	98.72	99.37	99.71	99.86	99.93	99.96	99.97	99.97
26/5/63	242.13	8.5367	71.72	75.07	77.85	80.24	82.29	84.07	85.7	87.23	88.79	90.5	92.3	94.18	96.05	97.63	98.73	99.38	99.72	99.88	99.95	99.98	99.99	99.99
26/5/82	242.32	8.543	72.98	76.18	78.84	81.14	83.12	84.85	86.44	87.94	89.48	91.16	92.92	94.74	96.53	98	98.97	99.51	99.78	99.9	99.94	99.96	99.97	99.97
26/5/102	242.52	8.5497	71.19	74.61	77.44	79.85	81.91	83.7	85.34	86.9	88.51	90.27	92.13	94.06	95.97	97.58	98.7	99.36	99.71	99.87	99.94	99.97	99.98	99.98
26/5/117	242.67	8.5548	68.76	72.28	75.27	77.88	80.14	82.13	83.96	85.71	87.52	89.51	91.6	93.76	95.88	97.62	98.78	99.44	99.76	99.9	99.96	99.98	99.99	99.99
26/5/142	242.92	8.5631	69.38	72.72	75.57	78.08	80.27	82.2	83.98	85.66	87.39	89.3	91.32	93.43	95.53	97.3	98.54	99.28	99.67	99.85	99.93	99.96	99.97	99.97
26/6/7	243.07	8.5682	66.54	70.08	73.11	75.78	78.11	80.18	82.11	83.97	85.93	88.13	90.47	92.91	95.32	97.31	98.63	99.37	99.73	99.89	99.95	99.97	99.98	99.98
26/6/26	243.26	8.5745	72.45	75.37	77.86	80.04	81.93	83.58	85.08	86.48	87.94	89.6	91.42	93.38	95.38	97.12	98.38	99.17	99.61	99.82	99.92	99.96	99.98	99.99
26/6/47	243.47	8.5816	63.2	67.11	70.66	73.88	76.7	79.14	81.31	83.28	85.27	87.46	89.8	92.26	94.73	96.83	98.3	99.17	99.63	99.84	99.93	99.96	99.97	99.97

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
26/6/63	243.63	8.5869	60.34	64.73	68.67	72.17	75.15	77.68	79.9	81.9	83.95	86.26	88.78	91.47	94.19	96.51	98.13	99.1	99.6	99.83	99.93	99.97	99.98	99.98
26cc/13	243.86	8.5946	62.91	66.54	69.88	72.99	75.8	78.32	80.63	82.79	84.97	87.32	89.77	92.3	94.79	96.88	98.32	99.17	99.61	99.81	99.9	99.93	99.94	99.94
27/1/1 avg	245.11	8.6365	62.76	66.49	69.86	72.94	75.7	78.17	80.45	82.6	84.82	87.25	89.8	92.46	95.06	97.2	98.6	99.37	99.74	99.9	99.96	99.98	99.98	99.98
27/1/25	245.35	8.6445	63.81	67.74	71.2	74.26	76.89	79.15	81.17	83.01	84.9	87.02	89.32	91.77	94.25	96.41	97.98	98.96	99.5	99.77	99.89	99.94	99.96	99.97
27/1/43	245.53	8.6506	64.51	68.42	71.81	74.77	77.29	79.46	81.41	83.22	85.13	87.29	89.64	92.14	94.66	96.8	98.29	99.17	99.63	99.84	99.93	99.96	99.97	99.97
27/1/65	245.75	8.6579	59.13	63.76	67.93	71.61	74.72	77.32	79.58	81.58	83.63	85.96	88.51	91.25	94.03	96.41	98.08	99.07	99.59	99.83	99.93	99.97	99.98	99.98
27/1/81	245.91	8.6633	60.28	64.8	68.77	72.21	75.08	77.46	79.54	81.37	83.32	85.67	88.35	91.31	94.34	96.87	98.51	99.39	99.79	99.95	100.01	100.03	100.04	100.04
27/1/96	246.06	8.6683	57.99	62.84	67.25	71.15	74.41	77.09	79.38	81.38	83.44	85.82	88.45	91.31	94.21	96.66	98.31	99.24	99.7	99.89	99.97	99.99	100	100
27/1/117	246.27	8.6753	59.92	64.61	68.77	72.38	75.35	77.77	79.84	81.61	83.54	85.89	88.59	91.59	94.66	97.16	98.72	99.5	99.83	99.95	99.98	99.99	99.99	99.99
27/1/142	246.52	8.6837	59.09	63.76	67.94	71.6	74.66	77.18	79.36	81.25	83.28	85.72	88.48	91.52	94.62	97.14	98.7	99.48	99.81	99.93	99.97	99.98	99.98	99.98
27/2/5	246.65	8.6881	60.03	64.53	68.59	72.2	75.28	77.88	80.15	82.15	84.2	86.55	89.13	91.92	94.74	97.07	98.59	99.4	99.77	99.92	99.97	99.98	99.98	99.98
27/2/27	246.87	8.6954	57.97	62.64	66.93	70.8	74.11	76.9	79.31	81.42	83.54	85.91	88.48	91.23	94.02	96.41	98.09	99.09	99.62	99.86	99.96	100	100.01	100.01
27/2/53	247.13	8.7041	62.52	66.37	69.91	73.18	76.11	78.7	81.02	83.12	85.19	87.39	89.69	92.08	94.46	96.52	98.02	98.97	99.5	99.77	99.89	99.94	99.96	99.97
27/2/73 avg	247.33	8.7108	67.98	71.38	74.36	77.03	79.39	81.48	83.41	85.23	87.08	89.09	91.19	93.36	95.5	97.31	98.56	99.31	99.7	99.88	99.96	99.99	100	100
27/2/93	247.53	8.7175	68.52	71.83	74.65	77.15	79.36	81.34	83.18	84.94	86.75	88.72	90.8	92.96	95.11	96.96	98.3	99.14	99.61	99.85	99.96	100.01	100.03	100.04
27/2/107	247.67	8.7222	68.79	72.28	75.2	77.71	79.88	81.79	83.55	85.24	86.99	88.92	90.97	93.11	95.24	97.07	98.37	99.18	99.62	99.84	99.94	99.98	100	100.01
27/2/132	247.92	8.7306	66.04	69.69	72.88	75.73	78.25	80.48	82.52	84.43	86.37	88.48	90.69	92.98	95.24	97.14	98.46	99.25	99.66	99.85	99.93	99.96	99.97	99.97
27/3/1	248.11	8.737	68.17	71.62	74.6	77.25	79.59	81.67	83.59	85.4	87.24	89.23	91.31	93.45	95.56	97.33	98.56	99.29	99.67	99.85	99.93	99.96	99.97	99.97
27/3/16	248.26	8.742	68.83	72.23	75.13	77.7	79.96	81.96	83.81	85.56	87.35	89.3	91.35	93.48	95.58	97.35	98.58	99.31	99.69	99.87	99.95	99.98	99.99	99.99
27/3/37	248.47	8.749	69.13	72.45	75.32	77.89	80.17	82.2	84.07	85.84	87.63	89.56	91.57	93.64	95.68	97.4	98.59	99.3	99.67	99.84	99.92	99.95	99.96	99.96
27/3/56	248.66	8.7554	69.15	72.4	75.19	77.67	79.87	81.84	83.66	85.38	87.14	89.05	91.06	93.15	95.23	97.02	98.32	99.14	99.6	99.83	99.93	99.98	100	100.01
27/3/83	248.93	8.7644	66.59	70.11	73.18	75.94	78.39	80.57	82.57	84.44	86.33	88.36	90.49	92.7	94.9	96.8	98.18	99.05	99.54	99.79	99.9	99.95	99.97	99.98
27/3/104	249.14	8.7715	64.67	68.39	71.73	74.78	77.51	79.94	82.15	84.2	86.24	88.41	90.65	92.95	95.21	97.11	98.43	99.22	99.64	99.84	99.93	99.96	99.97	99.97
27/3/117	249.27	8.7758	64.21	68.16	71.65	74.77	77.5	79.89	82.04	84.02	86.01	88.17	90.43	92.78	95.1	97.06	98.42	99.23	99.66	99.86	99.95	99.98	99.99	99.99
27/3/142 avg	249.52	8.7842	64.38	68.14	71.49	74.52	77.23	79.64	81.84	83.91	85.99	88.23	90.56	92.95	95.3	97.24	98.56	99.32	99.71	99.88	99.95	99.98	99.98	99.98
27/4/7	249.67	8.7892	62.83	66.7	70.2	73.41	76.29	78.85	81.17	83.3	85.4	87.62	89.92	92.29	94.64	96.66	98.12	99.04	99.56	99.82	99.94	99.99	100.01	100.02
27/4/32	249.92	8.7976	59.46	63.87	67.91	71.61	74.87	77.7	80.21	82.47	84.69	87.07	89.54	92.1	94.64	96.79	98.28	99.17	99.64	99.86	99.96	99.99	100	100
27/4/52	250.12	8.8043	60.97	65.12	68.91	72.39	75.47	78.16	80.55	82.71	84.88	87.21	89.64	92.17	94.69	96.82	98.3	99.18	99.65	99.87	99.97	100	100.01	100.01
27/4/67	250.27	8.8093	64.44	68.26	71.66	74.73	77.43	79.81	81.96	83.95	85.96	88.13	90.41	92.77	95.11	97.08	98.44	99.25	99.67	99.87	99.96	99.99	100	100
27/4/86	250.46	8.8157	60.14	64.58	68.55	72.08	75.13	77.77	80.13	82.29	84.47	86.85	89.36	91.97	94.56	96.74	98.25	99.14	99.61	99.83	99.92	99.95	99.96	99.96
27/4/112	250.72	8.8244	63.31	67.25	70.6	73.51	76.03	78.27	80.38	82.45	84.71	87.28	89.99	92.8	95.52	97.65	98.94	99.58	99.85	99.95	99.98	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
27/4/132	250.92	8.8311	64.48	68.37	71.61	74.38	76.78	78.93	80.99	83.05	85.26	87.71	90.26	92.86	95.37	97.4	98.72	99.45	99.8	99.95	100.01	100.03	100.04	100.04
27/5/0	251.1	8.8371	65.18	69.27	72.59	75.35	77.67	79.71	81.64	83.58	85.67	88.02	90.49	93.02	95.48	97.47	98.77	99.48	99.82	99.96	100.02	100.04	100.05	100.05
27/5/23	251.33	8.8448	65.58	69.49	72.63	75.24	77.46	79.46	81.4	83.38	85.53	87.93	90.43	92.98	95.44	97.43	98.73	99.44	99.78	99.93	99.99	100.01	100.02	100.02
27/5/38	251.48	8.8499	65.85	69.71	72.83	75.44	77.65	79.61	81.49	83.4	85.48	87.83	90.31	92.86	95.35	97.37	98.69	99.42	99.77	99.92	99.98	100	100.01	100.01
27/5/57 avg	251.67	8.8562	63.94	68.16	71.62	74.53	76.99	79.15	81.18	83.18	85.32	87.73	90.25	92.85	95.37	97.4	98.72	99.43	99.78	99.92	99.98	100	100	100
27/5/83	251.93	8.8649	63.83	67.89	71.26	74.12	76.57	78.73	80.76	82.74	84.91	87.31	89.82	92.4	94.92	97.01	98.43	99.26	99.69	99.89	99.98	100.01	100.02	100.02
27/5/105	252.13	8.8716	64.77	68.88	72.26	75.09	77.48	79.58	81.55	83.5	85.59	87.93	90.39	92.92	95.38	97.38	98.69	99.42	99.77	99.92	99.98	100	100.01	100.01
27/5/118	252.28	8.8767	62.62	66.7	70.13	73.09	75.65	77.93	80.07	82.16	84.41	86.88	89.46	92.1	94.68	96.83	98.3	99.16	99.61	99.82	99.91	99.94	99.95	99.95
27/5/143	252.53	8.885	63.8	67.84	71.25	74.22	76.8	79.1	81.25	83.35	85.54	87.93	90.41	92.94	95.39	97.38	98.69	99.42	99.77	99.92	99.98	100	100.01	100.01
27/6/7	252.67	8.8897	64.91	68.91	72.26	75.12	77.56	79.7	81.67	83.56	85.55	87.76	90.11	92.55	94.97	97	98.4	99.23	99.66	99.86	99.95	99.98	99.99	99.99
27/6/32	252.92	8.8981	65.25	69.01	72.16	74.88	77.23	79.31	81.25	83.14	85.19	87.48	89.9	92.41	94.89	96.97	98.4	99.25	99.69	99.89	99.98	100.01	100.02	100.02
27/6/53	253.13	8.9051	66.26	69.98	73.06	75.7	77.97	79.98	81.88	83.77	85.79	88.06	90.46	92.94	95.37	97.36	98.67	99.4	99.75	99.9	99.96	99.98	99.99	99.99
27/6/73	253.33	8.9118	66.12	69.75	72.83	75.54	77.91	80.03	82.03	83.98	86.03	88.3	90.67	93.11	95.48	97.42	98.7	99.41	99.75	99.9	99.96	99.98	99.99	99.99
27/6/87	253.47	8.9165	66.51	70.35	73.55	76.29	78.63	80.69	82.61	84.48	86.45	88.64	90.94	93.31	95.63	97.52	98.75	99.43	99.76	99.9	99.96	99.98	99.99	99.99
27/6/107	253.67	8.9232	66.87	70.57	73.63	76.24	78.47	80.44	82.3	84.13	86.09	88.3	90.64	93.07	95.45	97.4	98.69	99.41	99.76	99.91	99.97	99.99	100	100
27/6/132 avg	253.92	8.9316	66.38	70.02	73.1	75.79	78.12	80.2	82.15	84.05	86.06	88.3	90.65	93.08	95.46	97.41	98.69	99.41	99.76	99.91	99.97	99.99	100	100
27/7/0	254.1	8.9376	69.71	73.28	76.23	78.74	80.86	82.7	84.39	86.01	87.72	89.64	91.69	93.83	95.94	97.68	98.83	99.47	99.78	99.91	99.96	99.98	99.99	99.99
27/7/17	254.27	8.9433	70.56	74.09	76.93	79.3	81.29	83.03	84.65	86.23	87.91	89.78	91.76	93.82	95.85	97.55	98.71	99.38	99.73	99.89	99.96	99.98	99.99	99.99
27CC/10	254.49	8.9533	70.05	73.57	76.46	78.91	80.98	82.78	84.44	86.04	87.74	89.65	91.69	93.82	95.93	97.67	98.83	99.48	99.8	99.94	100	100.02	100.03	100.03
28/1/4	254.74	8.9675	68.59	72.26	75.32	77.97	80.26	82.28	84.15	85.95	87.8	89.81	91.89	94.02	96.09	97.78	98.89	99.51	99.81	99.94	99.99	100.01	100.02	100.02
28/1/23	254.93	8.9783	72.51	75.91	78.6	80.81	82.66	84.27	85.78	87.27	88.86	90.64	92.52	94.47	96.38	97.94	98.97	99.54	99.82	99.94	99.98	100	100.01	100.01
28/1/42	255.12	8.9891	69.68	73.45	76.48	79.01	81.13	82.98	84.7	86.39	88.17	90.15	92.21	94.33	96.38	98.02	99.05	99.59	99.84	99.94	99.97	99.98	99.98	99.98
28/1/58	255.28	8.9982	69.81	73.53	76.52	79.02	81.13	82.97	84.68	86.35	88.1	90.03	92.05	94.13	96.16	97.82	98.91	99.52	99.82	99.95	100	100.02	100.03	100.03
28/1/83	255.53	9.0124	69.82	73.51	76.53	79.08	81.25	83.14	84.89	86.57	88.32	90.23	92.22	94.26	96.24	97.86	98.93	99.52	99.81	99.93	99.98	100	100.01	100.01
28/1/103	255.73	9.0237	69.27	72.97	76.02	78.61	80.81	82.73	84.5	86.2	87.97	89.92	91.96	94.06	96.11	97.79	98.9	99.52	99.82	99.95	100	100.02	100.03	100.03
28/1/121 avg	255.91	9.034	70.68	74.3	77.26	79.74	81.82	83.62	85.27	86.84	88.49	90.32	92.25	94.26	96.23	97.85	98.92	99.51	99.8	99.93	99.98	100	100	100
28/1/141	256.11	9.0453	69.52	73.25	76.34	78.96	81.17	83.08	84.83	86.49	88.21	90.11	92.1	94.15	96.16	97.81	98.89	99.49	99.78	99.9	99.95	99.97	99.98	99.98
28/2/7	256.27	9.0544	69.79	73.45	76.49	79.08	81.27	83.16	84.88	86.51	88.21	90.09	92.07	94.12	96.14	97.8	98.89	99.5	99.8	99.93	99.98	100	100.01	100.01
28/2/33	256.53	9.0692	71.1	74.69	77.64	80.13	82.23	84.05	85.71	87.28	88.91	90.7	92.58	94.52	96.41	97.96	98.98	99.54	99.81	99.93	99.97	99.99	100	100
28/2/54	256.74	9.0811	71.68	75.16	78.03	80.46	82.51	84.27	85.86	87.35	88.88	90.57	92.37	94.25	96.12	97.69	98.77	99.41	99.74	99.89	99.96	99.98	99.99	99.99
28/2/83	257.03	9.0976	71.47	74.86	77.68	80.1	82.15	83.93	85.54	87.04	88.59	90.31	92.14	94.07	95.99	97.61	98.73	99.39	99.73	99.89	99.96	99.98	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
28/2/98	257.18	9.1062	70.95	74.49	77.44	79.96	82.1	83.94	85.59	87.12	88.68	90.4	92.23	94.14	96.05	97.66	98.76	99.41	99.74	99.89	99.96	99.98	99.99	99.99
28/2/113	257.33	9.1147	71.72	75.17	78.02	80.44	82.47	84.22	85.8	87.29	88.84	90.58	92.43	94.37	96.29	97.88	98.93	99.51	99.79	99.91	99.96	99.98	99.99	99.99
28/2/133	257.53	9.1261	70.92	74.48	77.42	79.91	82	83.79	85.41	86.92	88.48	90.22	92.07	94.01	95.95	97.58	98.71	99.37	99.71	99.87	99.94	99.96	99.97	99.97
28/3/1	257.71	9.1363	70.65	74.28	77.27	79.77	81.86	83.64	85.24	86.73	88.28	90.02	91.89	93.86	95.84	97.52	98.68	99.37	99.73	99.9	99.97	100	100.01	100.01
28/3/25	257.95	9.1499	71.79	75.32	78.22	80.66	82.69	84.42	85.97	87.41	88.9	90.56	92.34	94.21	96.09	97.68	98.77	99.41	99.74	99.89	99.96	99.98	99.99	99.99
28/3/42	258.12	9.1596	72.5	75.94	78.77	81.16	83.17	84.89	86.43	87.86	89.33	90.95	92.67	94.47	96.26	97.77	98.81	99.42	99.74	99.89	99.95	99.97	99.98	99.98
28/3/55	258.25	9.167	72.57	76.05	78.95	81.42	83.5	85.28	86.87	88.32	89.78	91.37	93.04	94.77	96.49	97.93	98.92	99.5	99.8	99.94	100	100.02	100.03	100.03
28/3/84 avg	258.54	9.1835	70.7	74.32	77.39	80.02	82.25	84.16	85.85	87.4	88.98	90.7	92.52	94.42	96.31	97.87	98.91	99.49	99.78	99.91	99.96	99.98	99.99	99.99
28/3/118	258.88	9.2028	71.67	74.95	77.67	80	82	83.75	85.36	86.9	88.5	90.27	92.14	94.09	96.02	97.64	98.75	99.4	99.74	99.89	99.96	99.98	99.99	99.99
28/3/137	259.07	9.2136	71.42	74.75	77.52	79.89	81.93	83.72	85.37	86.96	88.61	90.44	92.36	94.35	96.3	97.89	98.94	99.52	99.8	99.92	99.97	99.99	100	100
28/4/6	259.26	9.2244	72.04	75.39	78.19	80.6	82.67	84.47	86.11	87.66	89.24	90.98	92.8	94.68	96.53	98.04	99.04	99.59	99.86	99.98	100.02	100.04	100.05	100.05
28/4/33	259.53	9.2397	71.02	74.39	77.23	79.69	81.81	83.67	85.36	86.95	88.58	90.36	92.22	94.15	96.06	97.66	98.76	99.4	99.73	99.88	99.95	99.97	99.98	99.98
28/4/47	259.67	9.2477	71.24	74.67	77.56	80.05	82.18	84.02	85.68	87.21	88.77	90.48	92.29	94.19	96.08	97.67	98.77	99.42	99.76	99.92	99.99	100.01	100.02	100.02
28/4/66	259.86	9.2585	69.59	73.19	76.25	78.91	81.19	83.17	84.96	86.62	88.3	90.12	92.03	94.01	95.97	97.61	98.73	99.39	99.73	99.89	99.96	99.98	99.99	99.99
28/4/93	260.13	9.2738	71.29	74.81	77.7	80.14	82.2	84	85.65	87.22	88.84	90.61	92.45	94.34	96.2	97.75	98.81	99.43	99.75	99.9	99.96	99.98	99.99	99.99
28/4/108	260.28	9.2824	70.54	74.07	76.99	79.48	81.6	83.45	85.15	86.78	88.47	90.34	92.29	94.3	96.27	97.88	98.94	99.53	99.81	99.93	99.98	100	100.01	100.01
28/4/134	260.54	9.2971	69.89	73.5	76.51	79.08	81.26	83.15	84.87	86.48	88.14	89.97	91.9	93.9	95.88	97.55	98.7	99.37	99.72	99.88	99.95	99.98	99.99	99.99
28/5/1	260.71	9.3068	74.02	77.36	80.08	82.35	84.23	85.82	87.26	88.61	90.02	91.61	93.3	95.07	96.81	98.22	99.13	99.61	99.83	99.92	99.95	99.96	99.96	99.96
28/5/16	260.86	9.3153	70.59	74.16	77.13	79.67	81.81	83.64	85.3	86.85	88.46	90.26	92.18	94.19	96.18	97.82	98.91	99.51	99.8	99.93	99.98	100	100.01	100.01
28/5/42	261.12	9.3301	70.48	74.05	77.06	79.65	81.84	83.71	85.39	86.95	88.55	90.33	92.23	94.22	96.19	97.82	98.9	99.5	99.79	99.91	99.96	99.98	99.99	99.99
28/5/61	261.31	9.3409	72.19	75.43	78.16	80.5	82.48	84.18	85.7	87.11	88.57	90.23	92.03	93.95	95.9	97.56	98.71	99.39	99.74	99.9	99.97	99.99	100	100
28/5/85	261.55	9.3546	69.66	73.16	76.15	78.75	80.98	82.91	84.65	86.28	87.96	89.84	91.84	93.94	96.03	97.75	98.88	99.5	99.8	99.93	99.98	100	100.01	100.01
28/5/102	261.72	9.3642	72.59	75.86	78.61	80.97	82.97	84.67	86.19	87.58	89.02	90.64	92.39	94.24	96.11	97.7	98.8	99.45	99.79	99.94	100.01	100.03	100.04	100.04
28/5/121	261.91	9.375	73.18	76.37	79.03	81.3	83.23	84.88	86.35	87.71	89.12	90.71	92.43	94.27	96.13	97.71	98.8	99.44	99.77	99.92	99.98	100	100.01	100.01
28/5/141	262.11	9.3864	72.28	75.51	78.2	80.5	82.45	84.12	85.63	87.03	88.49	90.15	91.96	93.9	95.86	97.53	98.69	99.38	99.74	99.91	99.98	100.01	100.02	100.02
28/6/8	262.28	9.396	72.14	75.63	78.5	80.91	82.91	84.59	86.09	87.46	88.89	90.51	92.27	94.15	96.05	97.66	98.77	99.42	99.76	99.91	99.98	100	100.01	100.01
28cc/8	262.45	9.4057	70.61	74.17	77.14	79.68	81.82	83.64	85.28	86.8	88.38	90.15	92.06	94.08	96.1	97.77	98.88	99.49	99.79	99.92	99.97	99.99	100	100
29/1/0	264.3	9.5109	69.4	72.99	76.05	78.73	81.04	83.03	84.83	86.5	88.2	90.07	92.04	94.1	96.14	97.82	98.93	99.54	99.83	99.95	100	100.02	100.03	100.03
29/1/34	264.64	9.5302	71.65	75.13	78.02	80.49	82.57	84.35	85.95	87.43	88.96	90.67	92.5	94.42	96.33	97.91	98.96	99.54	99.82	99.94	99.98	100	100.01	100.01
29/1/58	264.88	9.5438	72.02	75.42	78.17	80.47	82.37	83.98	85.44	86.82	88.3	90.02	91.91	93.94	95.99	97.7	98.83	99.46	99.76	99.89	99.94	99.96	99.97	99.97
29/1/80	265.1	9.5563	72.13	75.7	78.51	80.79	82.65	84.21	85.63	87	88.48	90.2	92.09	94.1	96.12	97.79	98.89	99.5	99.79	99.91	99.96	99.98	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
29/1/96 avg	265.26	9.5654	72.49	76.01	78.8	81.06	82.9	84.44	85.85	87.2	88.66	90.35	92.21	94.19	96.18	97.82	98.91	99.51	99.8	99.92	99.97	99.98	99.99	99.99
29/1/117	265.47	9.5774	72.58	76.12	78.94	81.25	83.14	84.74	86.19	87.56	89.01	90.64	92.4	94.26	96.12	97.69	98.77	99.4	99.73	99.88	99.94	99.96	99.97	99.97
29/1/142	265.72	9.5916	71.1	74.68	77.59	80.01	82.02	83.74	85.3	86.77	88.31	90.05	91.92	93.89	95.86	97.53	98.69	99.38	99.74	99.91	99.98	100.01	100.02	100.02
29/2/12	265.92	9.6029	71.16	74.79	77.72	80.16	82.19	83.92	85.5	87	88.58	90.36	92.26	94.25	96.22	97.84	98.92	99.52	99.81	99.93	99.98	100	100.01	100.01
29/2/32	266.12	9.6143	71.26	74.96	77.92	80.36	82.37	84.09	85.66	87.17	88.76	90.54	92.43	94.4	96.33	97.91	98.95	99.52	99.8	99.92	99.96	99.98	99.98	99.98
29/2/46	266.26	9.6223	69.22	72.99	76.1	78.74	80.96	82.86	84.59	86.22	87.91	89.8	91.8	93.89	95.96	97.67	98.8	99.43	99.74	99.87	99.92	99.94	99.95	99.95
29/2/64	266.44	9.6325	71.56	75.09	77.97	80.4	82.44	84.19	85.78	87.29	88.86	90.61	92.47	94.41	96.32	97.9	98.94	99.52	99.8	99.92	99.97	99.99	100	100
29/2/85	266.65	9.6444	71.69	75.21	78.11	80.57	82.64	84.41	86.01	87.5	89.04	90.75	92.57	94.47	96.36	97.92	98.96	99.54	99.82	99.94	99.99	100.01	100.02	100.02
29/2/107	266.87	9.6569	70.73	74.32	77.29	79.83	81.99	83.84	85.5	87.04	88.61	90.33	92.16	94.08	95.99	97.61	98.73	99.39	99.73	99.89	99.96	99.98	99.99	99.99
29/2/133	267.13	9.6717	71.89	75.23	78.01	80.4	82.44	84.19	85.78	87.27	88.81	90.53	92.37	94.31	96.25	97.86	98.93	99.53	99.82	99.95	100	100.02	100.03	100.03
29/3/1	267.31	9.682	70.29	73.75	76.68	79.25	81.48	83.44	85.23	86.91	88.61	90.46	92.38	94.37	96.32	97.92	98.97	99.55	99.83	99.95	99.99	100.01	100.02	100.02
29/3/23 avg	267.53	9.6945	71.79	75.34	78.23	80.65	82.67	84.4	85.96	87.42	88.95	90.65	92.48	94.4	96.31	97.89	98.93	99.52	99.8	99.93	99.98	100	100.01	100.01
29/3/42	267.72	9.7053	78.02	80.87	83.14	85.02	86.57	87.87	89.04	90.12	91.25	92.54	93.95	95.46	96.98	98.25	99.11	99.6	99.84	99.95	99.99	100	100	100
29/3/57	267.87	9.7138	70.6	74.25	77.25	79.8	81.94	83.77	85.42	86.97	88.57	90.35	92.24	94.22	96.19	97.82	98.9	99.5	99.79	99.92	99.97	99.99	100	100
29/3/84	268.14	9.7291	72.49	76.02	78.87	81.24	83.21	84.89	86.41	87.84	89.33	91	92.78	94.64	96.48	98	99	99.55	99.82	99.93	99.97	99.99	99.99	99.99
29/3/104	268.34	9.7405	71.95	75.6	78.52	80.94	82.94	84.65	86.21	87.7	89.26	91.01	92.86	94.78	96.66	98.17	99.12	99.62	99.84	99.93	99.96	99.97	99.97	99.97
29/3/117	268.47	9.7479	72.47	76.07	78.95	81.33	83.3	84.98	86.51	87.97	89.5	91.22	93.04	94.92	96.76	98.23	99.16	99.64	99.85	99.94	99.97	99.98	99.98	99.98
29/3/138	268.68	9.7598	69.6	73.42	76.54	79.18	81.39	83.28	85	86.64	88.35	90.25	92.25	94.33	96.36	97.99	99.03	99.58	99.83	99.93	99.96	99.97	99.97	99.97
29/4/6	268.86	9.7701	71.25	74.87	77.8	80.25	82.3	84.05	85.64	87.15	88.73	90.49	92.36	94.32	96.25	97.85	98.91	99.5	99.79	99.91	99.96	99.98	99.99	99.99
29/4/48	269.28	9.7885	71.31	74.96	77.88	80.31	82.34	84.08	85.67	87.19	88.78	90.55	92.42	94.36	96.28	97.86	98.91	99.5	99.79	99.91	99.96	99.98	99.99	99.99
29/4/72	269.52	9.7959	69.3	73.27	76.47	79.14	81.38	83.31	85.07	86.74	88.46	90.34	92.29	94.3	96.26	97.87	98.94	99.54	99.83	99.96	100.01	100.03	100.04	100.04
29/4/95	269.75	9.803	70.01	73.69	76.71	79.28	81.46	83.35	85.07	86.7	88.37	90.21	92.15	94.17	96.17	97.81	98.9	99.5	99.79	99.92	99.97	99.99	100	100
29/4/107	269.87	9.8067	69.42	73.26	76.42	79.12	81.41	83.38	85.16	86.83	88.53	90.38	92.31	94.3	96.26	97.87	98.94	99.53	99.82	99.94	99.99	100.01	100.02	100.02
29/4/135	270.15	9.8153	70.44	74.33	77.48	80.12	82.32	84.19	85.88	87.47	89.11	90.92	92.81	94.76	96.66	98.18	99.14	99.64	99.87	99.96	99.99	100	100	100
29/5/1	270.31	9.8203	70.16	74.04	77.14	79.72	81.88	83.73	85.42	87.02	88.68	90.5	92.41	94.38	96.31	97.89	98.94	99.52	99.8	99.92	99.97	99.99	100	100
29/5/15	270.45	9.8246	72.21	75.82	78.7	81.09	83.09	84.79	86.33	87.79	89.3	90.98	92.76	94.62	96.46	97.98	98.98	99.54	99.81	99.93	99.97	99.99	99.99	99.99
29/5/42 avg	270.72	9.8329	71.31	74.94	77.85	80.28	82.31	84.04	85.61	87.09	88.65	90.4	92.27	94.24	96.2	97.82	98.9	99.5	99.79	99.92	99.97	99.99	100	100
29/5/61	270.91	9.8384	75.06	78.16	80.6	82.6	84.24	85.63	86.9	88.12	89.43	90.94	92.61	94.4	96.21	97.75	98.82	99.45	99.77	99.92	99.98	100	100.01	100.01
29/5/85	271.15	9.8447	72.44	75.66	78.33	80.63	82.61	84.34	85.92	87.4	88.91	90.55	92.28	94.09	95.9	97.46	98.58	99.28	99.67	99.86	99.95	99.99	100.01	100.02
29/5/104	271.34	9.8498	73.77	76.95	79.59	81.85	83.79	85.47	86.98	88.37	89.77	91.28	92.87	94.53	96.19	97.62	98.66	99.31	99.68	99.87	99.96	100	100.02	100.03
29/5/118	271.48	9.8535	75.94	78.79	81.11	83.07	84.73	86.16	87.45	88.65	89.9	91.3	92.82	94.45	96.11	97.56	98.62	99.29	99.66	99.85	99.94	99.98	100	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
29/5/142	271.72	9.8598	65.94	70.05	73.62	76.78	79.48	81.77	83.77	85.56	87.34	89.28	91.35	93.53	95.71	97.53	98.74	99.42	99.75	99.89	99.95	99.97	99.98	99.98
29/6/14	271.94	9.8657	70.83	74.34	77.3	79.87	82.06	83.93	85.58	87.07	88.57	90.24	92.04	93.96	95.91	97.57	98.72	99.4	99.75	99.91	99.98	100	100.01	100.01
29cc/17	272.19	9.8723	68.99	72.74	75.97	78.83	81.3	83.41	85.27	86.95	88.61	90.4	92.28	94.25	96.21	97.83	98.91	99.51	99.8	99.93	99.98	100	100.01	100.01
30/1/1	273.91	9.9179	65.28	69.28	72.8	76.01	78.88	81.42	83.71	85.82	87.85	89.95	92.05	94.16	96.19	97.84	98.92	99.52	99.81	99.94	99.99	100.01	100.02	100.02
30/1/14	274.04	9.9213	69.15	72.95	76.12	78.86	81.19	83.19	84.98	86.63	88.3	90.13	92.06	94.08	96.09	97.76	98.86	99.47	99.77	99.9	99.95	99.97	99.98	99.98
30/1/42	274.32	9.9287	69.4	73.37	76.6	79.34	81.63	83.57	85.32	86.98	88.7	90.61	92.61	94.68	96.69	98.27	99.23	99.7	99.9	99.98	100	100.01	100.01	100.01
30/1/58	274.48	9.933	71.21	74.83	77.74	80.18	82.23	83.99	85.61	87.16	88.78	90.6	92.52	94.53	96.5	98.09	99.1	99.63	99.87	99.97	100	100.01	100.01	100.01
30/1/82	274.72	9.9393	68.79	72.73	75.93	78.64	80.93	82.9	84.7	86.42	88.2	90.15	92.19	94.29	96.33	97.97	99.02	99.58	99.84	99.95	99.99	100	100	100
30/1/103	274.93	9.9449	70.41	74.08	76.98	79.36	81.33	83.03	84.61	86.16	87.83	89.72	91.75	93.87	95.97	97.7	98.84	99.47	99.78	99.91	99.96	99.98	99.99	99.99
30/1/122 avg	275.12	9.9499	69.1	73.04	76.17	78.75	80.9	82.74	84.44	86.09	87.86	89.84	91.94	94.11	96.24	97.95	99.03	99.59	99.85	99.95	99.98	99.99	99.99	99.99
30/1/141	275.31	9.955	70.07	73.79	76.73	79.16	81.17	82.91	84.52	86.11	87.82	89.77	91.86	94.05	96.2	97.93	99.02	99.59	99.85	99.95	99.98	99.99	99.99	99.99
30/2/5	275.45	9.9587	69.46	73.21	76.25	78.81	80.96	82.8	84.47	86.05	87.71	89.59	91.62	93.76	95.9	97.67	98.84	99.49	99.8	99.93	99.98	100	100.01	100.01
30/2/32	275.72	9:9658	69.71	73.28	76.23	78.78	80.97	82.87	84.6	86.24	87.93	89.81	91.81	93.9	95.98	97.7	98.83	99.45	99.75	99.88	99.93	99.95	99.96	99.96
30/2/53	275.93	9.9714	71.81	75.27	78.12	80.55	82.6	84.33	85.87	87.29	88.76	90.42	92.23	94.17	96.14	97.79	98.89	99.51	99.81	99.94	99.99	100.01	100.02	100.02
30/2/92	276.32	9.9817	71.29	74.89	77.81	80.27	82.32	84.06	85.63	87.1	88.63	90.36	92.22	94.19	96.16	97.8	98.88	99.48	99.77	99.9	99.95	99.97	99.98	99.98
30/2/112	276.52	9.987	71.19	74.89	77.86	80.34	82.39	84.12	85.67	87.13	88.66	90.39	92.26	94.24	96.22	97.86	98.94	99.54	99.83	99.95	100	100.02	100.03	100.03
30/2/133	276.73	9.9926	70.31	74.11	77.21	79.83	82.02	83.87	85.53	87.08	88.68	90.48	92.4	94.42	96.42	98.04	99.07	99.61	99.85	99.95	99.98	99.99	99.99	99.99
30/3/1	276.91	9.9974	71.57	75.1	77.97	80.42	82.49	84.27	85.89	87.42	89	90.77	92.64	94.6	96.54	98.1	99.09	99.61	99.85	99.95	99.98	99.99	99.99	99.99
30/3/15	277.05	10.0011	70.61	74.07	76.94	79.43	81.56	83.39	85.06	86.65	88.32	90.21	92.24	94.37	96.47	98.14	99.16	99.67	99.89	99.97	100	100.01	100.01	100.01
30/3/43	277.33	10.0085	71.61	74.98	77.69	79.97	81.89	83.56	85.1	86.59	88.17	89.97	91.92	93.98	96.04	97.74	98.86	99.48	99.78	99.91	99.96	99.98	99.99	99.99
30/3/65	277.55	10.0143	71.89	75.51	78.48	81.01	83.12	84.89	86.46	87.9	89.38	91.04	92.83	94.72	96.61	98.14	99.11	99.62	99.85	99.94	99.97	99.98	99.98	99.98
30/3/84	277.74	10.0194	71.8	75.49	78.5	81.02	83.09	84.8	86.29	87.63	89.02	90.62	92.38	94.28	96.21	97.83	98.91	99.51	99.8	99.93	99.98	100	100.01	100.01
30/3/103	277.93	10.0244	70.78	74.34	77.24	79.7	81.76	83.51	85.1	86.6	88.19	90.01	91.98	94.08	96.17	97.88	98.98	99.56	99.83	99.94	99.98	99.99	99.99	99.99
30/3/117	278.07	10.0281	70.14	73.75	76.72	79.24	81.37	83.18	84.82	86.35	87.96	89.78	91.75	93.84	95.93	97.67	98.82	99.46	99.77	99.9	99.95	99.97	99.98	99.98
30/3/138 avg	278.28	10.0337	70.56	74.19	77.18	79.71	81.81	83.59	85.16	86.62	88.15	89.91	91.82	93.87	95.93	97.66	98.82	99.46	99.78	99.91	99.96	99.98	99.99	99.99
30/4/9	278.49	10.0392	73.19	76.48	79.12	81.33	83.16	84.72	86.15	87.52	88.99	90.7	92.56	94.54	96.51	98.11	99.12	99.64	99.87	99.96	99.99	100	100	100
30/4/32	278.72	10.0453	69.72	73.37	76.43	79.08	81.33	83.24	84.94	86.51	88.14	89.99	91.99	94.11	96.23	97.95	99.04	99.61	99.87	99.97	100	100.01	100.01	100.01
30/4/48	278.88	10.0496	69.54	73.27	76.34	78.95	81.14	83	84.66	86.2	87.81	89.63	91.61	93.71	95.82	97.59	98.77	99.44	99.77	99.91	99.97	99.99	100	100
30/4/73	279.13	10.0562	69.75	73.59	76.72	79.35	81.51	83.32	84.94	86.47	88.1	89.99	92.04	94.21	96.36	98.07	99.12	99.65	99.87	99.95	99.98	99.99	99.99	99.99
30/4/93	279.33	10.0615	69.22	73.09	76.21	78.81	80.94	82.73	84.34	85.87	87.52	89.43	91.52	93.74	95.96	97.77	98.93	99.55	99.83	99.95	99.99	100	100	100
30/4/113	279.53	10.0668	70.75	74.43	77.42	79.91	81.97	83.7	85.26	86.72	88.27	90.04	91.96	94	96.04	97.74	98.87	99.5	99.8	99.93	99.98	100	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
30/4/135	279.75	10.0726	68.44	72.58	75.92	78.68	80.93	82.8	84.47	86.04	87.71	89.62	91.69	93.88	96.05	97.82	98.95	99.55	99.82	99.93	99.97	99.98	99.98	99.98
30/5/6	279.96	10.0782	71.86	75.63	78.55	80.9	82.79	84.38	85.85	87.29	88.85	90.65	92.58	94.59	96.57	98.15	99.14	99.65	99.88	99.97	100	100.01	100.01	100.01
30/5/15	280.05	10.0806	69.15	73.18	76.39	79.02	81.15	82.93	84.54	86.08	87.73	89.64	91.71	93.89	96.05	97.81	98.93	99.53	99.8	99.91	99.95	99.96	99.96	99.96
30/5/35	280.25	10.0859	67.74	71.91	75.3	78.1	80.39	82.3	84.01	85.61	87.3	89.22	91.3	93.49	95.68	97.5	98.72	99.41	99.75	99.9	99.96	99.98	99.99	99.99
30/5/84	280.74	10.0989	68.91	72.79	75.9	78.46	80.55	82.31	83.93	85.5	87.22	89.21	91.37	93.65	95.91	97.74	98.91	99.53	99.81	99.92	99.96	99.97	99.97	99.97
30/5/102	280.92	10.1036	68.93	72.99	76.22	78.85	80.97	82.73	84.31	85.82	87.47	89.39	91.49	93.73	95.96	97.77	98.93	99.54	99.82	99.93	99.97	99.98	99.98	99.98
31/1/1	283.51	10.1723	64.62	68.81	72.4	75.56	78.3	80.69	82.85	84.86	86.87	89.02	91.24	93.51	95.73	97.55	98.75	99.42	99.75	99.89	99.95	99.97	99.98	99.98
31/1/17	283.67	10.1765	70.86	74.61	77.57	80	82	83.71	85.29	86.83	88.48	90.34	92.32	94.38	96.4	98.03	99.07	99.62	99.87	99.97	100	100.01	100.01	100.01
31/1/44 avg	283.94	10.1837	70.21	74.08	77.14	79.64	81.71	83.47	85.08	86.63	88.27	90.1	92.06	94.09	96.1	97.75	98.85	99.47	99.77	99.89	99.94	99.96	99.97	99.97
31/1/58	284.08	10.1874	71.14	74.93	77.9	80.33	82.34	84.07	85.68	87.27	88.94	90.8	92.73	94.71	96.62	98.14	99.1	99.61	99.84	99.93	99.96	99.97	99.97	99.97
31/1/83	284.33	10.194	72.24	75.88	78.7	80.97	82.82	84.4	85.86	87.29	88.83	90.57	92.43	94.37	96.28	97.85	98.9	99.49	99.78	99.9	99.95	99.97	99.98	99.98
31/1/105	284.55	10.1998	70.32	74.26	77.38	79.92	82	83.76	85.36	86.89	88.5	90.3	92.22	94.22	96.19	97.82	98.91	99.52	99.82	99.95	100	100.02	100.03	100.03
31/1/118	284.68	10.2033	69.7	73.69	76.86	79.45	81.57	83.36	84.99	86.55	88.2	90.05	92.02	94.07	96.1	97.77	98.88	99.5	99.8	99.93	99.98	100	100.01	100.01
31/1/138	284.88	10.2086	70.03	73.96	77.06	79.59	81.65	83.4	85.01	86.58	88.26	90.16	92.18	94.28	96.33	97.98	99.03	99.59	99.84	99.94	99.97	99.98	99.98	99.98
31/2/9	285.09	10.2141	71.54	75.25	78.14	80.48	82.39	84.02	85.54	87.03	88.64	90.47	92.43	94.47	96.46	98.06	99.08	99.61	99.85	99.95	99.98	99.99	99.99	99.99
31/2/29	285.29	10.2194	70.6	74.5	77.57	80.07	82.11	83.84	85.42	86.93	88.53	90.33	92.25	94.25	96.22	97.84	98.91	99.51	99.8	99.93	99.98	100	100.01	100.01
31/2/48	285.48	10.2245	70.9	74.63	77.56	79.95	81.91	83.58	85.12	86.61	88.22	90.05	92.01	94.07	96.1	97.78	98.89	99.51	99.81	99.94	99.99	100.01	100.02	100.02
31/2/73	285.73	10.2311	72.41	75.82	78.52	80.75	82.6	84.19	85.66	87.09	88.62	90.37	92.25	94.23	96.2	97.82	98.9	99.5	99.79	99.92	99.97	99.99	100	100
31/2/88 avg	285.88	10.2351	72.39	75.67	78.28	80.47	82.31	83.91	85.4	86.86	88.44	90.25	92.2	94.25	96.28	97.93	98.99	99.57	99.84	99.95	99.99	100	100.01	100.01
31/2/110	286.1	10.2409	71.27	74.86	77.74	80.13	82.11	83.79	85.33	86.8	88.36	90.14	92.06	94.09	96.11	97.78	98.89	99.51	99.81	99.94	99.99	100.01	100.02	100.02
31/2/134	286.34	10.2473	70.2	74.1	77.21	79.76	81.84	83.59	85.17	86.67	88.25	90.05	91.98	94.02	96.05	97.73	98.85	99.48	99.79	99.92	99.97	99.99	100	100
31/3/1	286.51	10.2518	72.05	75.77	78.66	80.99	82.88	84.47	85.93	87.34	88.86	90.59	92.45	94.4	96.32	97.9	98.95	99.53	99.81	99.93	99.97	99.99	99.99	99.99
31/3/23	286.73	10.2576	70.39	74.22	77.22	79.64	81.6	83.26	84.78	86.25	87.84	89.68	91.68	93.79	95.89	97.63	98.8	99.46	99.78	99.92	99.97	99.99	100	100
31/3/38	286.88	10.2616	70.82	74.54	77.47	79.85	81.79	83.43	84.93	86.38	87.95	89.76	91.73	93.82	95.9	97.63	98.8	99.46	99.78	99.92	99.98	100	100.01	100.01
31/3/57	287.04	10.2658	70.73	74.42	77.29	79.61	81.5	83.11	84.6	86.06	87.66	89.52	91.54	93.69	95.83	97.61	98.8	99.47	99.8	99.94	100	100.02	100.03	100.03
31/3/82	287.32	10.2732	70.19	74.01	77.04	79.52	81.54	83.24	84.79	86.27	87.87	89.71	91.7	93.8	95.89	97.63	98.79	99.44	99.76	99.9	99.96	99.98	99.99	99.99
31/3/102	287.52	10.2785	69.55	73.5	76.63	79.2	81.3	83.07	84.68	86.21	87.84	89.69	91.68	93.78	95.87	97.6	98.76	99.42	99.75	99.89	99.95	99.97	99.98	99.98
31/3/117	287.67	10.2825	71.39	75.14	78.05	80.4	82.3	83.91	85.39	86.84	88.42	90.24	92.2	94.26	96.29	97.94	99	99.57	99.83	99.94	99.98	99.99	99.99	99.99
31/3/141	287.91	10.2889	72.52	75.98	78.73	81	82.88	84.48	85.95	87.37	88.89	90.63	92.51	94.49	96.45	98.04	99.06	99.61	99.86	99.96	99.99	100	100	100
31/4/8	288.08	10.2934	72.42	75.93	78.72	81.03	82.93	84.55	86.03	87.46	88.99	90.74	92.62	94.59	96.53	98.1	99.1	99.62	99.86	99.96	99.99	100	100	100
31/4/30	288.3	10.2992	72.49	75.97	78.72	80.97	82.81	84.37	85.8	87.19	88.7	90.45	92.35	94.36	96.35	97.97	99.02	99.58	99.84	99.95	99.99	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
31/4/55 avg	288.55	10.3058	70.85	74.46	77.41	79.9	81.96	83.71	85.29	86.76	88.31	90.08	91.99	94.02	96.04	97.73	98.86	99.49	99.81	99.94	100	100.02	100.03	100.03
31/4/70	288.7	10.3098	74.19	77.36	79.9	82.01	83.77	85.27	86.65	87.99	89.43	91.08	92.87	94.76	96.64	98.16	99.13	99.64	99.87	99.96	99.99	100	100	100
31/4/89	288.89	10.3148	73.44	76.65	79.25	81.44	83.28	84.86	86.31	87.72	89.23	90.98	92.86	94.84	96.79	98.33	99.27	99.73	99.92	99.99	100.01	100.02	100.02	100.02
31/4/110	289.1	10.3204	73.55	76.78	79.39	81.58	83.4	84.95	86.35	87.67	89.08	90.7	92.47	94.36	96.26	97.85	98.91	99.5	99.79	99.92	99.97	99.99	100	100
31/4/134	289.34	10.3267	72.7	76.03	78.78	81.12	83.07	84.72	86.21	87.62	89.12	90.86	92.74	94.73	96.69	98.25	99.21	99.69	99.9	99.98	100	100.01	100.01	100.01
31/5/0	289.5	10.331	71.23	74.71	77.62	80.13	82.24	84.02	85.61	87.09	88.63	90.38	92.28	94.3	96.32	97.97	99.03	99.59	99.85	99.95	99.98	99.99	99.99	99.99
31/5/23	289.73	10.3371	70.9	74.46	77.33	79.72	81.7	83.38	84.92	86.4	88	89.86	91.88	94.02	96.15	97.88	98.99	99.57	99.84	99.95	99.99	100	100	100
31/5/43	289.93	10.3424	69.49	73.28	76.41	79.06	81.25	83.09	84.72	86.24	87.85	89.71	91.74	93.91	96.08	97.85	98.98	99.57	99.84	99.95	99.99	100	100	100
31/5/62	290.12	10.3474	70.11	73.81	76.87	79.45	81.59	83.38	84.96	86.41	87.94	89.7	91.64	93.73	95.84	97.61	98.8	99.47	99.8	99.94	100	100.02	100.03	100.03
31/5/83	290.33	10.353	69.06	72.78	75.91	78.6	80.88	82.83	84.58	86.2	87.87	89.74	91.75	93.86	95.96	97.7	98.85	99.48	99.78	99.91	99.96	99.98	99.99	99.99
31/5/101	290.51	10.3577	70.7	74.3	77.18	79.56	81.53	83.2	84.72	86.17	87.74	89.56	91.55	93.68	95.82	97.6	98.79	99.46	99.78	99.92	99.98	100	100.01	100.01
31/5/120	290.7	10.3628	69.54	73.31	76.32	78.83	80.93	82.73	84.39	86	87.72	89.68	91.78	93.98	96.15	97.9	99	99.58	99.84	99.94	99.97	99.98	99.98	99.98
31cc/0	290.74	10.3638	72.29	76.04	78.98	81.35	83.25	84.82	86.23	87.56	88.99	90.65	92.46	94.38	96.3	97.89	98.94	99.52	99.8	99.92	99.96	99.98	99.98	99.98
32/1/1	293.11	10.4266	64.98	69.07	72.57	75.66	78.34	80.66	82.76	84.71	86.68	88.82	91.05	93.36	95.64	97.52	98.76	99.45	99.78	99.92	99.98	100	100.01	100.01
32/1/23	293.33	10.4325	72.24	75.72	78.44	80.66	82.47	84.01	85.44	86.86	88.42	90.23	92.2	94.28	96.33	97.99	99.04	99.59	99.84	99.94	99.97	99.98	99.98	99.98
32/1/41	293.51	10.4372	70.98	74.69	77.64	80.06	82.03	83.69	85.21	86.68	88.27	90.12	92.12	94.23	96.32	98	99.06	99.61	99.86	99.96	99.99	100	100	100
32/1/61	293.71	10.4425	70.72	74.34	77.28	79.72	81.72	83.4	84.91	86.33	87.86	89.64	91.6	93.7	95.82	97.59	98.78	99.45	99.78	99.92	99.98	100	100.01	100.01
32/1/83	293.93	10.4484	71.5	75.27	78.32	80.83	82.86	84.53	85.99	87.33	88.75	90.4	92.22	94.18	96.16	97.81	98.91	99.53	99.83	99.96	100.01	100.03	100.04	100.04
32/1/102 avg	294.12	10.4534	71.51	75.23	78.15	80.51	82.4	83.97	85.39	86.75	88.23	89.98	91.91	93.98	96.05	97.77	98.9	99.52	99.82	99.94	99.99	100	100.01	100.01
32/1/121	294.31	10.4584	70	73.77	76.77	79.24	81.26	82.98	84.56	86.1	87.77	89.7	91.78	93.97	96.13	97.88	99	99.59	99.86	99.97	100.01	100.02	100.02	100.02
32/1/141	294.51	10.4637	68.87	72.97	76.24	78.92	81.08	82.88	84.49	86.02	87.67	89.59	91.68	93.89	96.08	97.86	98.99	99.59	99.86	99.97	100.01	100.02	100.02	100.02
32/2/11	294.71	10.469	71.61	75.52	78.55	80.95	82.84	84.4	85.81	87.17	88.66	90.42	92.34	94.38	96.4	98.03	99.07	99.61	99.85	99.95	99.98	99.99	99.99	99.99
32/2/30	294.9	10.4741	71.03	74.87	77.85	80.24	82.16	83.77	85.26	86.74	88.39	90.33	92.42	94.6	96.71	98.34	99.29	99.74	99.92	99.98	100	100	100	100
32/2/52	295.12	10.4799	68.68	72.78	76.06	78.76	80.96	82.81	84.48	86.08	87.79	89.74	91.83	94.02	96.17	97.91	99.02	99.6	99.87	99.98	100.02	100.03	100.03	100.03
32/2/73	295.33	10.4855	69.1	73.13	76.38	79.07	81.27	83.12	84.79	86.36	88.01	89.86	91.84	93.92	95.98	97.69	98.83	99.47	99.78	99.91	99.96	99.98	99.99	99.99
32/2/93	295.53	10.4908	69.47	73.32	76.44	79.05	81.2	83.03	84.7	86.29	87.98	89.9	91.95	94.09	96.2	97.91	99	99.58	99.85	99.96	100	100.01	100.01	100.01
32/2/113	295.73	10.4961	69.24	73.07	76.25	78.94	81.16	83.02	84.66	86.17	87.76	89.57	91.55	93.66	95.78	97.55	98.74	99.41	99.74	99.88	99.94	99.96	99.97	99.97
32/2/133	295.93	10.5014	70.94	74.74	77.76	80.22	82.2	83.86	85.36	86.78	88.3	90.05	91.96	93.99	96.02	97.71	98.84	99.47	99.78	99.91	99.96	99.98	99.99	99.99
32/3/1	296.11	10.5061	72.53	76	78.7	80.9	82.71	84.28	85.77	87.28	88.92	90.79	92.77	94.81	96.77	98.3	99.23	99.69	99.88	99.95	99.97	99.98	99.98	99.98
32/3/40	296.5	10.5165	70.83	74.62	77.65	80.12	82.12	83.79	85.29	86.71	88.24	90	91.92	93.96	96	97.7	98.84	99.48	99.8	99.94	99.99	100.01	100.02	100.02
32/3/62	296.72	10.5223	68.45	72.65	76.01	78.72	80.89	82.68	84.28	85.79	87.42	89.3	91.35	93.53	95.71	97.52	98.73	99.42	99.76	99.9	99.96	99.98	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
32/3/83	296.93	10.5279	68.57	72.71	76.07	78.85	81.12	83.02	84.72	86.31	87.97	89.83	91.82	93.9	95.96	97.66	98.8	99.44	99.76	99.9	99.95	99.97	99.98	99.98
32/3/102 avg	297.12	10.5329	72.18	75.57	78.28	80.53	82.4	84.01	85.49	86.93	88.47	90.23	92.14	94.15	96.16	97.81	98.91	99.52	99.81	99.94	99.99	100	100.01	100.01
32/3/123	297.33	10.5385	72.66	75.92	78.54	80.73	82.56	84.15	85.63	87.06	88.59	90.34	92.23	94.22	96.19	97.82	98.9	99.51	99.8	99.92	99.97	99.99	100	100
32/3/140	297.5	10.543	70.92	74.39	77.2	79.55	81.51	83.19	84.73	86.21	87.8	89.62	91.61	93.72	95.83	97.59	98.77	99.44	99.77	99.91	99.97	99.99	100	100
32/4/10	297.7	10.5483	73.39	76.69	79.26	81.38	83.15	84.69	86.13	87.56	89.1	90.86	92.73	94.69	96.61	98.15	99.12	99.63	99.86	99.95	99.98	99.99	99.99	99.99
32/4/30	297.9	10.5536	72.82	76.26	78.96	81.17	83	84.57	86.02	87.43	88.94	90.65	92.49	94.42	96.34	97.92	98.96	99.54	99.82	99.94	99.98	100	100	100
32/4/48	298.08	10.5583	70.33	73.93	76.86	79.34	81.44	83.25	84.92	86.53	88.22	90.12	92.14	94.24	96.29	97.95	99.01	99.58	99.84	99.95	99.99	100	100	100
32/4/68	298.28	10.5636	72	75.31	77.95	80.15	81.99	83.59	85.08	86.54	88.11	89.92	91.88	93.95	96.01	97.72	98.86	99.5	99.81	99.94	99.99	100.01	100.02	100.02
32/4/92	298.52	10.57	72.03	75.37	78.09	80.38	82.3	83.95	85.46	86.9	88.43	90.17	92.06	94.06	96.05	97.71	98.82	99.45	99.76	99.89	99.94	99.96	99.97	99.97
32/4/110	298.7	10.5748	71.38	74.93	77.86	80.33	82.39	84.13	85.68	87.11	88.6	90.29	92.13	94.09	96.06	97.71	98.82	99.45	99.76	99.9	99.96	99.98	99.99	99.99
32/4/133	298.93	10.5809	70.33	74	77.01	79.52	81.6	83.35	84.92	86.38	87.93	89.72	91.67	93.75	95.84	97.59	98.77	99.44	99.77	99.91	99.97	99.99	100	100
32/5/1	299.11	10.5856	70.99	74.57	77.47	79.88	81.87	83.55	85.08	86.53	88.08	89.86	91.8	93.87	95.94	97.66	98.82	99.47	99.79	99.93	99.98	100	100.01	100.01
32/5/28	299.38	10.5928	72.55	75.99	78.69	80.87	82.64	84.13	85.51	86.87	88.38	90.16	92.12	94.21	96.28	97.96	99.03	99.59	99.84	99.94	99.97	99.98	99.98	99.98
32/5/40 avg	299.5	10.596	68.82	72.68	75.78	78.34	80.42	82.19	83.8	85.34	87.02	88.97	91.1	93.35	95.61	97.48	98.73	99.43	99.77	99.91	99.97	99.99	100	100
32cc/2	299.67	10.6005	67.26	71.21	74.47	77.24	79.57	81.58	83.42	85.19	87.05	89.14	91.36	93.66	95.91	97.73	98.9	99.52	99.81	99.93	99.97	99.98	99.98	99.98
33/1/1	302.71	10.681	66.1	70.25	73.72	76.68	79.18	81.33	83.27	85.09	86.97	89.04	91.22	93.48	95.7	97.53	98.75	99.44	99.78	99.92	99.98	100	100.01	100.01
33/1/27	302.97	10.6879	71.58	75.2	78.09	80.46	82.4	84.02	85.48	86.86	88.34	90.06	91.95	93.97	96	97.7	98.84	99.49	99.81	99.95	100	100.02	100.03	100.03
33/1/40	303.1	10.6914	70.61	74.27	77.24	79.72	81.78	83.52	85.09	86.56	88.11	89.88	91.81	93.86	95.91	97.62	98.78	99.44	99.77	99.91	99.97	99.99	100	100
33/1/59	303.29	10.6964	71.25	74.83	77.7	80.08	82.04	83.7	85.21	86.66	88.22	90.03	92	94.09	96.17	97.87	98.97	99.56	99.83	99.94	99.98	99.99	99.99	99.99
33/1/83	303.53	10.7028	70.87	74.53	77.46	79.88	81.86	83.53	85.05	86.51	88.09	89.92	91.91	94.03	96.13	97.85	98.96	99.55	99.82	99.93	99.97	99.98	99.98	99.98
33/1/107	303.77	10.7091	70.17	73.94	76.98	79.5	81.57	83.32	84.91	86.44	88.09	90	92.06	94.23	96.36	98.05	99.1	99.63	99.86	99.95	99.98	99.99	99.99	99.99
33/1/121	303.91	10.7128	69.72	73.52	76.63	79.23	81.38	83.21	84.87	86.44	88.1	89.98	92	94.12	96.2	97.89	98.98	99.56	99.83	99.94	99.98	99.99	99.99	99.99
33/1/143	304.13	10.7187	71.93	75.38	78.11	80.35	82.2	83.79	85.27	86.71	88.27	90.06	91.99	94.03	96.05	97.72	98.84	99.47	99.78	99.91	99.96	99.98	99.99	99.99
33/2/9	304.29	10.7229	70.28	74.16	77.28	79.86	81.97	83.75	85.36	86.9	88.52	90.36	92.32	94.37	96.38	98.01	99.05	99.6	99.85	99.95	99.98	99.99	99.99	99.99
33/2/27	304.47	10.7277	71.47	75.07	77.89	80.18	82.05	83.65	85.14	86.61	88.22	90.07	92.07	94.17	96.23	97.9	98.98	99.56	99.83	99.94	99.98	99.99	99.99	99.99
33/2/46	304.66	10.7327	71.25	74.99	77.95	80.36	82.31	83.95	85.43	86.84	88.36	90.11	92.02	94.04	96.05	97.72	98.84	99.47	99.77	99.9	99.95	99.97	99.98	99.98
33/2/82	305.02	10.7422	69.27	73.17	76.34	78.98	81.15	82.98	84.63	86.19	87.85	89.75	91.8	93.96	96.1	97.84	98.96	99.56	99.84	99.95	99.99	100	100	100
33/2/95	305.15	10.7457	68.63	72.66	75.93	78.62	80.81	82.64	84.28	85.83	87.48	89.37	91.42	93.59	95.75	97.55	98.76	99.44	99.78	99.92	99.98	100	100.01	100.01
33/2/114	305.34	10.7507	70.06	73.94	77.03	79.53	81.54	83.21	84.73	86.18	87.76	89.6	91.61	93.75	95.88	97.65	98.84	99.51	99.84	99.98	100.04	100.06	100.07	100.07
33/2/135	305.55	10.7563	69.19	73.18	76.4	79.06	81.24	83.07	84.71	86.26	87.89	89.74	91.74	93.85	95.94	97.67	98.82	99.46	99.77	99.9	99.95	99.97	99.98	99.98
33/3/1 avg	305.71	10.7605	71.53	75.14	78.05	80.47	82.44	84.09	85.58	87	88.54	90.35	92.32	94.41	96.48	98.13	99.15	99.67	99.89	99.97	99.99	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
33/3/23	305.93	10.7664	69.24	73.09	76.22	78.84	81.01	82.84	84.49	86.04	87.68	89.54	91.56	93.69	95.82	97.59	98.78	99.45	99.78	99.92	99.98	100	100.01	100.01
33/3/41	306.11	10.7711	70.27	74.16	77.26	79.78	81.82	83.52	85.05	86.51	88.07	89.86	91.81	93.88	95.95	97.67	98.82	99.47	99.79	99.93	99.98	100	100.01	100.01
33/3/57	306.27	10.7754	70.53	74.36	77.39	79.87	81.89	83.59	85.14	86.63	88.23	90.07	92.06	94.16	96.23	97.91	98.99	99.56	99.82	99.93	99.97	99.98	99.98	99.98
33/3/84	306.54	10.7825	69.96	73.83	76.96	79.56	81.68	83.46	85.06	86.58	88.19	90.03	92.02	94.12	96.2	97.89	98.98	99.56	99.83	99.94	99.98	99.99	99.99	99.99
33/3/105	306.75	10.7881	69.31	73.23	76.45	79.16	81.38	83.23	84.89	86.45	88.1	90	92.06	94.23	96.37	98.08	99.13	99.66	99.89	99.97	100	100.01	100.01	100.01
33/3/116	306.86	10.791	71.67	75.38	78.36	80.81	82.8	84.45	85.93	87.32	88.81	90.53	92.41	94.41	96.41	98.04	99.09	99.64	99.89	99.99	100.02	100.03	100.03	100.03
33/3/138	307.08	10.7968	70.61	74.44	77.48	79.95	81.95	83.63	85.15	86.59	88.14	89.93	91.88	93.94	96	97.71	98.85	99.48	99.79	99.92	99.97	99.99	100	100
33/4/10	307.3	10.8027	69.82	73.56	76.63	79.22	81.37	83.18	84.81	86.35	87.98	89.85	91.87	94.01	96.13	97.86	98.97	99.56	99.83	99.94	99.98	99.99	99.99	99.99
33/4/29	307.49	10.8077	71.29	74.96	77.93	80.39	82.4	84.08	85.59	87	88.5	90.22	92.1	94.1	96.11	97.78	98.89	99.51	99.81	99.94	99.99	100.01	100.02	100.02
33/4/50	307.7	10.8133	71.58	75.26	78.21	80.64	82.63	84.3	85.8	87.21	88.71	90.42	92.28	94.25	96.22	97.85	98.93	99.53	99.82	99.95	100	100.02	100.03	100.03
33/4/73	307.93	10.8193	71.08	74.88	77.96	80.51	82.59	84.32	85.86	87.3	88.82	90.56	92.45	94.45	96.43	98.04	99.06	99.6	99.84	99.94	99.97	99.98	99.98	99.98
33/4/94	308.14	10.8249	70.91	74.69	77.71	80.2	82.24	83.95	85.5	86.98	88.56	90.37	92.32	94.37	96.39	98.02	99.05	99.59	99.83	99.93	99.96	99.97	99.97	99.97
33/4/110	308.3	10.8292	72.08	75.87	78.81	81.17	83.07	84.66	86.11	87.52	89.04	90.78	92.65	94.61	96.54	98.09	99.08	99.6	99.83	99.92	99.95	99.96	99.96	99.96
33/4/133	308.53	10.8352	69.78	73.7	76.89	79.56	81.76	83.61	85.27	86.83	88.46	90.3	92.26	94.31	96.33	97.97	99.02	99.58	99.83	99.93	99.96	99.97	99.97	99.97
33/5/1	308.71	10.84	69.92	73.72	76.89	79.58	81.83	83.73	85.41	86.96	88.55	90.32	92.21	94.2	96.18	97.82	98.91	99.52	99.82	99.95	100	100.02	100.03	100.03
33/5/29	308.99	10.8474	71.28	74.88	77.83	80.31	82.38	84.14	85.72	87.2	88.74	90.47	92.33	94.29	96.24	97.86	98.94	99.54	99.83	99.95	100	100.02	100.03	100.03
33/5/41	309.11	10.8516	69.63	73.51	76.7	79.38	81.6	83.46	85.12	86.66	88.27	90.1	92.07	94.15	96.21	97.89	98.97	99.55	99.82	99.93	99.97	99.98	99.98	99.98
33/5/58	309.28	10.8543	69.21	73.1	76.34	79.1	81.39	83.31	85.01	86.57	88.19	90.03	92.01	94.11	96.2	97.9	98.99	99.57	99.84	99.95	99.99	100	100	100
33/5/84 avg	309.54	10.8583	68.51	72.47	75.76	78.57	80.91	82.88	84.64	86.26	87.95	89.84	91.87	94	96.11	97.84	98.95	99.55	99.82	99.94	99.98	99.99	99.99	99.99
33/5/104	309.74	10.8615	71.85	75.53	78.52	81.02	83.09	84.84	86.4	87.84	89.33	90.99	92.76	94.62	96.47	98	99.01	99.57	99.84	99.95	99.99	100	100	100
34/1/1	312.31	10.9018	68.13	72.12	75.5	78.43	80.9	82.99	84.85	86.56	88.29	90.19	92.19	94.28	96.33	97.99	99.04	99.59	99.84	99.94	99.97	99.98	99.98	99.98
34/1/24	312.54	10.9054	73.24	76.67	79.43	81.71	83.57	85.12	86.51	87.83	89.24	90.89	92.69	94.61	96.53	98.09	99.08	99.6	99.83	99.92	99.95	99.96	99.96	99.96
34/1/37	312.67	10.9075	73.69	77.11	79.85	82.12	83.97	85.51	86.89	88.19	89.57	91.17	92.92	94.79	96.65	98.16	99.12	99.63	99.86	99.95	99.98	99.99	99.99	99.99
34/1/57	312.87	10.9106	73.29	76.74	79.57	81.96	83.94	85.59	87.06	88.42	89.85	91.48	93.24	95.1	96.93	98.39	99.28	99.72	99.9	99.97	99.99	100	100	100
34/1/77	313.07	10.9138	73.3	76.8	79.68	82.09	84.07	85.71	87.15	88.46	89.82	91.38	93.08	94.9	96.72	98.2	99.15	99.65	99.88	99.97	100	100.01	100.01	100.01
34/1/101	313.31	10.9175	72.39	75.83	78.72	81.2	83.26	84.99	86.51	87.9	89.34	90.98	92.76	94.66	96.55	98.1	99.09	99.61	99.85	99.95	99.98	99.99	99.99	99.99
34/1/123	313.53	10.921	75.01	78.12	80.72	82.96	84.84	86.42	87.81	89.06	90.34	91.78	93.35	95.02	96.7	98.11	99.05	99.57	99.82	99.93	99.97	99.98	99.98	99.98
34/1/141 avg	313.71	10.9238	72.12	75.6	78.55	81.1	83.24	85.05	86.64	88.09	89.56	91.21	92.96	94.81	96.65	98.15	99.11	99.62	99.85	99.95	99.98	99.99	99.99	99.99
34/2/10	313.9	10.9268	71.84	75.43	78.44	81.02	83.18	84.99	86.59	88.05	89.54	91.2	92.97	94.83	96.67	98.16	99.11	99.61	99.84	99.93	99.96	99.97	99.97	99.97
34/2/29	314.09	10.9298	72.06	75.64	78.62	81.15	83.26	85.03	86.59	88.01	89.46	91.07	92.8	94.63	96.45	97.96	98.97	99.53	99.8	99.92	99.96	99.98	99.98	99.98
34/2/49	314.29	10.9329	72.76	76.29	79.16	81.55	83.51	85.16	86.63	88	89.43	91.04	92.78	94.61	96.43	97.94	98.95	99.52	99.8	99.92	99.96	99.98	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
34/2/65	314.45	10.9354	71.73	75.25	78.22	80.78	82.93	84.73	86.31	87.73	89.18	90.81	92.57	94.44	96.32	97.89	98.94	99.53	99.82	99.94	99.99	100.01	100.02	100.02
34/2/89	314.69	10.9392	72.21	75.71	78.62	81.12	83.22	84.98	86.54	87.97	89.44	91.09	92.86	94.74	96.61	98.13	99.1	99.61	99.84	99.93	99.96	99.97	99.97	99.97
34/2/110	314.9	10.9425	72.82	76.26	79.12	81.56	83.6	85.32	86.84	88.24	89.67	91.28	93.01	94.84	96.66	98.15	99.1	99.6	99.83	99.92	99.95	99.96	99.96	99.96
34/2/133	315.13	10.9461	70.37	74.01	77.06	79.7	81.93	83.82	85.5	87.05	88.64	90.42	92.33	94.34	96.34	97.97	99.02	99.58	99.84	99.94	99.98	99.99	99.99	99.99
34/3/0	315.3	10.9496	70.71	74.35	77.38	79.98	82.15	83.99	85.63	87.15	88.72	90.49	92.39	94.4	96.39	98.01	99.05	99.6	99.85	99.95	99.98	99.99	99.99	99.99
34/3/22	315.52	10.9569	71.31	75.01	78.04	80.58	82.69	84.47	86.06	87.54	89.06	90.75	92.56	94.46	96.34	97.9	98.94	99.52	99.8	99.92	99.96	99.98	99.99	99.99
34/3/41	315.71	10.9631	70.65	74.27	77.27	79.85	82.03	83.9	85.59	87.18	88.81	90.62	92.53	94.52	96.47	98.05	99.06	99.6	99.85	99.95	99.98	99.99	99.99	99.99
34/3/76	316.06	10.9746	72.81	76.29	79.09	81.43	83.37	85.02	86.5	87.89	89.34	90.97	92.72	94.57	96.42	97.95	98.97	99.54	99.82	99.94	99.98	100	100.01	100.01
34/3/97	316.27	10.9815	70.72	74.37	77.4	80.01	82.22	84.11	85.81	87.41	89.04	90.83	92.71	94.67	96.59	98.13	99.11	99.62	99.85	99.94	99.97	99.98	99.98	99.98
34/3/118 avg	316.48	10.9884	69.9	73.66	76.82	79.58	81.92	83.92	85.71	87.37	89.05	90.89	92.82	94.81	96.75	98.28	99.23	99.7	99.9	99.98	100	100.01	100.01	100.01
34/3/137	316.67	10.9947	68.72	72.58	75.86	78.75	81.23	83.36	85.27	87.05	88.83	90.76	92.75	94.78	96.75	98.29	99.23	99.69	99.89	99.96	99.98	99.99	99.99	99.99
34/4/8	316.88	11.0016	73.1	76.55	79.42	81.9	83.98	85.74	87.31	88.78	90.28	91.95	93.7	95.51	97.27	98.63	99.43	99.81	99.96	100.01	100.03	100.03	100.03	100.03
34/4/30	317.1	11.0088	73.27	76.75	79.57	81.94	83.9	85.55	87.02	88.39	89.82	91.43	93.15	94.97	96.77	98.23	99.17	99.67	99.9	99.99	100.02	100.03	100.03	100.03
34/4/50	317.3	11.0154	70.59	74.25	77.26	79.82	81.98	83.83	85.51	87.1	88.75	90.58	92.51	94.52	96.49	98.08	99.08	99.6	99.84	99.93	99.96	99.97	99.97	99.97
34/4/70	317.5	11.022	72.81	76.34	79.22	81.65	83.68	85.4	86.93	88.33	89.76	91.34	93.03	94.8	96.56	98.03	99.01	99.56	99.83	99.95	99.99	100.01	100.02	100.02
34/4/88	317.68	11.0279	71	74.61	77.66	80.31	82.55	84.45	86.14	87.69	89.25	90.98	92.81	94.72	96.61	98.14	99.11	99.62	99.85	99.94	99.97	99.98	99.98	99.98
34/4/110	317.9	11.0351	71.18	74.82	77.85	80.45	82.64	84.51	86.18	87.71	89.26	90.95	92.73	94.59	96.43	97.95	98.97	99.54	99.82	99.94	99.98	100	100.01	100.01
34/4/133	318.13	11.0427	68.39	72.3	75.64	78.57	81.05	83.15	85.02	86.74	88.48	90.4	92.42	94.52	96.57	98.2	99.2	99.7	99.91	99.99	100.01	100.02	100.02	100.02
34/5/5	318.35	11.0499	72.35	75.99	79	81.55	83.65	85.39	86.92	88.32	89.76	91.39	93.15	95.01	96.85	98.32	99.23	99.69	99.89	99.96	99.98	99.99	99.99	99.99
34/5/30	318.6	11.0582	71.1	74.65	77.61	80.14	82.25	84.03	85.61	87.07	88.59	90.33	92.23	94.26	96.29	97.95	99.02	99.59	99.85	99.96	100	100.01	100.01	100.01
35/1/1	321.91	11.167	66.84	70.81	74.29	77.43	80.16	82.5	84.59	86.5	88.38	90.4	92.47	94.58	96.63	98.24	99.21	99.69	99.89	99.97	99.99	100	100	100
35/1/23	322.13	11.1742	74.62	77.83	80.42	82.61	84.44	86	87.4	88.71	90.08	91.63	93.3	95.07	96.83	98.26	99.17	99.65	99.87	99.96	99.99	100	100	100
35/1/43	322.33	11.1808	73.85	77.16	79.86	82.17	84.1	85.74	87.22	88.62	90.08	91.73	93.49	95.33	97.13	98.53	99.36	99.75	99.91	99.96	99.97	99.97	99.97	99.97
35/1/64 avg	322.54	11.1877	73.57	76.83	79.46	81.69	83.57	85.2	86.68	88.1	89.58	91.25	93.03	94.9	96.74	98.23	99.16	99.64	99.86	99.94	99.97	99.98	99.98	99.98
35/1/82	322.72	11.1936	72.67	75.99	78.69	80.98	82.92	84.58	86.1	87.54	89.05	90.76	92.6	94.55	96.48	98.06	99.08	99.62	99.87	99.97	100	100.01	100.01	100.01
35/1/100	322.9	11.1996	72.82	76.29	79.09	81.43	83.36	84.98	86.43	87.79	89.22	90.86	92.64	94.55	96.46	98.03	99.05	99.6	99.85	99.95	99.99	100	100	100
35/1/119	323.09	11.2058	72.01	75.59	78.5	80.96	83	84.71	86.24	87.66	89.14	90.82	92.63	94.55	96.47	98.03	99.03	99.56	99.8	99.9	99.93	99.94	99.94	99.94
35/1/141	323.31	11.213	73.44	76.76	79.46	81.76	83.7	85.36	86.86	88.28	89.76	91.43	93.21	95.07	96.9	98.35	99.24	99.68	99.87	99.94	99.96	99.97	99.97	99.97
35/2/8	323.48	11.2186	69.62	73.29	76.42	79.16	81.49	83.46	85.2	86.78	88.38	90.18	92.12	94.18	96.24	97.93	99.02	99.6	99.87	99.98	100.02	100.03	100.03	100.03
35/2/32	323.72	11.2265	70.66	74.33	77.42	80.07	82.29	84.14	85.76	87.21	88.69	90.36	92.18	94.14	96.12	97.78	98.88	99.5	99.8	99.93	99.98	100	100.01	100.01
35/2/51	323.91	11.2328	70.68	74.27	77.25	79.78	81.88	83.65	85.23	86.69	88.23	90.01	91.96	94.04	96.12	97.83	98.94	99.54	99.82	99.93	99.97	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	8.5	8.75	9	9.25	9.5	9.75	10	10.25	10.5	10.75	11	11.25	11.5	11.25	12	12.25	12.5	12.75	13	13.25	13.5	13.75
35/2/90	324.3	11.2456	71.68	75.07	77.88	80.31	82.37	84.13	85.72	87.23	88.81	90.6	92.53	94.56	96.57	98.17	99.16	99.66	99.87	99.95	99.97	99.98	99.98	99.98
35/2/110	324.5	11.2522	72.99	76.35	79.12	81.5	83.5	85.2	86.73	88.16	89.65	91.33	93.13	95.02	96.88	98.35	99.26	99.71	99.9	99.97	99.99	100	100	100
35/2/130	324.7	11.2587	71.1	74.69	77.64	80.16	82.28	84.07	85.68	87.18	88.74	90.5	92.4	94.41	96.41	98.03	99.06	99.6	99.84	99.94	99.97	99.98	99.98	99.98
35/3/1	324.91	11.2657	71.84	75.42	78.34	80.82	82.89	84.63	86.19	87.66	89.19	90.93	92.8	94.77	96.72	98.27	99.22	99.69	99.89	99.96	99.98	99.99	99.99	99.99
35/3/22	325.12	11.2726	72.9	76.36	79.13	81.46	83.38	84.99	86.44	87.82	89.29	90.98	92.82	94.78	96.72	98.27	99.22	99.69	99.89	99.97	99.99	100	100	100
35/3/43 avg	325.33	11.2795	70.4	74.11	77.21	79.88	82.11	83.98	85.65	87.21	88.84	90.7	92.7	94.79	96.84	98.42	99.34	99.76	99.93	99.98	100	100	100	100
35/3/67	325.57	11.2874	70.54	74.36	77.51	80.2	82.41	84.24	85.87	87.4	89.01	90.87	92.86	94.94	96.97	98.51	99.38	99.77	99.91	99.96	99.97	99.97	99.97	99.97
35/3/81	325.71	11.292	70.21	74.04	77.18	79.82	81.99	83.8	85.41	86.92	88.51	90.34	92.32	94.41	96.48	98.13	99.15	99.66	99.88	99.96	99.99	100	100	100
35/3/104	325.94	11.2995	72.01	75.67	78.65	81.15	83.19	84.87	86.37	87.79	89.31	91.09	93.02	95.06	97.05	98.57	99.43	99.82	99.96	100	100.01	100.01	100.01	100.01
35/3/117	326.07	11.3038	69.83	73.74	77	79.78	82.06	83.93	85.57	87.07	88.64	90.46	92.44	94.54	96.62	98.26	99.23	99.7	99.89	99.96	99.98	99.99	99.99	99.99
35/3/138	326.28	11.3107	73.76	77.05	79.7	81.92	83.76	85.31	86.72	88.07	89.51	91.18	92.99	94.9	96.79	98.3	99.22	99.68	99.88	99.95	99.97	99.98	99.98	99.98
35/4/10	326.5	11.3179	71.3	74.86	77.82	80.35	82.46	84.23	85.82	87.32	88.9	90.72	92.68	94.75	96.79	98.37	99.3	99.73	99.9	99.96	99.98	99.98	99.98	99.98
35/4/30	326.7	11.3245	70.81	74.5	77.58	80.21	82.39	84.21	85.84	87.37	88.97	90.8	92.76	94.82	96.83	98.39	99.31	99.75	99.93	99.99	100.01	100.02	100.02	100.02
35/4/48	326.88	11.3304	71.21	74.73	77.61	80.05	82.09	83.83	85.41	86.92	88.53	90.38	92.37	94.46	96.51	98.14	99.15	99.66	99.88	99.96	99.99	100	100	100
35/4/69	327.09	11.3373	72.05	75.55	78.41	80.84	82.85	84.55	86.09	87.57	89.15	90.98	92.94	94.99	96.98	98.5	99.38	99.78	99.94	99.99	100	100	100	100
35/4/88	327.28	11.3436	72.58	76.09	78.87	81.17	83.06	84.67	86.16	87.63	89.22	91.05	93	95.02	96.98	98.48	99.35	99.76	99.92	99.97	99.98	99.98	99.98	99.98
35/4/110 avg	327.5	11.3508	70.48	74.27	77.36	79.95	82.09	83.87	85.48	87	88.62	90.46	92.44	94.53	96.57	98.19	99.19	99.68	99.89	99.97	100	100.01	100.01	100.01
35/4/134	327.74	11.3587	70.92	74.74	77.81	80.36	82.45	84.19	85.74	87.19	88.72	90.47	92.36	94.36	96.35	97.97	99.01	99.56	99.81	99.91	99.94	99.95	99.95	99.95
35/5/1	327.91	11.3643	69.35	73.3	76.47	79.11	81.29	83.14	84.82	86.42	88.11	90.02	92.05	94.17	96.25	97.93	99.01	99.58	99.84	99.95	99.99	100	100	100
35/5/16	328.06	11.3692	68.75	72.76	75.94	78.56	80.71	82.54	84.22	85.85	87.6	89.59	91.71	93.92	96.09	97.84	98.96	99.56	99.83	99.94	99.98	99.99	99.99	99.99
35/5/37	328.27	11.3761	68.51	72.68	76.01	78.73	80.93	82.77	84.43	86.01	87.7	89.64	91.73	93.93	96.1	97.86	98.98	99.57	99.84	99.95	99.99	100	100	100
35/5/57	328.47	11.3827	67.4	71.48	74.81	77.62	79.95	81.93	83.73	85.45	87.27	89.34	91.56	93.87	96.13	97.93	99.04	99.6	99.85	99.94	99.97	99.98	99.98	99.98
35/5/82	328.72	11.3909	70.46	74.37	77.41	79.85	81.79	83.37	84.76	86.01	87.67	89.55	91.54	93.62	95.69	97.44	98.65	99.37	99.74	99.91	99.98	100.01	100.02	100.02

Appendix B Table 11 (cont.): Quarter phi sediment texture data 14-14.75 phi (File on CD: App B Table 11 8 to 14 phi).

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
14/1/0 avg	120.3	5.1273	99.99	99.99	99.99	99.99
14/1/21 avg	120.51	5.1326	100	100	100	100
14/1/39	120.69	5.1372	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
14/1/60	120.9	5.1425	99.97	99.97	99.97	99.97
14/1/81	121.11	5.1479	99.99	99.99	99.99	99.99
14/1/96	121.26	5.1517	99.99	99.99	99.99	99.99
14/1/119	121.49	5.1576	100	100	100	100
14/1/139	121.69	5.1626	100	100	100	100
14/2/10	121.9	5.168	100	100	100	100
14/2/29	122.09	5.1728	99.96	99.96	99.96	99.96
14/2/46	122.26	5.1771	100.01	100.01	100.01	100.01
14/2/71	122.51	5.1835	100.01	100.01	100.01	100.01
14/2/91	122.71	5.1886	100	100	100	100
14/2/112	122.92	5.1939	99.99	99.99	99.99	99.99
14/2/130	123.1	5.1979	99.99	99.99	99.99	99.99
14/3/0	123.3	5.2009	100	100	100	100
14/3/23	123.53	5.2044	100	100	100	100
14/3/39	123.69	5.2069	100.01	100.01	100.01	100.01
14/3/58	123.88	5.2098	99.98	99.98	99.98	99.98
14/3/81	124.11	5.2132	100	100	100	100
14/3/100	124.3	5.2161	100.02	100.02	100.02	100.02
14/3/120	124.5	5.2192	99.95	99.95	99.95	99.95
14/3/138	124.68	5.2219	99.99	99.99	99.99	99.99
14/4/10	124.9	5.2252	99.99	99.99	99.99	99.99
14/4/30	125.1	5.2283	99.98	99.98	99.98	99.98
14/4/50	125.3	5.2313	99.99	99.99	99.99	99.99
14/4/68	125.48	5.234	100.01	100.01	100.01	100.01
14/4/91	125.71	5.2375	99.99	99.99	99.99	99.99
14/4/111	125.91	5.2406	99.99	99.99	99.99	99.99
14/4/130	126.1	5.2435	99.99	99.99	99.99	99.99
14/5/0	126.3	5.2465	99.98	99.98	99.98	99.98
14/5/26	126.56	5.2504	99.96	99.96	99.96	99.96
14/5/40	126.7	5.2526	99.97	99.97	99.97	99.97
14/5/60	126.9	5.2556	99.98	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
14/5/82	127.12	5.2589	100.02	100.02	100.02	100.02
14/5/100	127.3	5.2617	99.98	99.98	99.98	99.98
14/5/121	127.51	5.2649	99.98	99.98	99.98	99.98
14/5/140	127.7	5.2678	99.99	99.99	99.99	99.99
14/6/10	127.9	5.2708	99.97	99.97	99.97	99.97
14/6/30	128.1	5.2738	99.99	99.99	99.99	99.99
14/6/49	128.29	5.2767	100	100	100	100
14/6/69	128.49	5.2798	100.03	100.03	100.03	100.03
14/6/92	128.72	5.2832	100.03	100.03	100.03	100.03
14/6/112	128.92	5.2863	100.02	100.02	100.02	100.02
14/6/130	129.1	5.289	99.95	99.95	99.95	99.95
14/7/0	129.3	5.2921	100.01	100.01	100.01	100.01
14/7/20	129.5	5.2951	99.98	99.98	99.98	99.98
14cc/10	129.69	5.298	100	100	100	100
15/1/0	129.9	5.3012	99.99	99.99	99.99	99.99
15/1/22	130.12	5.3045	99.98	99.98	99.98	99.98
15/1/39	130.29	5.3071	99.99	99.99	99.99	99.99
15/1/60	130.5	5.3103	100.01	100.01	100.01	100.01
15/1/79	130.69	5.3132	100.02	100.02	100.02	100.02
15/1/99	130.89	5.3162	100.01	100.01	100.01	100.01
15/1/120	131.1	5.3194	100	100	100	100
15/1/140	131.3	5.3224	99.99	99.99	99.99	99.99
15/2/11	131.51	5.3256	99.97	99.97	99.97	99.97
15/2/30	131.7	5.3285	100.01	100.01	100.01	100.01
15/2/51	131.91	5.3317	99.98	99.98	99.98	99.98
15/2/71	132.11	5.3347	100	100	100	100
15/2/93	132.33	5.3381	100.04	100.04	100.04	100.04
15/2/113	132.53	5.3411	100.02	100.02	100.02	100.02
15/2/134 avg	132.74	5.3443	99.98	99.98	99.98	99.98
15/3/0	132.9	5.3467	99.99	99.99	99.99	99.99
15/3/17	133.07	5.3493	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
15/3/39	133.29	5.3526	99.99	99.99	99.99	99.99
15/3/56	133.46	5.3552	100.02	100.02	100.02	100.02
15/3/78	133.68	5.3586	100	100	100	100
15/3/99	133.89	5.3617	100.01	100.01	100.01	100.01
15/3/120	134.1	5.3649	100.04	100.04	100.04	100.04
15/3/140	134.3	5.368	99.99	99.99	99.99	99.99
15/4/10	134.5	5.371	100	100	100	100
15/4/30	134.7	5.374	99.99	99.99	99.99	99.99
15/4/50	134.9	5.3771	100	100	100	100
15/4/70	135.1	5.3801	100.02	100.02	100.02	100.02
15/4/90	135.3	5.3832	100	100	100	100
15/4/110	135.5	5.3862	99.99	99.99	99.99	99.99
15/4/130	135.7	5.3892	100.02	100.02	100.02	100.02
15/5/0	135.9	5.3923	100	100	100	100
15/5/16	136.06	5.3947	100.01	100.01	100.01	100.01
15/5/42	136.32	5.3986	100.02	100.02	100.02	100.02
15/5/61	136.51	5.4015	100.02	100.02	100.02	100.02
15/5/102	136.92	5.4078	99.94	99.94	99.94	99.94
15/5/123	137.13	5.4109	99.98	99.98	99.98	99.98
15/5/142	137.32	5.4138	100	100	100	100
15/6/12	137.52	5.4169	99.99	99.99	99.99	99.99
15/6/31	137.71	5.4197	100.02	100.02	100.02	100.02
15/6/51	137.91	5.4228	100.01	100.01	100.01	100.01
15/6/65	138.05	5.4249	100.02	100.02	100.02	100.02
15/6/87	138.27	5.4282	100.01	100.01	100.01	100.01
15/6/126	138.47	5.4313	100.01	100.01	100.01	100.01
15/6/107	138.66	5.4342	99.98	99.98	99.98	99.98
15/7/0	138.9	5.4378	99.97	99.97	99.97	99.97
15/7/17	139.07	5.4404	100.01	100.01	100.01	100.01
15cc/9	139.22	5.4427	99.99	99.99	99.99	99.99
16/1/0	139.5	5.4469	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
16/1/25	139.75	5.4507	100.03	100.03	100.03	100.03
16/1/43	139.93	5.4535	100.01	100.01	100.01	100.01
16/1/67	140.17	5.4571	100	100	100	100
16/1/84	140.34	5.4597	100.01	100.01	100.01	100.01
16/1/104	140.54	5.4627	99.99	99.99	99.99	99.99
16/1/123	140.73	5.4656	99.98	99.98	99.98	99.98
16/1/142	140.92	5.4685	99.99	99.99	99.99	99.99
16/2/13	141.13	5.4717	100	100	100	100
16/2/36	141.36	5.4752	99.97	99.97	99.97	99.97
16/2/54	141.54	5.4779	100.01	100.01	100.01	100.01
16/2/79	141.79	5.4817	100	100	100	100
16/2/92	141.92	5.4837	99.98	99.98	99.98	99.98
16/2/112	142.12	5.4867	99.99	99.99	99.99	99.99
16/2/132	142.32	5.4897	100	100	100	100
16/3/0	142.5	5.4925	100	100	100	100
16/3/25	142.75	5.4963	100.02	100.02	100.02	100.02
16/3/43	142.93	5.499	99.98	99.98	99.98	99.98
16/3/65	143.15	5.5023	100	100	100	100
16/3/82	143.32	5.5049	100	100	100	100
16/3/103	143.53	5.5081	99.98	99.98	99.98	99.98
16/3/124	143.74	5.5116	100.01	100.01	100.01	100.01
16/3/134	143.84	5.5145	99.99	99.99	99.99	99.99
16/4/7	144.07	5.5211	100	100	100	100
16/4/26	144.26	5.5266	99.98	99.98	99.98	99.98
16/4/46	144.46	5.5324	99.98	99.98	99.98	99.98
16/4/67	144.67	5.5385	99.99	99.99	99.99	99.99
16/4/93	144.93	5.546	99.99	99.99	99.99	99.99
16/4/113	145.13	5.5518	99.99	99.99	99.99	99.99
16/4/132	145.32	5.5573	99.98	99.98	99.98	99.98
16/5/0	145.5	5.5626	100.03	100.03	100.03	100.03
16/5/14	145.64	5.5666	100.04	100.04	100.04	100.04

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
16/5/43	145.93	5.575	100	100	100	100
16/5/63	146.13	5.5808	99.98	99.98	99.98	99.98
16/5/86	146.36	5.5875	100.01	100.01	100.01	100.01
16/5/102	146.52	5.5921	100.01	100.01	100.01	100.01
16/5/121	146.71	5.5976	99.98	99.98	99.98	99.98
16/5/142	146.92	5.6037	99.98	99.98	99.98	99.98
16/6/6	147.06	5.6077	99.97	99.97	99.97	99.97
16/6/26	147.26	5.6135	100	100	100	100
16/6/47	147.47	5.6196	99.98	99.98	99.98	99.98
16/6/64	147.64	5.6245	100.01	100.01	100.01	100.01
16/6/93	147.93	5.6329	100.01	100.01	100.01	100.01
16/6/115	148.15	5.6393	100	100	100	100
16/6/133	148.33	5.6445	100	100	100	100
16/7/0	148.5	5.6494	99.99	99.99	99.99	99.99
16/7/17	148.67	5.6544	99.98	99.98	99.98	99.98
16cc/8	148.77	5.6573	100.01	100.01	100.01	100.01
17/1/0	149.1	5.6668	99.99	99.99	99.99	99.99
17/1/26	149.36	5.6743	99.99	99.99	99.99	99.99
17/1/42	149.52	5.679	100.01	100.01	100.01	100.01
17/1/82	149.92	5.6906	99.99	99.99	99.99	99.99
17/1/101	150.11	5.6961	99.99	99.99	99.99	99.99
17/1/121	150.31	5.7019	99.99	99.99	99.99	99.99
17/1/141	150.51	5.7076	99.95	99.95	99.95	99.95
17/2/7	150.67	5.7123	99.99	99.99	99.99	99.99
17/2/27	150.87	5.7181	99.99	99.99	99.99	99.99
17/2/47	151.07	5.7239	99.97	99.97	99.97	99.97
17/2/73	151.33	5.7314	100.01	100.01	100.01	100.01
17/2/92	151.52	5.7369	100	100	100	100
17/2/115	151.75	5.7436	100	100	100	100
17/2/136	151.96	5.7496	100	100	100	100
17/3/0	152.1	5.7537	99.99	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
17/3/15	152.25	5.758	99.97	99.97	99.97	99.97
17/3/37	152.47	5.7644	99.99	99.99	99.99	99.99
17/3/65	152.75	5.7725	100	100	100	100
17/3/81	152.91	5.7772	99.99	99.99	99.99	99.99
17/3/102	153.12	5.7832	99.99	99.99	99.99	99.99
17/3/116	153.26	5.7873	100.02	100.02	100.02	100.02
17/3/135	153.45	5.7928	99.98	99.98	99.98	99.98
17/4/6	153.66	5.7989	99.96	99.96	99.96	99.96
17/4/37	153.97	5.8079	100	100	100	100
17/4/53	154.13	5.8125	99.99	99.99	99.99	99.99
17/4/72	154.32	5.818	99.98	99.98	99.98	99.98
17/4/94	154.54	5.8244	99.97	99.97	99.97	99.97
17/4/117	154.77	5.831	99.96	99.96	99.96	99.96
17/4/135	154.95	5.8362	99.99	99.99	99.99	99.99
17/5/0	155.1	5.8406	100.02	100.02	100.02	100.02
17/5/14	155.24	5.8446	100	100	100	100
17/5/38	155.48	5.8516	100.04	100.04	100.04	100.04
17/5/57	155.67	5.8571	100	100	100	100
17/5/84	155.94	5.8649	100	100	100	100
17/5/103	156.13	5.8704	100	100	100	100
17/5/117	156.27	5.8745	100	100	100	100
17/5/137	156.47	5.8803	99.98	99.98	99.98	99.98
17/6/11	156.71	5.8872	100	100	100	100
17/6/35	156.95	5.8942	100.02	100.02	100.02	100.02
17/6/52	157.12	5.8991	99.98	99.98	99.98	99.98
17/6/77	157.37	5.9063	100.01	100.01	100.01	100.01
17/6/92	157.52	5.9107	99.98	99.98	99.98	99.98
17/6/116	157.76	5.9176	99.98	99.98	99.98	99.98
17/6/133	157.93	5.9225	100.01	100.01	100.01	100.01
17/7/0	158.1	5.9275	99.98	99.98	99.98	99.98
17/7/17	158.27	5.9324	99.91	99.91	99.91	99.91

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
17cc/6	158.52	5.9396	100.02	100.02	100.02	100.02
18/1/0	158.7	5.9448	99.97	99.97	99.97	99.97
18/1/25	158.95	5.9521	99.98	99.98	99.98	99.98
18/1/43	159.13	5.9573	100	100	100	100
18/1/65	159.35	5.9637	100	100	100	100
18/1/79	159.49	5.9677	100.01	100.01	100.01	100.01
18/1/102	159.72	5.9744	100.01	100.01	100.01	100.01
18/1/116	159.86	5.9784	100	100	100	100
18/1/141	160.11	5.9857	100.01	100.01	100.01	100.01
18/2/13	160.33	5.9921	99.97	99.97	99.97	99.97
18/2/34	160.54	5.9981	100.02	100.02	100.02	100.02
18/2/53	160.73	6.0036	99.99	99.99	99.99	99.99
18/2/79	160.99	6.0112	100.02	100.02	100.02	100.02
18/2/96	161.16	6.0161	100.01	100.01	100.01	100.01
18/2/112	161.32	6.0207	99.99	99.99	99.99	99.99
18/2/133	161.53	6.0268	100	100	100	100
18/3/0	161.7	6.0317	99.97	99.97	99.97	99.97
18/3/14 2nd run	161.84	6.0358	99.99	99.99	99.99	99.99
18/3/42 2nd run	162.12	6.0439	100.01	100.01	100.01	100.01
18/3/56 2nd run	162.26	6.0479	100.02	100.02	100.02	100.02
18/3/85	162.55	6.0563	100	100	100	100
18/3/117	162.87	6.0656	99.99	99.99	99.99	99.99
18/3/135	163.05	6.0708	99.98	99.98	99.98	99.98
18/4/13	163.33	6.0789	100	100	100	100
18/4/36	163.56	6.0856	100	100	100	100
18/4/56	163.73	6.0905	99.98	99.98	99.98	99.98
18/4/73	163.93	6.0963	100	100	100	100
18/4/93	164.13	6.1021	100.01	100.01	100.01	100.01
18/4/111 2nd run	164.31	6.1073	100.03	100.03	100.03	100.03
18/4/132 avg	164.52	6.1134	100	100	100	100
18/5/0 avg	164.7	6.1186	100.02	100.02	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
18/5/26 avg	164.96	6.1261	99.99	99.99	99.99	99.99
18/5/43	165.13	6.1311	99.98	99.98	99.98	99.98
18/5/65	165.35	6.1374	99.99	99.99	99.99	99.99
18/5/80	165.5	6.1418	100.03	100.03	100.03	100.03
18/5/104	165.74	6.1487	100	100	100	100
18/5/125	165.95	6.1548	100.01	100.01	100.01	100.01
18/5/141	166.11	6.1594	100	100	100	100
18/6/6	166.26	6.1638	99.98	99.98	99.98	99.98
18/6/26	166.46	6.1696	99.99	99.99	99.99	99.99
18/6/46	166.66	6.1754	100.01	100.01	100.01	100.01
18/6/66	166.86	6.1812	99.95	99.95	99.95	99.95
18/6/86	167.06	6.187	99.97	99.97	99.97	99.97
18/6/104	167.24	6.1922	99.98	99.98	99.98	99.98
18/6/124	167.44	6.198	100.01	100.01	100.01	100.01
18cc/7(2nd attempt)	167.57	6.2017	99.99	99.99	99.99	99.99
19/1/0	168.3	6.2229	99.99	100	100	100
19/1/22	168.52	6.2292	100	100	100	100
19/1/41	168.71	6.2347	100	100	100	100
19/1/62	168.92	6.2408	100	100	100	100
19/1/83	169.13	6.2469	100	100	100	100
19/1/104	169.34	6.253	99.99	99.99	99.99	99.99
19/1/121	169.51	6.2579	100	100	100	100
19/1/142	169.72	6.264	100	100	100	100
19/2/5	169.85	6.2678	100.02	100.02	100.02	100.02
19/2/26	170.06	6.2738	100.01	100.01	100.01	100.01
19/2/52	170.32	6.2814	100	100	100	100
19/2/72	170.52	6.2872	99.99	99.99	99.99	99.99
19/2/93	170.73	6.2933	99.99	99.99	99.99	99.99
19/2/114	170.94	6.2993	100.01	100.01	100.01	100.01
19/2/135	171.15	6.3054	99.99	99.99	99.99	99.99
19/3/0	171.3	6.3098	100.02	100.02	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
19/3/27	171.57	6.3176	100.02	100.02	100.02	100.02
19/3/42	171.72	6.3219	100.01	100.01	100.01	100.01
19/3/62	171.92	6.3277	99.97	99.97	99.97	99.97
19/3/83	172.13	6.3338	99.96	99.96	99.96	99.96
19/3/102	172.32	6.3393	99.98	99.98	99.98	99.98
19/3/117	172.47	6.3436	99.97	99.97	99.97	99.97
19/3/136	172.66	6.3491	100.01	100.01	100.01	100.01
19/4/6	172.86	6.3549	100.04	100.04	100.04	100.04
19/4/27	173.07	6.361	100.02	100.02	100.02	100.02
19/4/47	173.27	6.3668	100.03	100.03	100.03	100.03
19/4/72	173.52	6.3741	99.98	99.98	99.98	99.98
19/4/92	173.72	6.3798	100.03	100.03	100.03	100.03
19/4/113	173.93	6.3859	100.02	100.02	100.02	100.02
19/4/134	174.14	6.392	100.02	100.02	100.02	100.02
19/5/0	174.3	6.3966	100.05	100.05	100.05	100.05
19/5/24	174.54	6.4036	99.99	99.99	99.99	99.99
19/5/42	174.72	6.4088	99.96	99.96	99.96	99.96
19/5/56	174.86	6.4129	100.01	100.01	100.01	100.01
19/5/96	175.26	6.4244	100.01	100.01	100.01	100.01
19/5/117	175.47	6.4305	100	100	100	100
19/5/141	175.71	6.4375	99.98	99.98	99.98	99.98
19/6/6	175.86	6.4418	100	100	100	100
19/6/26	176.06	6.4476	100.01	100.01	100.01	100.01
19/6/52	176.32	6.4551	100.02	100.02	100.02	100.02
19/6/67	176.47	6.4595	99.99	99.99	99.99	99.99
19/6/84	176.64	6.4644	99.99	99.99	99.99	99.99
19/6/112	176.92	6.4725	99.99	99.99	99.99	99.99
19/6/134	177.14	6.4789	100.02	100.02	100.02	100.02
19/7/0	177.3	6.4835	100.03	100.03	100.03	100.03
19/7/22	177.52	6.4899	100	100	100	100
19cc/0	177.82	6.4986	99.98	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
20/1/0	177.9	6.5009	100.02	100.02	100.02	100.02
20/1/15	178.05	6.5052	100	100	100	100
20/1/37	178.27	6.5116	99.98	99.98	99.98	99.98
20/1/58	178.48	6.5177	100.02	100.02	100.02	100.02
20/1/78	178.68	6.5235	99.98	99.98	99.98	99.98
20/1/97	178.87	6.529	99.98	99.98	99.98	99.98
20/1/118	179.08	6.5351	99.99	99.99	99.99	99.99
20/1/137	179.27	6.5406	99.98	99.98	99.98	99.98
20/2/5	179.45	6.5458	99.98	99.98	99.98	99.98
20/2/27	179.67	6.5522	99.98	99.98	99.98	99.98
20/2/46	179.86	6.5577	100.03	100.03	100.03	100.03
20/2/77	180.17	6.5666	100.02	100.02	100.02	100.02
20/2/93	180.33	6.5713	99.98	99.98	99.98	99.98
20/2/106	180.46	6.575	99.99	99.99	99.99	99.99
20/2/133	180.73	6.5829	100	100	100	100
20/3/1	180.91	6.5881	100	100	100	100
20/3/24	181.14	6.5947	100.02	100.02	100.02	100.02
20/3/42	181.32	6.6	100.02	100.02	100.02	100.02
20/3/67	181.57	6.6072	100.01	100.01	100.01	100.01
20/3/82 avg	181.72	6.6115	100	100	100	100
20/3/96	181.86	6.6156	100.01	100.01	100.01	100.01
20/3/116	182.06	6.6214	99.96	99.96	99.96	99.96
20/3/133	182.23	6.6263	100.05	100.05	100.05	100.05
20/4/7	182.47	6.6333	99.99	99.99	99.99	99.99
20/4/28	182.68	6.6393	100.01	100.01	100.01	100.01
20/4/48	182.88	6.6451	99.98	99.98	99.98	99.98
20/4/68	183.08	6.6509	100	100	100	100
20/4/86	183.26	6.6561	100.02	100.02	100.02	100.02
20/4/105	183.45	6.6616	99.99	99.99	99.99	99.99
20/4/132	183.72	6.6695	99.98	99.98	99.98	99.98
20/5/1 avg	183.91	6.675	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
20/5/25	184.15	6.6819	99.98	99.98	99.98	99.98
20/5/42 2nd attempt	184.32	6.6868	100	100	100	100
20/5/61	184.51	6.6923	99.98	99.98	99.98	99.98
20/5/82	184.72	6.6984	100	100	100	100
20/5/101	184.91	6.7039	100	100	100	100
20/5/117	185.07	6.7086	100	100	100	100
20/5/137	185.27	6.7144	99.99	99.99	99.99	99.99
20/6/7	185.47	6.7201	99.99	99.99	99.99	99.99
20/6/34	185.74	6.728	100	100	100	100
20/6/52	185.92	6.7332	100.02	100.02	100.02	100.02
20/6/68	186.08	6.7378	100	100	100	100
20/6/92	186.32	6.7448	100.01	100.01	100.01	100.01
20/6/111	186.51	6.7503	99.97	99.97	99.97	99.97
20/6/132	186.72	6.7563	100.01	100.01	100.01	100.01
20/7/0	186.9	6.7616	100	100	100	100
20/7/17	187.07	6.7665	99.99	99.99	99.99	99.99
20CC/7	187.22	6.7708	100.02	100.02	100.02	100.02
21/1/1 avg	187.51	6.7792	100	100	100	100
21/1/26	187.76	6.7865	100	100	100	100
21/1/43	187.93	6.7914	99.98	99.98	99.98	99.98
21/1/58	188.08	6.7957	100.02	100.02	100.02	100.02
21/1/82	188.32	6.8027	99.98	99.98	99.98	99.98
21/1/102	188.52	6.8085	99.99	99.99	99.99	99.99
21/1/117	188.67	6.8128	99.99	99.99	99.99	99.99
21/1/142	188.92	6.8201	100	100	100	100
21/2/8	189.08	6.8247	99.98	99.98	99.98	99.98
21/2/33	189.33	6.8319	100.02	100.02	100.02	100.02
21/2/46 avg	189.46	6.8357	99.99	99.99	99.99	99.99
21/2/75	189.75	6.8441	99.99	99.99	99.99	99.99
21/2/93	189.93	6.8493	99.98	99.98	99.98	99.98
21/2/117	190.17	6.8563	99.99	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
21/2/142	190.42	6.8635	99.97	99.97	99.97	99.97
21/3/1	190.51	6.8661	99.96	99.96	99.96	99.96
21/3/16	190.66	6.8705	99.99	99.99	99.99	99.99
21/3/37	190.87	6.8765	99.98	99.98	99.98	99.98
21/3/62	191.12	6.8838	100	100	100	100
21/3/82	191.32	6.8896	99.97	99.97	99.97	99.97
21/3/102 avg	191.52	6.8954	99.97	99.97	99.97	99.97
21/3/121	191.71	6.9009	99.98	99.98	99.98	99.98
21/3/136	191.86	6.9052	100	100	100	100
21/4/7	192.07	6.9113	100	100	100	100
21/4/36	192.36	6.9197	99.98	99.98	99.98	99.98
21/4/52	192.52	6.9243	99.98	99.98	99.98	99.98
21/4/73	192.73	6.9304	99.99	99.99	99.99	99.99
21/4/96	192.96	6.9371	99.98	99.98	99.98	99.98
21/4/112	193.12	6.9417	99.98	99.98	99.98	99.98
21/4/133	193.33	6.9478	100	100	100	100
21/5/0 avg	193.5	6.9527	100.02	100.02	100.02	100.02
21/5/22	193.72	6.9591	100.02	100.02	100.02	100.02
21/5/42	193.92	6.9649	99.98	99.98	99.98	99.98
21/5/62	194.12	6.9707	99.98	99.98	99.98	99.98
21/5/84	194.34	6.977	100.01	100.01	100.01	100.01
21/5/102	194.52	6.9822	100	100	100	100
21/5/122	194.72	6.988	100.01	100.01	100.01	100.01
21/5/140	194.9	6.9932	100.02	100.02	100.02	100.02
21/6/7	195.07	6.9982	99.99	99.99	99.99	99.99
21/6/33	195.33	7.0057	100	100	100	100
21/6/49 avg	195.49	7.0103	100.01	100.01	100.01	100.01
21/6/66	195.66	7.0153	100.01	100.01	100.01	100.01
21/6/87	195.87	7.0213	100.02	100.02	100.02	100.02
21/6/107	196.07	7.0271	100.03	100.03	100.03	100.03
21/6/134	196.34	7.035	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
21/7/0	196.5	7.0396	99.98	99.98	99.98	99.98
21/7/22	196.72	7.046	100	100	100	100
21CC/6	197	7.0541	99.97	99.97	99.97	99.97
22/1/1	197.11	7.0573	99.98	99.98	99.98	99.98
22/1/16	197.26	7.0616	100.01	100.01	100.01	100.01
22/1/38 avg	197.48	7.068	100	100	100	100
22/1/58	197.68	7.0738	100	100	100	100
22/1/84	197.94	7.0813	100.04	100.04	100.04	100.04
22/1/104	198.14	7.0871	100.04	100.04	100.04	100.04
22/1/122	198.32	7.0923	99.97	99.97	99.97	99.97
22/1/142	198.52	7.0981	99.98	99.98	99.98	99.98
22/2/13	198.73	7.1042	99.98	99.98	99.98	99.98
22/2/32	198.92	7.1097	100	100	100	100
22/2/54	199.14	7.116	99.98	99.98	99.98	99.98
22/2/74	199.34	7.1218	100.02	100.02	100.02	100.02
22/2/93 avg	199.53	7.1273	99.99	99.99	99.99	99.99
22/2/112	199.72	7.1328	99.99	99.99	99.99	99.99
22/2/133	199.93	7.1389	99.99	99.99	99.99	99.99
22/3/1	200.11	7.1441	99.98	99.98	99.98	99.98
22/3/15	200.25	7.1482	100.02	100.02	100.02	100.02
22/3/42	200.52	7.156	100.01	100.01	100.01	100.01
22/3/56	200.66	7.1601	100.03	100.03	100.03	100.03
22/3/82	200.92	7.1676	100	100	100	100
22/3/95	201.05	7.1714	100	100	100	100
22/3/117	201.27	7.1777	100	100	100	100
22/3/132 avg	201.42	7.1821	100.02	100.02	100.02	100.02
22/4/7	201.67	7.1893	99.98	99.98	99.98	99.98
22/4/33	201.93	7.1968	100	100	100	100
22/4/73	202.33	7.2084	100	100	100	100
22/4/92	202.52	7.2139	99.99	99.99	99.99	99.99
22/4/113	202.73	7.22	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
22/4/133	202.93	7.2258	99.98	99.98	99.98	99.98
22CC/7	203.17	7.2328	100	100	100	100
23/1/1	206.71	7.3502	100	100	100	100
23/1/15	206.85	7.3549	100.01	100.01	100.01	100.01
23/1/43 avg	207.13	7.3643	100.01	100.01	100.01	100.01
23/1/58	207.28	7.3693	100.01	100.01	100.01	100.01
23/1/78	207.48	7.376	100.03	100.03	100.03	100.03
23/1/103	207.73	7.3844	99.99	99.99	99.99	99.99
23/1/118	207.88	7.3894	99.97	99.97	99.97	99.97
23/1/142	208.12	7.3974	100	100	100	100
23/2/6	208.26	7.4021	99.98	99.98	99.98	99.98
23/2/32	208.52	7.4108	99.99	99.99	99.99	99.99
23/2/53	208.73	7.4179	99.98	99.98	99.98	99.98
23/2/86	209.06	7.4289	100.01	100.01	100.01	100.01
23/2/107 avg	209.27	7.436	99.99	99.99	99.99	99.99
23/2/134	209.54	7.445	100.01	100.01	100.01	100.01
23/3/0	209.7	7.4504	99.99	99.99	99.99	99.99
23/3/15	209.85	7.4554	99.97	99.97	99.97	99.97
23/3/42	210.12	7.4644	100	100	100	100
23/3/63	210.33	7.4715	99.97	99.97	99.97	99.97
23/3/83	210.53	7.4782	100.01	100.01	100.01	100.01
23/3/102	210.72	7.4845	100.03	100.03	100.03	100.03
23/3/117	210.87	7.4896	99.97	99.97	99.97	99.97
23/3/136	211.06	7.4959	99.99	99.99	99.99	99.99
23/4/7 avg	211.27	7.503	99.99	99.99	99.99	99.99
23/4/32	211.52	7.5113	99.99	99.99	99.99	99.99
23/4/52	211.72	7.518	100.01	100.01	100.01	100.01
23/4/73	211.93	7.5251	99.99	99.99	99.99	99.99
23/4/93	212.13	7.5318	99.98	99.98	99.98	99.98
23/4/112	212.32	7.5381	100.01	100.01	100.01	100.01
23/4/133	212.53	7.5452	99.98	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
23/5/1	212.71	7.5512	100	100	100	100
23/5/24	212.94	7.5589	100.01	100.01	100.01	100.01
23/5/42	213.12	7.5649	99.97	99.97	99.97	99.97
23/5/83 avg	213.53	7.5787	100	100	100	100
23/5/102	213.72	7.585	100.01	100.01	100.01	100.01
23/5/122	213.92	7.5917	100.02	100.02	100.02	100.02
23/5/142	214.12	7.5984	100	100	100	100
23/6/7	214.27	7.6034	100.02	100.02	100.02	100.02
23/6/31	214.51	7.6115	100.01	100.01	100.01	100.01
23/6/52	214.72	7.6185	99.98	99.98	99.98	99.98
23/6/85	215.05	7.6296	100.03	100.03	100.03	100.03
23/6/111	215.31	7.6383	100.01	100.01	100.01	100.01
23/6/133	215.53	7.6456	100	100	100	100
23/7/1 avg	215.71	7.6517	100.01	100.01	100.01	100.01
23/7/23	215.93	7.659	100.01	100.01	100.01	100.01
23CC/7	216.22	7.6688	100.03	100.03	100.03	100.03
24/1/1	216.31	7.6718	100.01	100.01	100.01	100.01
24/1/27	216.57	7.6805	100.01	100.01	100.01	100.01
24/1/43	216.73	7.6858	100.03	100.03	100.03	100.03
24/1/64	216.94	7.6929	100	100	100	100
24/1/82	217.12	7.6989	99.97	99.97	99.97	99.97
24/1/104	217.34	7.7063	99.98	99.98	99.98	99.98
24/1/123	217.53	7.7126	99.98	99.98	99.98	99.98
24/1/142 avg	217.72	7.719	100	100	100	100
24/2/12	217.92	7.7257	100.01	100.01	100.01	100.01
24/2/28	218.08	7.7311	99.99	99.99	99.99	99.99
24/2/46	218.26	7.7371	100	100	100	100
24/2/72	218.52	7.7458	100	100	100	100
24/2/87	218.67	7.7508	100.01	100.01	100.01	100.01
24/2/107	218.87	7.7575	100.01	100.01	100.01	100.01
24/2/135	219.15	7.7669	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
24/3/1	219.31	7.7723	99.98	99.98	99.98	99.98
24/3/23	219.53	7.7796	99.99	99.99	99.99	99.99
24/3/42 avg	219.72	7.786	99.97	99.97	99.97	99.97
24/3/56	219.86	7.7907	100.01	100.01	100.01	100.01
24/3/82	220.12	7.7994	100	100	100	100
24/3/102	220.32	7.8061	100.01	100.01	100.01	100.01
24/3/116	220.46	7.8108	99.99	99.99	99.99	99.99
24/3/133	220.63	7.8165	100.01	100.01	100.01	100.01
24/4/7	220.87	7.8245	99.97	99.97	99.97	99.97
24/4/32	221.12	7.8329	99.99	99.99	99.99	99.99
24/4/47	221.27	7.8379	99.96	99.96	99.96	99.96
24/4/72	221.52	7.8463	100.04	100.04	100.04	100.04
24/4/86 avg	221.66	7.851	99.99	99.99	99.99	99.99
24/4/112	221.92	7.8597	99.99	99.99	99.99	99.99
24/4/133	222.13	7.8667	100.01	100.01	100.01	100.01
24/5/1	222.31	7.8728	100	100	100	100
24/5/15	222.45	7.8774	99.97	99.97	99.97	99.97
24/5/43	222.73	7.8868	99.99	99.99	99.99	99.99
24/5/63	222.93	7.8935	100.02	100.02	100.02	100.02
24/5/84	223.14	7.9006	99.98	99.98	99.98	99.98
24/5/103	223.33	7.9069	100	100	100	100
24/5/118	223.48	7.9119	99.99	99.99	99.99	99.99
24/5/142 avg	223.72	7.92	100	100	100	100
24/6/7	223.87	7.925	99.98	99.98	99.98	99.98
24/6/27	224.07	7.9317	100.02	100.02	100.02	100.02
24/6/47	224.27	7.9384	99.99	99.99	99.99	99.99
24/6/67	224.47	7.9451	100	100	100	100
24/6/86	224.66	7.9515	99.98	99.98	99.98	99.98
24/6/107	224.87	7.9585	100	100	100	100
24/6/132	225.12	7.9669	99.99	99.99	99.99	99.99
24CC/9	225.36	7.9749	100.02	100.02	100.02	100.02

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
25/1/1	225.91	7.9933	100.01	100.01	100.01	100.01
25/1/23	226.13	8.0007	99.99	99.99	99.99	99.99
25/1/42 avg	226.32	8.0071	99.99	99.99	99.99	99.99
25/1/63	226.53	8.0141	99.98	99.98	99.98	99.98
25/1/85	226.75	8.0215	100.02	100.02	100.02	100.02
25/1/103	226.93	8.0275	99.99	99.99	99.99	99.99
25/1/125	227.13	8.0342	100	100	100	100
25/1/144	227.34	8.0412	100	100	100	100
25/2/5	227.45	8.0449	100	100	100	100
25/2/32	227.72	8.054	99.97	99.97	99.97	99.97
25/2/53	227.93	8.061	100.01	100.01	100.01	100.01
25/2/72	228.12	8.0674	99.99	99.99	99.99	99.99
25/2/95	228.35	8.0751	99.96	99.96	99.96	99.96
25/2/112 avg	228.52	8.0808	99.99	99.99	99.99	99.99
25/2/134	228.74	8.0881	100.01	100.01	100.01	100.01
25/3/0	228.9	8.0935	100	100	100	100
25/3/23	229.13	8.1012	99.97	99.97	99.97	99.97
25/3/43	229.33	8.1079	99.95	99.95	99.95	99.95
25/3/63	229.53	8.1146	100.02	100.02	100.02	100.02
25/3/95	229.85	8.1253	99.99	99.99	99.99	99.99
25/3/118	230.08	8.133	100.01	100.01	100.01	100.01
25/3/137	230.27	8.1394	100.01	100.01	100.01	100.01
25/4/7	230.47	8.1461	99.99	99.99	99.99	99.99
25/4/32	230.72	8.1545	100.03	100.03	100.03	100.03
25/4/53 avg	230.93	8.1615	100	100	100	100
25/4/74	231.14	8.1685	100.02	100.02	100.02	100.02
25/4/93	231.33	8.1749	99.98	99.98	99.98	99.98
25/4/112	231.52	8.1813	99.99	99.99	99.99	99.99
25/4/133	231.73	8.1883	99.99	99.99	99.99	99.99
25/5/1	231.91	8.1943	100.01	100.01	100.01	100.01
25/5/16	232.06	8.1994	99.97	99.97	99.97	99.97

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
25/5/38	232.28	8.2067	99.98	99.98	99.98	99.98
25/5/62	232.52	8.2148	100.01	100.01	100.01	100.01
25/5/82	232.72	8.2215	100.01	100.01	100.01	100.01
25/5/102 avg	232.92	8.2282	100.01	100.01	100.01	100.01
25/5/117	233.07	8.2332	100	100	100	100
25/5/137	233.27	8.2399	100.01	100.01	100.01	100.01
25/6/7	233.47	8.2466	99.98	99.98	99.98	99.98
25/6/27	233.67	8.2533	99.99	99.99	99.99	99.99
25/6/48	233.88	8.2603	100.01	100.01	100.01	100.01
25/6/75	234.15	8.2694	100.02	100.02	100.02	100.02
25/6/93	234.33	8.2754	99.99	99.99	99.99	99.99
25/6/112	234.52	8.2818	100	100	100	100
25/6/133	234.73	8.2888	100.03	100.03	100.03	100.03
25/7/1	234.91	8.2948	99.99	99.99	99.99	99.99
25/7/17 avg	235.07	8.3002	100.01	100.01	100.01	100.01
25cc/10	235.26	8.3065	99.97	99.97	99.97	99.97
26/1/1	235.51	8.3149	99.98	99.98	99.98	99.98
26/1/23	235.73	8.3223	100.01	100.01	100.01	100.01
26/1/58	236.08	8.334	100.01	100.01	100.01	100.01
26/1/82	236.32	8.342	99.99	99.99	99.99	99.99
26/1/102	236.52	8.3487	100.03	100.03	100.03	100.03
26/1/117	236.67	8.3538	99.99	99.99	99.99	99.99
26/1/142	236.92	8.3621	100.03	100.03	100.03	100.03
26/2/13	237.13	8.3692	100.01	100.01	100.01	100.01
26/2/32 avg	237.32	8.3755	100	100	100	100
26/2/56	237.56	8.3836	100.01	100.01	100.01	100.01
26/2/93	237.93	8.396	99.99	99.99	99.99	99.99
26/2/112	238.12	8.4023	100.02	100.02	100.02	100.02
26/2/133	238.33	8.4094	100	100	100	100
26/3/1	238.51	8.4154	99.95	99.95	99.95	99.95
26/3/22	238.72	8.4224	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
26/3/43	238.93	8.4295	100	100	100	100
26/3/56	239.06	8.4338	99.99	99.99	99.99	99.99
26/3/82	239.32	8.4425	100.01	100.01	100.01	100.01
26/3/102	239.52	8.4492	99.99	99.99	99.99	99.99
26/3/117 avg	239.67	8.4543	99.98	99.98	99.98	99.98
26/3/133	239.83	8.4596	100.03	100.03	100.03	100.03
26/4/7	240.07	8.4677	100.01	100.01	100.01	100.01
26/4/32	240.32	8.476	99.96	99.96	99.96	99.96
26/4/52	240.52	8.4827	100.01	100.01	100.01	100.01
26/4/72	240.72	8.4894	100.01	100.01	100.01	100.01
26/4/92	240.92	8.4961	99.99	99.99	99.99	99.99
26/4/112	241.12	8.5028	99.98	99.98	99.98	99.98
26/4/132	241.32	8.5095	99.99	99.99	99.99	99.99
26/5/0	241.5	8.5156	100	100	100	100
26/5/15	241.65	8.5206	99.97	99.97	99.97	99.97
26/5/42 avg	241.92	8.5296	99.97	99.97	99.97	99.97
26/5/63	242.13	8.5367	99.99	99.99	99.99	99.99
26/5/82	242.32	8.543	99.97	99.97	99.97	99.97
26/5/102	242.52	8.5497	99.98	99.98	99.98	99.98
26/5/117	242.67	8.5548	99.99	99.99	99.99	99.99
26/5/142	242.92	8.5631	99.97	99.97	99.97	99.97
26/6/7	243.07	8.5682	99.98	99.98	99.98	99.98
26/6/26	243.26	8.5745	99.99	99.99	99.99	99.99
26/6/47	243.47	8.5816	99.97	99.97	99.97	99.97
26/6/63	243.63	8.5869	99.98	99.98	99.98	99.98
26cc/13	243.86	8.5946	99.94	99.94	99.94	99.94
27/1/1 avg	245.11	8.6365	99.98	99.98	99.98	99.98
27/1/25	245.35	8.6445	99.97	99.97	99.97	99.97
27/1/43	245.53	8.6506	99.97	99.97	99.97	99.97
27/1/65	245.75	8.6579	99.98	99.98	99.98	99.98
27/1/81	245.91	8.6633	100.04	100.04	100.04	100.04

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
27/1/96	246.06	8.6683	100	100	100	100
27/1/117	246.27	8.6753	99.99	99.99	99.99	99.99
27/1/142	246.52	8.6837	99.98	99.98	99.98	99.98
27/2/5	246.65	8.6881	99.98	99.98	99.98	99.98
27/2/27	246.87	8.6954	100.01	100.01	100.01	100.01
27/2/53	247.13	8.7041	99.97	99.97	99.97	99.97
27/2/73 avg	247.33	8.7108	100	100	100	100
27/2/93	247.53	8.7175	100.04	100.04	100.04	100.04
27/2/107	247.67	8.7222	100.01	100.01	100.01	100.01
27/2/132	247.92	8.7306	99.97	99.97	99.97	99.97
27/3/1	248.11	8.737	99.97	99.97	99.97	99.97
27/3/16	248.26	8.742	99.99	99.99	99.99	99.99
27/3/37	248.47	8.749	99.96	99.96	99.96	99.96
27/3/56	248.66	8.7554	100.01	100.01	100.01	100.01
27/3/83	248.93	8.7644	99.98	99.98	99.98	99.98
27/3/104	249.14	8.7715	99.97	99.97	99.97	99.97
27/3/117	249.27	8.7758	99.99	99.99	99.99	99.99
27/3/142 avg	249.52	8.7842	99.98	99.98	99.98	99.98
27/4/7	249.67	8.7892	100.02	100.02	100.02	100.02
27/4/32	249.92	8.7976	100	100	100	100
27/4/52	250.12	8.8043	100.01	100.01	100.01	100.01
27/4/67	250.27	8.8093	100	100	100	100
27/4/86	250.46	8.8157	99.96	99.96	99.96	99.96
27/4/112	250.72	8.8244	99.99	99.99	99.99	99.99
27/4/132	250.92	8.8311	100.04	100.04	100.04	100.04
27/5/0	251.1	8.8371	100.05	100.05	100.05	100.05
27/5/23	251.33	8.8448	100.02	100.02	100.02	100.02
27/5/38	251.48	8.8499	100.01	100.01	100.01	100.01
27/5/57 avg	251.67	8.8562	100	100	100	100
27/5/83	251.93	8.8649	100.02	100.02	100.02	100.02
27/5/105	252.13	8.8716	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
27/5/118	252.28	8.8767	99.95	99.95	99.95	99.95
27/5/143	252.53	8.885	100.01	100.01	100.01	100.01
27/6/7	252.67	8.8897	99.99	99.99	99.99	99.99
27/6/32	252.92	8.8981	100.02	100.02	100.02	100.02
27/6/53	253.13	8.9051	99.99	99.99	99.99	99.99
27/6/73	253.33	8.9118	99.99	99.99	99.99	99.99
27/6/87	253.47	8.9165	99.99	99.99	99.99	99.99
27/6/107	253.67	8.9232	100	100	100	100
27/6/132 avg	253.92	8.9316	100	100	100	100
27/7/0	254.1	8.9376	99.99	99.99	99.99	99.99
27/7/17	254.27	8.9433	99.99	99.99	99.99	99.99
27CC/10	254.49	8.9533	100.03	100.03	100.03	100.03
28/1/4	254.74	8.9675	100.02	100.02	100.02	100.02
28/1/23	254.93	8.9783	100.01	100.01	100.01	100.01
28/1/42	255.12	8.9891	99.98	99.98	99.98	99.98
28/1/58	255.28	8.9982	100.03	100.03	100.03	100.03
28/1/83	255.53	9.0124	100.01	100.01	100.01	100.01
28/1/103	255.73	9.0237	100.03	100.03	100.03	100.03
28/1/121 avg	255.91	9.034	100	100	100	100
28/1/141	256.11	9.0453	99.98	99.98	99.98	99.98
28/2/7	256.27	9.0544	100.01	100.01	100.01	100.01
28/2/33	256.53	9.0692	100	100	100	100
28/2/54	256.74	9.0811	99.99	99.99	99.99	99.99
28/2/83	257.03	9.0976	99.99	99.99	99.99	99.99
28/2/98	257.18	9.1062	99.99	99.99	99.99	99.99
28/2/113	257.33	9.1147	99.99	99.99	99.99	99.99
28/2/133	257.53	9.1261	99.97	99.97	99.97	99.97
28/3/1	257.71	9.1363	100.01	100.01	100.01	100.01
28/3/25	257.95	9.1499	99.99	99.99	99.99	99.99
28/3/42	258.12	9.1596	99.98	99.98	99.98	99.98
28/3/55	258.25	9.167	100.03	100.03	100.03	100.03

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
28/3/84 avg	258.54	9.1835	99.99	99.99	99.99	99.99
28/3/118	258.88	9.2028	99.99	99.99	99.99	99.99
28/3/137	259.07	9.2136	100	100	100	100
28/4/6	259.26	9.2244	100.05	100.05	100.05	100.05
28/4/33	259.53	9.2397	99.98	99.98	99.98	99.98
28/4/47	259.67	9.2477	100.02	100.02	100.02	100.02
28/4/66	259.86	9.2585	99.99	99.99	99.99	99.99
28/4/93	260.13	9.2738	99.99	99.99	99.99	99.99
28/4/108	260.28	9.2824	100.01	100.01	100.01	100.01
28/4/134	260.54	9.2971	99.99	99.99	99.99	99.99
28/5/1	260.71	9.3068	99.96	99.96	99.96	99.96
28/5/16	260.86	9.3153	100.01	100.01	100.01	100.01
28/5/42	261.12	9.3301	99.99	99.99	99.99	99.99
28/5/61	261.31	9.3409	100	100	100	100
28/5/85	261.55	9.3546	100.01	100.01	100.01	100.01
28/5/102	261.72	9.3642	100.04	100.04	100.04	100.04
28/5/121	261.91	9.375	100.01	100.01	100.01	100.01
28/5/141	262.11	9.3864	100.02	100.02	100.02	100.02
28/6/8	262.28	9.396	100.01	100.01	100.01	100.01
28cc/8	262.45	9.4057	100	100	100	100
29/1/0	264.3	9.5109	100.03	100.03	100.03	100.03
29/1/34	264.64	9.5302	100.01	100.01	100.01	100.01
29/1/58	264.88	9.5438	99.97	99.97	99.97	99.97
29/1/80	265.1	9.5563	99.99	99.99	99.99	99.99
29/1/96 avg	265.26	9.5654	99.99	99.99	99.99	99.99
29/1/117	265.47	9.5774	99.97	99.97	99.97	99.97
29/1/142	265.72	9.5916	100.02	100.02	100.02	100.02
29/2/12	265.92	9.6029	100.01	100.01	100.01	100.01
29/2/32	266.12	9.6143	99.98	99.98	99.98	99.98
29/2/46	266.26	9.6223	99.95	99.95	99.95	99.95
29/2/64	266.44	9.6325	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
29/2/85	266.65	9.6444	100.02	100.02	100.02	100.02
29/2/107	266.87	9.6569	99.99	99.99	99.99	99.99
29/2/133	267.13	9.6717	100.03	100.03	100.03	100.03
29/3/1	267.31	9.682	100.02	100.02	100.02	100.02
29/3/23 avg	267.53	9.6945	100.01	100.01	100.01	100.01
29/3/42	267.72	9.7053	100	100	100	100
29/3/57	267.87	9.7138	100	100	100	100
29/3/84	268.14	9.7291	99.99	99.99	99.99	99.99
29/3/104	268.34	9.7405	99.97	99.97	99.97	99.97
29/3/117	268.47	9.7479	99.98	99.98	99.98	99.98
29/3/138	268.68	9.7598	99.97	99.97	99.97	99.97
29/4/6	268.86	9.7701	99.99	99.99	99.99	99.99
29/4/48	269.28	9.7885	99.99	99.99	99.99	99.99
29/4/72	269.52	9.7959	100.04	100.04	100.04	100.04
29/4/95	269.75	9.803	100	100	100	100
29/4/107	269.87	9.8067	100.02	100.02	100.02	100.02
29/4/135	270.15	9.8153	100	100	100	100
29/5/1	270.31	9.8203	100	100	100	100
29/5/15	270.45	9.8246	99.99	99.99	99.99	99.99
29/5/42 avg	270.72	9.8329	100	100	100	100
29/5/61	270.91	9.8384	100.01	100.01	100.01	100.01
29/5/85	271.15	9.8447	100.02	100.02	100.02	100.02
29/5/104	271.34	9.8498	100.03	100.03	100.03	100.03
29/5/118	271.48	9.8535	100.01	100.01	100.01	100.01
29/5/142	271.72	9.8598	99.98	99.98	99.98	99.98
29/6/14	271.94	9.8657	100.01	100.01	100.01	100.01
29cc/17	272.19	9.8723	100.01	100.01	100.01	100.01
30/1/1	273.91	9.9179	100.02	100.02	100.02	100.02
30/1/14	274.04	9.9213	99.98	99.98	99.98	99.98
30/1/42	274.32	9.9287	100.01	100.01	100.01	100.01
30/1/58	274.48	9.933	100.01	100.01	100.01	100.01

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
30/1/82	274.72	9.9393	100	100	100	100
30/1/103	274.93	9.9449	99.99	99.99	99.99	99.99
30/1/122 avg	275.12	9.9499	99.99	99.99	99.99	99.99
30/1/141	275.31	9.955	99.99	99.99	99.99	99.99
30/2/5	275.45	9.9587	100.01	100.01	100.01	100.01
30/2/32	275.72	9.9658	99.96	99.96	99.96	99.96
30/2/53	275.93	9.9714	100.02	100.02	100.02	100.02
30/2/92	276.32	9.9817	99.98	99.98	99.98	99.98
30/2/112	276.52	9.987	100.03	100.03	100.03	100.03
30/2/133	276.73	9.9926	99.99	99.99	99.99	99.99
30/3/1	276.91	9.9974	99.99	99.99	99.99	99.99
30/3/15	277.05	10.0011	100.01	100.01	100.01	100.01
30/3/43	277.33	10.0085	99.99	99.99	99.99	99.99
30/3/65	277.55	10.0143	99.98	99.98	99.98	99.98
30/3/84	277.74	10.0194	100.01	100.01	100.01	100.01
30/3/103	277.93	10.0244	99.99	99.99	99.99	99.99
30/3/117	278.07	10.0281	99.98	99.98	99.98	99.98
30/3/138 avg	278.28	10.0337	99.99	99.99	99.99	99.99
30/4/9	278.49	10.0392	100	100	100	100
30/4/32	278.72	10.0453	100.01	100.01	100.01	100.01
30/4/48	278.88	10.0496	100	100	100	100
30/4/73	279.13	10.0562	99.99	99.99	99.99	99.99
30/4/93	279.33	10.0615	100	100	100	100
30/4/113	279.53	10.0668	100.01	100.01	100.01	100.01
30/4/135	279.75	10.0726	99.98	99.98	99.98	99.98
30/5/6	279.96	10.0782	100.01	100.01	100.01	100.01
30/5/15	280.05	10.0806	99.96	99.96	99.96	99.96
30/5/35	280.25	10.0859	99.99	99.99	99.99	99.99
30/5/84	280.74	10.0989	99.97	99.97	99.97	99.97
30/5/102	280.92	10.1036	99.98	99.98	99.98	99.98
31/1/1	283.51	10.1723	99.98	99.98	99.98	99.98

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
31/1/17	283.67	10.1765	100.01	100.01	100.01	100.01
31/1/44 avg	283.94	10.1837	99.97	99.97	99.97	99.97
31/1/58	284.08	10.1874	99.97	99.97	99.97	99.97
31/1/83	284.33	10.194	99.98	99.98	99.98	99.98
31/1/105	284.55	10.1998	100.03	100.03	100.03	100.03
31/1/118	284.68	10.2033	100.01	100.01	100.01	100.01
31/1/138	284.88	10.2086	99.98	99.98	99.98	99.98
31/2/9	285.09	10.2141	99.99	99.99	99.99	99.99
31/2/29	285.29	10.2194	100.01	100.01	100.01	100.01
31/2/48	285.48	10.2245	100.02	100.02	100.02	100.02
31/2/73	285.73	10.2311	100	100	100	100
31/2/88 avg	285.88	10.2351	100.01	100.01	100.01	100.01
31/2/110	286.1	10.2409	100.02	100.02	100.02	100.02
31/2/134	286.34	10.2473	100	100	100	100
31/3/1	286.51	10.2518	99.99	99.99	99.99	99.99
31/3/23	286.73	10.2576	100	100	100	100
31/3/38	286.88	10.2616	100.01	100.01	100.01	100.01
31/3/57	287.04	10.2658	100.03	100.03	100.03	100.03
31/3/82	287.32	10.2732	99.99	99.99	99.99	99.99
31/3/102	287.52	10.2785	99.98	99.98	99.98	99.98
31/3/117	287.67	10.2825	99.99	99.99	99.99	99.99
31/3/141	287.91	10.2889	100	100	100	100
31/4/8	288.08	10.2934	100	100	100	100
31/4/30	288.3	10.2992	100	100	100	100
31/4/55 avg	288.55	10.3058	100.03	100.03	100.03	100.03
31/4/70	288.7	10.3098	100	100	100	100
31/4/89	288.89	10.3148	100.02	100.02	100.02	100.02
31/4/110	289.1	10.3204	100	100	100	100
31/4/134	289.34	10.3267	100.01	100.01	100.01	100.01
31/5/0	289.5	10.331	99.99	99.99	99.99	99.99
31/5/23	289.73	10.3371	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
31/5/43	289.93	10.3424	100	100	100	100
31/5/62	290.12	10.3474	100.03	100.03	100.03	100.03
31/5/83	290.33	10.353	99.99	99.99	99.99	99.99
31/5/101	290.51	10.3577	100.01	100.01	100.01	100.01
31/5/120	290.7	10.3628	99.98	99.98	99.98	99.98
31cc/0	290.74	10.3638	99.98	99.98	99.98	99.98
32/1/1	293.11	10.4266	100.01	100.01	100.01	100.01
32/1/23	293.33	10.4325	99.98	99.98	99.98	99.98
32/1/41	293.51	10.4372	100	100	100	100
32/1/61	293.71	10.4425	100.01	100.01	100.01	100.01
32/1/83	293.93	10.4484	100.04	100.04	100.04	100.04
32/1/102 avg	294.12	10.4534	100.01	100.01	100.01	100.01
32/1/121	294.31	10.4584	100.02	100.02	100.02	100.02
32/1/141	294.51	10.4637	100.02	100.02	100.02	100.02
32/2/11	294.71	10.469	99.99	99.99	99.99	99.99
32/2/30	294.9	10.4741	100	100	100	100
32/2/52	295.12	10.4799	100.03	100.03	100.03	100.03
32/2/73	295.33	10.4855	99.99	99.99	99.99	99.99
32/2/93	295.53	10.4908	100.01	100.01	100.01	100.01
32/2/113	295.73	10.4961	99.97	99.97	99.97	99.97
32/2/133	295.93	10.5014	99.99	99.99	99.99	99.99
32/3/1	296.11	10.5061	99.98	99.98	99.98	99.98
32/3/40	296.5	10.5165	100.02	100.02	100.02	100.02
32/3/62	296.72	10.5223	99.99	99.99	99.99	99.99
32/3/83	296.93	10.5279	99.98	99.98	99.98	99.98
32/3/102 avg	297.12	10.5329	100.01	100.01	100.01	100.01
32/3/123	297.33	10.5385	100	100	100	100
32/3/140	297.5	10.543	100	100	100	100
32/4/10	297.7	10.5483	99.99	99.99	99.99	99.99
32/4/30	297.9	10.5536	100	100	100	100
32/4/48	298.08	10.5583	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
32/4/68	298.28	10.5636	100.02	100.02	100.02	100.02
32/4/92	298.52	10.57	99.97	99.97	99.97	99.97
32/4/110	298.7	10.5748	99.99	99.99	99.99	99.99
32/4/133	298.93	10.5809	100	100	100	100
32/5/1	299.11	10.5856	100.01	100.01	100.01	100.01
32/5/28	299.38	10.5928	99.98	99.98	99.98	99.98
32/5/40 avg	299.5	10.596	100	100	100	100
32cc/2	299.67	10.6005	99.98	99.98	99.98	99.98
33/1/1	302.71	10.681	100.01	100.01	100.01	100.01
33/1/27	302.97	10.6879	100.03	100.03	100.03	100.03
33/1/40	303.1	10.6914	100	100	100	100
33/1/59	303.29	10.6964	99.99	99.99	99.99	99.99
33/1/83	303.53	10.7028	99.98	99.98	99.98	99.98
33/1/107	303.77	10.7091	99.99	99.99	99.99	99.99
33/1/121	303.91	10.7128	99.99	99.99	99.99	99.99
33/1/143	304.13	10.7187	99.99	99.99	99.99	99.99
33/2/9	304.29	10.7229	99.99	99.99	99.99	99.99
33/2/27	304.47	10.7277	99.99	99.99	99.99	99.99
33/2/46	304.66	10.7327	99.98	99.98	99.98	99.98
33/2/82	305.02	10.7422	100	100	100	100
33/2/95	305.15	10.7457	100.01	100.01	100.01	100.01
33/2/114	305.34	10.7507	100.07	100.07	100.07	100.07
33/2/135	305.55	10.7563	99.98	99.98	99.98	99.98
33/3/1 avg	305.71	10.7605	100	100	100	100
33/3/23	305.93	10.7664	100.01	100.01	100.01	100.01
33/3/41	306.11	10.7711	100.01	100.01	100.01	100.01
33/3/57	306.27	10.7754	99.98	99.98	99.98	99.98
33/3/84	306.54	10.7825	99.99	99.99	99.99	99.99
33/3/105	306.75	10.7881	100.01	100.01	100.01	100.01
33/3/116	306.86	10.791	100.03	100.03	100.03	100.03
33/3/138	307.08	10.7968	100	100	100	100

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
33/4/10	307.3	10.8027	99.99	99.99	99.99	99.99
33/4/29	307.49	10.8077	100.02	100.02	100.02	100.02
33/4/50	307.7	10.8133	100.03	100.03	100.03	100.03
33/4/73	307.93	10.8193	99.98	99.98	99.98	99.98
33/4/94	308.14	10.8249	99.97	99.97	99.97	99.97
33/4/110	308.3	10.8292	99.96	99.96	99.96	99.96
33/4/133	308.53	10.8352	99.97	99.97	99.97	99.97
33/5/1	308.71	10.84	100.03	100.03	100.03	100.03
33/5/29	308.99	10.8474	100.03	100.03	100.03	100.03
33/5/41	309.11	10.8516	99.98	99.98	99.98	99.98
33/5/58	309.28	10.8543	100	100	100	100
33/5/84 avg	309.54	10.8583	99.99	99.99	99.99	99.99
33/5/104	309.74	10.8615	100	100	100	100
34/1/1	312.31	10.9018	99.98	99.98	99.98	99.98
34/1/24	312.54	10.9054	99.96	99.96	99.96	99.96
34/1/37	312.67	10.9075	99.99	99.99	99.99	99.99
34/1/57	312.87	10.9106	100	100	100	100
34/1/77	313.07	10.9138	100.01	100.01	100.01	100.01
34/1/101	313.31	10.9175	99.99	99.99	99.99	99.99
34/1/123	313.53	10.921	99.98	99.98	99.98	99.98
34/1/141 avg	313.71	10.9238	99.99	99.99	99.99	99.99
34/2/10	313.9	10.9268	99.97	99.97	99.97	99.97
34/2/29	314.09	10.9298	99.98	99.98	99.98	99.98
34/2/49	314.29	10.9329	99.99	99.99	99.99	99.99
34/2/65	314.45	10.9354	100.02	100.02	100.02	100.02
34/2/89	314.69	10.9392	99.97	99.97	99.97	99.97
34/2/110	314.9	10.9425	99.96	99.96	99.96	99.96
34/2/133	315.13	10.9461	99.99	99.99	99.99	99.99
34/3/0	315.3	10.9496	99.99	99.99	99.99	99.99
34/3/22	315.52	10.9569	99.99	99.99	99.99	99.99
34/3/41	315.71	10.9631	99.99	99.99	99.99	99.99

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
34/3/76	316.06	10.9746	100.01	100.01	100.01	100.01
34/3/97	316.27	10.9815	99.98	99.98	99.98	99.98
34/3/118 avg	316.48	10.9884	100.01	100.01	100.01	100.01
34/3/137	316.67	10.9947	99.99	99.99	99.99	99.99
34/4/8	316.88	11.0016	100.03	100.03	100.03	100.03
34/4/30	317.1	11.0088	100.03	100.03	100.03	100.03
34/4/50	317.3	11.0154	99.97	99.97	99.97	99.97
34/4/70	317.5	11.022	100.02	100.02	100.02	100.02
34/4/88	317.68	11.0279	99.98	99.98	99.98	99.98
34/4/110	317.9	11.0351	100.01	100.01	100.01	100.01
34/4/133	318.13	11.0427	100.02	100.02	100.02	100.02
34/5/5	318.35	11.0499	99.99	99.99	99.99	99.99
34/5/30	318.6	11.0582	100.01	100.01	100.01	100.01
35/1/1	321.91	11.167	100	100	100	100
35/1/23	322.13	11.1742	100	100	100	100
35/1/43	322.33	11.1808	99.97	99.97	99.97	99.97
35/1/64 avg	322.54	11.1877	99.98	99.98	99.98	99.98
35/1/82	322.72	11.1936	100.01	100.01	100.01	100.01
35/1/100	322.9	11.1996	100	100	100	100
35/1/119	323.09	11.2058	99.94	99.94	99.94	99.94
35/1/141	323.31	11.213	99.97	99.97	99.97	99.97
35/2/8	323.48	11.2186	100.03	100.03	100.03	100.03
35/2/32	323.72	11.2265	100.01	100.01	100.01	100.01
35/2/51	323.91	11.2328	99.98	99.98	99.98	99.98
35/2/90	324.3	11.2456	99.98	99.98	99.98	99.98
35/2/110	324.5	11.2522	100	100	100	100
35/2/130	324.7	11.2587	99.98	99.98	99.98	99.98
35/3/1	324.91	11.2657	99.99	99.99	99.99	99.99
35/3/22	325.12	11.2726	100	100	100	100
35/3/43 avg	325.33	11.2795	100	100	100	100
35/3/67	325.57	11.2874	99.97	99.97	99.97	99.97

Hole 593 Sample No.	depth (mbsf)	Age (Ma)	14	14.25	14.5	14.75
35/3/81	325.71	11.292	100	100	100	100
35/3/104	325.94	11.2995	100.01	100.01	100.01	100.01
35/3/117	326.07	11.3038	99.99	99.99	99.99	99.99
35/3/138	326.28	11.3107	99.98	99.98	99.98	99.98
35/4/10	326.5	11.3179	99.98	99.98	99.98	99.98
35/4/30	326.7	11.3245	100.02	100.02	100.02	100.02
35/4/48	326.88	11.3304	100	100	100	100
35/4/69	327.09	11.3373	100	100	100	100
35/4/88	327.28	11.3436	99.98	99.98	99.98	99.98
35/4/110 avg	327.5	11.3508	100.01	100.01	100.01	100.01
35/4/134	327.74	11.3587	99.95	99.95	99.95	99.95
35/5/1	327.91	11.3643	100	100	100	100
35/5/16	328.06	11.3692	99.99	99.99	99.99	99.99
35/5/37	328.27	11.3761	100	100	100	100
35/5/57	328.47	11.3827	99.98	99.98	99.98	99.98
35/5/82	328.72	11.3909	100.02	100.02	100.02	100.02

Appendix B Table 12: Hole 593 modal size (μm) and volume % (120-329 mbsf) (File on CD: App B Table 12).

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
14/1/0 avg	120.30	5.0181	0.41	2.88			5.52	7.03			52.56	0.72				
14/1/21 avg	120.51	5.0231	0.41	2.86			5.52	6.82			52.56	0.64				
14/1/39	120.69	5.0273	0.41	2.96			4.65	6.95			52.56	0.83				
14/1/60	120.90	5.0323	0.41	2.81			4.65	7.75			52.56	0.84				
14/1/81	121.11	5.0373	0.41	2.62			5.52	7.74			44.19	0.89				
14/1/96	121.26	5.0408	0.41	2.64			5.52	7.68			44.19	0.81				
14/1/119	121.49	5.0462	0.41	2.66			5.52	7.49			52.56	0.75				
14/1/139	121.69	5.051	0.35	2.81			5.52	6.93			37.16	0.77				
14/2/10	121.90	5.0559	0.41	2.9			5.52	7.06			44.19	0.78				
14/2/29	122.09	5.0604	0.41	3.08			4.65	6.93			44.19	0.77				
14/2/46	122.26	5.0645	0.41	2.68			5.52	7.19			52.56	0.99				
14/2/71	122.51	5.0704	0.41	2.81			5.52	6.9			44.19	1.04				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
14/2/91	122.71	5.0751	0.41	2.62	0.35	2.62	5.52	6.9			37.16	0.88				
14/2/112	122.92	5.0801	0.41	2.95	0.35	2.95	4.65	7.42			44.19	0.23				
14/2/130	123.10	5.0843	0.41	2.79	0.35	2.79	5.52	7.16			37.16	1.05				
14/3/0	123.30	5.0891	0.41	2.94	0.35	2.94	4.65	7.4			37.16	0.69				
14/3/23	123.53	5.0945	0.41	2.67			4.65	7.09			44.19	1.2				
14/3/39	123.69	5.0983	0.35	2.82			4.65	7.7			52.56	0.78				
14/3/58	123.88	5.1028	0.41	2.73	0.35	2.73	4.65	7.42			52.56	1.05				
14/3/81	124.11	5.1082	0.35	2.88			4.65	7.01			52.56	0.95				
14/3/100	124.30	5.1127	0.35	2.68			5.52	6.85			52.56	0.79				
14/3/120	124.50	5.1174	0.35	2.62			5.52	6.94			52.56	0.96			250	0.38
14/3/138	124.68	5.1217	0.35	2.72			5.52	7.07			52.56	0.75				
14/4/10	124.90	5.1269	0.35	2.8			4.65	7.34			44.19	0.62				
14/4/30	125.10	5.1316	0.41	2.64	0.35	2.64	4.65	6.64	3.91	6.64	44.19	1.07				
14/4/50	125.30	5.1364	0.35	2.82			4.65	7.2			44.19	1.06				
14/4/68	125.48	5.1406	0.41	3.27			3.91	7.58			37.16	0.94				
14/4/91	125.71	5.1461	0.41	3.22			3.91	7.88			44.19	0.61				
14/4/111	125.91	5.1508	0.41	2.88			4.65	7.79			37.16	0.73				
14/4/130	126.10	5.1553	0.41	3.21			3.91	7.72			44.19	0.65				
14/5/0	126.30	5.16	0.41	2.84			4.65	7.54			44.19	0.71				
14/5/26	126.56	5.1651	0.41	2.7			4.65	6.99			31.25	1.02				
14/5/40	126.70	5.1679	0.41	3.1			4.65	7.95			37.16	0.42				
14/5/60	126.90	5.1718	0.41	2.64			5.52	6.98			52.56	1.22				
14/5/82	127.12	5.1762	0.35	2.94			4.65	7.16			37.16	0.77				
14/5/100	127.30	5.1797	0.41	2.83			5.52	6.89			44.19	1.02				
14/5/121	127.51	5.1839	0.41	2.82			4.65	7.26			52.56	0.64				
14/5/140	127.70	5.1876	0.35	2.63			5.52	7.55			44.19	1				
14/6/10	127.90	5.1916	0.35	2.74			5.52	7.25			44.19	0.81				
14/6/30	128.10	5.1955	0.35	2.54			5.52	7.33			52.56	0.89				
14/6/49	128.29	5.1993	0.35	2.68			5.52	7.27			44.19	0.82				
14/6/69	128.49	5.2032	0.41	2.58	0.35	2.58	5.52	7.19			44.19	1.15				
14/6/92	128.72	5.2078	0.41	2.75			5.52	7.44			44.19	0.92				
14/6/112	128.92	5.2117	0.41	2.91			4.65	6.97			44.19	0.51				
14/6/130	129.10	5.2153	0.41	2.73			5.52	7.1			44.19	0.71	37.16	0.71		
14/7/0	129.30	5.2192	0.35	2.51			5.52	6.96			52.56	1.09				
14/7/20	129.50	5.2231	0.41	2.75			5.52	7.05			37.16	0.87				
14cc/10	129.69	5.2269	0.41	2.8			4.65	7.25			37.16	0.82				
15/1/0	129.90	5.231	0.41	2.89			4.65	7.45			37.16	0.94				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
15/1/22	130.12	5.2354	0.41	3.09			4.65	7.39			52.56	0.73				
15/1/39	130.29	5.2387	0.41	2.79	0.35	2.79	5.52	6.93			62.5	1.08				
15/1/60	130.50	5.2429	0.35	2.88			4.65	7.67			52.56	0.51				
15/1/79	130.69	5.2466	0.41	3.14			4.65	7.72			44.19	0.65				
15/1/99	130.89	5.2506	0.41	3.15			5.52	7.99			44.19	0.58				
15/1/120	131.10	5.2547	0.41	3.25			4.65	7.68			44.19	0.47				
15/1/140	131.30	5.2587	0.41	3.29			5.52	7.33	4.65	7.33	44.19	0.56	37.16	0.56		
15/2/11	131.51	5.2628	0.41	3.68			4.65	7.52			44.19	0.44				
15/2/30	131.70	5.2666	0.41	3.41			4.65	8.05			44.19	0.46				
15/2/51	131.91	5.2707	0.41	3.52			5.52	8.12			44.19	0.49				
15/2/71	132.11	5.2746	0.41	3.29			5.52	7.45			44.19	0.55	37.16	0.55		
15/2/93	132.33	5.279	0.41	3.25			5.52	7.72			44.19	0.39				
15/2/113	132.53	5.2829	0.41	3.29			5.52	7.86			44.19	0.49				
15/2/134 avg	132.74	5.2871	0.41	3.58			5.52	8.1			52.56	0.38				
15/3/0	132.90	5.2902	0.41	3.81			4.65	7.17			44.19	0.4				
15/3/17	133.07	5.2936	0.41	3.43	0.35	3.43	5.52	7.28			44.19	0.42				
15/3/39	133.29	5.2979	0.41	3.35			5.52	7.26			44.19	0.4				
15/3/56	133.46	5.3013	0.41	3.32			5.52	7.28			44.19	0.35				
15/3/78	133.68	5.3056	0.41	3.72			5.52	7.47			44.19	0.4				
15/3/99	133.89	5.3098	0.41	3.38			4.65	7.37			44.19	0.4				
15/3/120	134.10	5.3139	0.35	3.07			5.52	7.09			44.19	0.75				
15/3/140	134.30	5.3179	0.41	3.42	0.35	3.42	5.52	7.24			44.19	0.49				
15/4/10	134.50	5.3218	0.41	3.63			4.65	7.13			44.19	0.46	37.16	0.46		
15/4/30	134.70	5.3258	0.41	3.49			4.65	7.27			44.19	0.69				
15/4/50	134.90	5.3297	0.41	3.76			4.65	7.4			44.19	0.55	37.16	0.55		
15/4/70	135.10	5.3337	0.35	3.42			4.65	7.07			44.19	0.56				
15/4/90	135.30	5.3376	0.41	3.48			4.65	6.78			44.19	0.55				
15/4/110	135.50	5.3415	0.41	3.27			5.52	7.81			44.19	0.54				
15/4/130	135.70	5.3455	0.41	3.4			4.65	7.32			44.19	0.57				
15/5/0	135.90	5.3494	0.41	3.37			4.65	7.36			44.19	0.53				
15/5/16	136.06	5.3526	0.41	3.28			5.52	7.42			44.19	0.59				
15/5/42	136.32	5.3577	0.41	3.73			4.65	7.75			44.19	0.45				
15/5/61	136.51	5.3615	0.41	3.44			4.65	7.44			37.16	0.45				
15/5/102	136.92	5.3696	0.41	3.52			5.52	7.32			44.19	0.5				
15/5/123	137.13	5.3737	0.35	3.2			5.52	6.89	4.65	6.89	44.19	0.69				
15/5/142	137.32	5.3775	0.41	3.44			4.65	6.76			52.56	0.54				
15/6/12	137.52	5.3814	0.41	3.96			4.65	6.92	3.91	6.92	44.19	0.6				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
15/6/31	137.71	5.3852	0.41	3.61			4.65	6.8			52.56	0.52				
15/6/51	137.91	5.3891	0.35	4.17			4.65	7.08			44.19	0.55				
15/6/65	138.05	5.3919	0.41	3.95			4.65	7.2			44.19	0.49				
15/6/87	138.27	5.3962	0.35	3.62			4.65	7.4			44.19	0.43				
15/6/126	138.47	5.4002	0.41	3.54			4.65	7.51			37.16	0.36				
15/6/107	138.66	5.4039	0.41	3.8			4.65	7.33			37.16	0.54				
15/7/0	138.90	5.4086	0.35	3.19			4.65	7.32			37.16	0.53				
15/7/17	139.07	5.412	0.35	3.21			4.65	7.41			37.16	0.59				
15cc/9	139.22	5.415	0.41	3.79			4.65	7.34			44.19	0.49				
16/1/0	139.50	5.4205	0.41	3.49			4.65	6.82			52.56	0.58				
16/1/25	139.75	5.4254	0.41	3.42			5.52	6.68			52.56	0.55				
16/1/43	139.93	5.429	0.35	3.31			5.52	6.76			52.56	0.44	44.19	0.44		
16/1/67	140.17	5.4337	0.41	3.53			4.65	7.01			44.19	0.59				
16/1/84	140.34	5.4371	0.35	3.4			5.52	7.02			44.19	0.62				
16/1/104	140.54	5.441	0.41	3.47			5.52	6.89	4.65	6.89	44.19	0.62				
16/1/123	140.73	5.4447	0.41	3.72			5.52	7.28			44.19	0.48				
16/1/142	140.92	5.4485	0.41	3.51	0.35	3.51	4.65	6.87			44.19	0.62				
16/2/13	141.13	5.4526	0.35	3.29			4.65	6.93			52.56	0.54	44.19	0.54		
16/2/36	141.36	5.4572	0.41	3.88			4.65	7.31			44.19	0.47				
16/2/54	141.54	5.4607	0.35	3.43			5.52	7.29			44.19	0.63				
16/2/79	141.79	5.4657	0.35	3.15			5.52	7.29			37.16	0.77				
16/2/92	141.92	5.4682	0.41	3.5			5.52	7.21			44.19	0.57				
16/2/112	142.12	5.4722	0.41	3.37			5.52	7.18			52.56	0.44				
16/2/132	142.32	5.4761	0.35	3.26			4.65	7.04			44.19	0.71				
16/3/0	142.50	5.4797	0.35	3.39			4.65	7.26			44.19	0.43				
16/3/25	142.75	5.4846	0.41	3.42			4.65	7.42			44.19	0.34				
16/3/43	142.93	5.4882	0.35	3.43			4.65	7.5			44.19	0.4	37.16	0.4		
16/3/65	143.15	5.4925	0.35	3.4			4.65	7.33			37.16	0.67				
16/3/82	143.32	5.4959	0.35	3.44			4.65	7.19			44.19	0.53				
16/3/103	143.53	5.5	0.35	3.22			4.65	7.61			44.19	0.33				
16/3/124	143.74	5.5061	0.41	3.29			4.65	7.9			37.16	0.41				
16/3/134	143.84	5.509	0.35	3.24			5.52	7.65			37.16	0.62				
16/4/7	144.07	5.5157	0.41	3.28			4.65	7.87			44.19	0.44				
16/4/26	144.26	5.5212	0.35	3.32			4.65	7.49			44.19	0.61				
16/4/46	144.46	5.527	0.35	3.29			4.65	7.25			44.19	0.42				
16/4/67	144.67	5.5331	0.35	3.19			4.65	7.06			44.19	0.68				
16/4/93	144.93	5.5407	0.41	2.91	0.35	2.91	5.52	7.75			52.56	0.5				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
16/4/113	145.13	5.5465	0.35	2.91			5.52	7.52			44.19	0.73				
16/4/132	145.32	5.552	0.35	2.76			5.52	7.65			44.19	0.64				
16/5/0	145.50	5.5572	0.41	2.87			4.65	7.78			52.56	0.39				
16/5/14	145.64	5.5613	0.41	2.82			5.52	8.21			52.56	0.37				
16/5/43	145.93	5.5697	0.41	3.06			5.52	7.66			44.19	0.58				
16/5/63	146.13	5.5755	0.41	2.71			5.52	8.24			44.19	0.51				
16/5/86	146.36	5.5822	0.41	2.56	0.35	2.56	5.52	7.5			52.56	0.6	44.19	0.6		
16/5/102	146.52	5.5869	0.35	2.52			6.57	7.11			44.19	0.89				
16/5/121	146.71	5.5924	0.41	3			5.52	7.78			44.19	0.67				
16/5/142	146.92	5.5985	0.41	2.92	0.35	2.92	4.65	7.17			44.19	0.55				
16/6/6	147.06	5.6026	0.41	3.23			4.65	6.95			44.19	0.77				
16/6/26	147.26	5.6084	0.41	3.33			4.65	7.44			37.16	0.54				
16/6/47	147.47	5.6145	0.35	2.82			5.52	7.44			44.19	1.06				
16/6/64	147.64	5.6194	0.41	3.03	0.35	3.03	5.52	7.75			44.19	0.47				
16/6/93	147.93	5.6278	0.41	2.71	0.35	2.71	5.52	8			52.56	0.53				
16/6/115	148.15	5.6342	0.35	2.84			5.52	7.65			52.56	0.65				
16/6/133	148.33	5.6395	0.35	2.73			5.52	7.09			44.19	0.86				
16/7/0	148.50	5.6444	0.35	2.84			5.52	7.22			52.56	0.67				
16/7/17	148.67	5.6493	0.41	3.14			5.52	7.71			37.16	0.55				
16cc/8	148.77	5.6522	0.35	2.8			5.52	7.14			44.19	0.77				
17/1/0	149.10	5.6618	0.41	3.08			5.52	7.52			44.19	0.66				
17/1/26	149.36	5.6694	0.35	2.78			5.52	7.06			52.56	0.63				
17/1/42	149.52	5.674	0.35	2.77			5.52	7.01			44.19	1.14				
17/1/82	149.92	5.6857	0.41	3.3			4.65	7.86			44.19	0.54	37.16	0.54		
17/1/101	150.11	5.6912	0.35	3.18			4.65	6.86			52.56	0.76	44.19	0.76		
17/1/121	150.31	5.697	0.35	2.92			4.65	6.49			44.19	1.29				
17/1/141	150.51	5.7028	0.35	3.06			4.65	6.46			44.19	1.2				
17/2/7	150.67	5.7074	0.41	3.13			5.52	7.75			44.19	0.5				
17/2/27	150.87	5.7133	0.35	2.63			6.57	6.88			44.19	0.98				
17/2/47	151.07	5.7191	0.41	3.09			5.52	7.11			52.56	0.78				
17/2/73	151.33	5.7266	0.35	2.89			5.52	6.52			52.56	0.96				
17/2/92	151.52	5.7321	0.35	3.05			4.65	6.82			44.19	0.92				
17/2/115	151.75	5.7388	0.35	2.98			4.65	6.85			52.56	0.89	44.19	0.89		
17/2/136	151.96	5.7449	0.35	2.78			5.52	7.19			44.19	0.84				
17/3/0	152.10	5.749	0.41	3.4			4.65	7.78			44.19	0.52				
17/3/15	152.25	5.7533	0.35	2.89			4.65	7.01			52.56	0.95	44.19	0.95		
17/3/37	152.47	5.7597	0.35	2.71			5.52	6.81			44.19	1.21				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
17/3/65	152.75	5.7679	0.41	2.95			5.52	7.59			44.19	0.74				
17/3/81	152.91	5.7725	0.41	2.86			5.52	6.92			44.19	0.79				
17/3/102	153.12	5.7786	0.41	3.31			5.52	7.73	4.65	7.73	44.19	0.55				
17/3/116	153.26	5.7827	0.41	2.82	0.35	2.82	5.52	6.82			44.19	1.17				
17/3/135	153.45	5.7882	0.35	2.83			5.52	6.5			44.19	1.17				
17/4/6	153.66	5.7943	0.35	2.83			5.52	6.45			44.19	1.33				
17/4/37	153.97	5.8033	0.35	3.19			4.65	6.7			52.56	0.65				
17/4/53	154.13	5.808	0.35	2.94			4.65	6.96			44.19	0.77				
17/4/72	154.32	5.8135	0.35	2.95			4.65	7.13			37.16	0.79				
17/4/94	154.54	5.8199	0.41	2.86	0.35	2.86	5.52	7.07	4.65	7.07	44.19	1.08				
17/4/117	154.77	5.8266	0.35	3.13			4.65	7.18			52.56	0.62				
17/4/135	154.95	5.8318	0.35	2.96			4.65	7.09			44.19	0.91				
17/5/0	155.10	5.8361	0.41	3.3			4.65	7.79			44.19	0.45				
17/5/14	155.24	5.8402	0.35	2.93			4.65	7.17			44.19	0.46				
17/5/38	155.48	5.8472	0.35	2.79			4.65	7.06			44.19	0.82				
17/5/57	155.67	5.8527	0.41	3.22			4.65	7.01			44.19	0.76				
17/5/84	155.94	5.8606	0.41	3.18			5.52	7.62			44.19	0.45				
17/5/103	156.13	5.8661	0.41	3.05			5.52	7.03			37.16	0.91	31.25	0.91		
17/5/117	156.27	5.8701	0.41	3.02			5.52	6.97			44.19	0.82				
17/5/137	156.47	5.8759	0.35	3.05			4.65	6.43			52.56	0.67				
17/6/11	156.71	5.8829	0.35	2.74			5.52	6.94								
17/6/35	156.95	5.8899	0.35	2.81			5.52	7.35			44.19	0.63				
17/6/52	157.12	5.8948	0.35	2.73			5.52	7.14			44.19	0.91				
17/6/77	157.37	5.9021	0.35	2.75			5.52	6.72								
17/6/92	157.52	5.9065	0.35	2.69			5.52	6.55			52.56	0.64				
17/6/116	157.76	5.9134	0.41	3.45			4.65	7.28			44.19	0.54				
17/6/133	157.93	5.9184	0.35	3			4.65	6.96								
17/7/0	158.10	5.9233	0.35	3.03			5.52	7.03	4.65	7.03	62.5	0.59				
17/7/17	158.27	5.9282	0.35	2.93			5.52	6.74			44.19	0.73			297.3	0.29
17cc/6	158.52	5.9355	0.41	3.13			5.52	6.8			31.25	0.86				
18/1/0	158.70	5.9407	0.41	3.29			4.65	7.39			44.19	0.47				
18/1/25	158.95	5.948	0.35	3.01			5.52	6.75			62.5	0.38				
18/1/43	159.13	5.9532	0.41	3.09			5.52	7.26			44.19	0.38				
18/1/65	159.35	5.9596	0.35	2.73			6.57	6.46			62.5	0.63				
18/1/79	159.49	5.9637	0.35	2.76			6.57	6.57			52.56	0.81			250	0.3
18/1/102	159.72	5.9704	0.35	3.38			5.52	7.2			44.19	0.64				
18/1/116	159.86	5.9744	0.35	3.32			5.52	6.81			44.19	0.79				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
18/1/141	160.11	5.9817	0.35	2.77			6.57	6.62			44.19	1.23	37.16	1.23		
18/2/13	160.33	5.9881	0.35	3.27			5.52	6.55			44.19	0.95				
18/2/34	160.54	5.9942	0.35	3.07			5.52	6.41			44.19	1.45				
18/2/53	160.73	5.9997	0.35	3.46			5.52	7.23			37.16	0.52				
18/2/79	160.99	6.0073	0.35	3.5			4.65	6.41			44.19	0.71				
18/2/96	161.16	6.0122	0.35	2.98			6.57	5.79			44.19	1.04				
18/2/112	161.32	6.0169	0.35	3.23			5.52	6.7			37.16	0.78				
18/2/133	161.53	6.023	0.35	3.14			5.52	6.76			44.19	0.58				
18/3/0	161.70	6.0279	0.35	3.06			5.52	6.04			31.25	0.86				
18/3/14 2nd run	161.84	6.032	0.35	2.98			5.52	7.34			44.19	0.52				
18/3/42 2nd run	162.12	6.0401	0.35	2.63			5.52	7.18			44.19	0.67				
18/3/56 2nd run	162.26	6.0442	0.35	2.93			5.52	7.28			44.19	0.64				
18/3/85	162.55	6.0526	0.41	3.05			4.65	7.55			44.19	0.59				
18/3/117	162.87	6.0619	0.41	2.81			5.52	7.98			44.19	0.24				
18/3/135	163.05	6.0671	0.41	2.88			5.52	7.62			44.19	0.68				
18/4/13	163.33	6.0753	0.41	2.64			5.52	8.31			44.19	0.43				
18/4/36	163.56	6.0819	0.41	2.86			5.52	7.86			44.19	0.69				
18/4/56	163.73	6.0869	0.41	2.9			5.52	8.16			44.19	0.63				
18/4/73	163.93	6.0927	0.41	2.88			5.52	7.85			44.19	0.62				
18/4/93	164.13	6.0985	0.41	2.76			5.52	8.01			44.19	0.72				
18/4/111 2nd run	164.31	6.1037	0.41	2.46			5.52	8.58			44.19	0.59				
18/4/132 avg	164.52	6.1098	0.41	2.6			5.52	8.28			52.56	0.53				
18/5/0 avg	164.70	6.1151					6.57	10.1			52.56	0.64				
18/5/26 avg	164.96	6.1226					6.57	9.85			52.56	0.69				
18/5/43	165.13	6.1276	0.41	2.87			5.52	7.65			44.19	0.36				
18/5/65	165.35	6.1339	0.41	2.79			5.52	8.18			44.19	0.35				
18/5/80	165.50	6.1383	0.41	2.85			5.52	7.84			44.19	0.34				
18/5/104	165.74	6.1453	0.41	2.58			5.52	7.87			44.19	0.66	37.16	0.66		
18/5/125	165.95	6.1514	0.41	2.66			5.52	7.96			44.19	0.38				
18/5/141	166.11	6.156	0.41	2.64			5.52	8.1			44.19	0.56				
18/6/6	166.26	6.1604	0.41	2.62			5.52	8.91			44.19	0.32				
18/6/26	166.46	6.1662	0.41	2.67			5.52	8.5			44.19	0.42				
18/6/46	166.66	6.172	0.41	2.52			5.52	9.18			44.19	0.38				
18/6/66	166.86	6.1778	0.41	2.46			5.52	9.39			44.19	0.35				
18/6/86	167.06	6.1836	0.41	2.61			5.52	8.83			44.19	0.46				
18/6/104	167.24	6.1889	0.41	2.57			5.52	8.68			44.19	0.46				
18/6/124	167.44	6.1947	0.41	2.45			5.52	8.87			44.19	0.43				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
18cc/7(2nd attempt)	167.57	6.1984	0.41	2.63			5.52	8.53			52.56	0.68				
19/1/0	168.30	6.2196					6.57	10.41			52.56	0.73				
19/1/22	168.52	6.226	0.41	2.44			5.52	8.25			52.56	0.73				
19/1/41	168.71	6.2316	0.41	2.62			5.52	7.89			44.19	0.62				
19/1/62	168.92	6.2377	0.41	2.47			6.57	8.37			52.56	0.6				
19/1/83	169.13	6.2438	0.41	2.62			5.52	7.98			52.56	0.58				
19/1/104	169.34	6.2499	0.41	2.76			5.52	7.73			44.19	0.67				
19/1/121	169.51	6.2548	0.41	2.86			5.52	7.72			44.19	0.73				
19/1/142	169.72	6.2609	0.41	2.82			5.52	7.65			52.56	0.61				
19/2/5	169.85	6.2647	0.41	2.55			5.52	8.18			44.19	0.63				
19/2/26	170.06	6.2708	0.41	2.62			5.52	7.95			52.56	0.65				
19/2/52	170.32	6.2783	0.41	2.53			6.57	7.89			44.19	0.61				
19/2/72	170.52	6.2841	0.41	2.32			6.57	8.26			52.56	0.6				
19/2/93	170.73	6.2902	0.41	2.46			5.52	8.58			52.56	0.54				
19/2/114	170.94	6.2963	0.41	2.39			5.52	8.54			52.56	0.61	44.19	0.61		
19/2/135	171.15	6.3025	0.41	2.55			5.52	8.48			52.56	0.65				
19/3/0	171.30	6.3068	0.41	2.78			5.52	8.23			44.19	0.67				
19/3/27	171.57	6.3147	0.41	2.47			5.52	9			44.19	0.66				
19/3/42	171.72	6.319	0.41	2.4			5.52	8.29			44.19	0.75				
19/3/62	171.92	6.3248	0.41	2.56			5.52	7.81			44.19	0.7				
19/3/83	172.13	6.3309	0.41	2.42			5.52	8.02			44.19	0.59				
19/3/102	172.32	6.3364	0.41	2.7			5.52	8.27			44.19	0.64				
19/3/117	172.47	6.3408	0.41	2.47			5.52	7.94			44.19	0.8				
19/3/136	172.66	6.3463	0.41	2.54			5.52	8.74			52.56	0.51	44.19	0.51		
19/4/6	172.86	6.3521	0.41	2.29			5.52	8.47			44.19	0.7				
19/4/27	173.07	6.3582	0.41	2.52			5.52	7.96			44.19	0.69				
19/4/47	173.27	6.364	0.41	2.41			5.52	8.26			44.19	0.61				
19/4/72	173.52	6.3713	0.41	2.32			5.52	8.39			44.19	0.68				
19/4/92	173.72	6.3771	0.41	2.48			5.52	7.97			44.19	0.68				
19/4/113	173.93	6.3832	0.41	2.46			5.52	8.08			44.19	0.51				
19/4/134	174.14	6.3893	0.41	2.58			5.52	7.91			52.56	0.57	44.19	0.57		
19/5/0	174.54	6.4009	0.41	2.82			5.52	8.06			44.19	0.62				
19/5/24	174.72	6.4062	0.41	2.65			5.52	8.63			52.56	0.47				
19/5/42	174.86	6.4102	0.41	2.42			5.52	9.08			52.56	0.44				
19/5/56	175.26	6.4219	0.41	2.38			5.52	9.07			52.56	0.47				
19/5/96	175.47	6.428	0.41	2.32			5.52	9.14			44.19	0.52				
19/5/117	175.71	6.4349	0.41	2.38			5.52	8.99			44.19	0.53				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
19/5/141	175.71	6.4349	0.41	2.45			5.52	8.88			52.56	0.49				
19/6/6	175.86	6.4393	0.41	2.38			5.52	8.96			52.56	0.46				
19/6/26	176.06	6.4451	0.41	2.3			5.52	8.85			52.56	0.54				
19/6/52	176.32	6.4527	0.41	2.42			5.52	8.69			52.56	0.59				
19/6/67	176.47	6.457	0.41	2.42			5.52	8.86			52.56	0.45				
19/6/84	176.64	6.462	0.41	2.42			5.52	9.07			52.56	0.43	44.19	0.43		
19/6/112	176.92	6.4701	0.41	2.46			5.52	8.33			52.56	0.56				
19/6/134	177.14	6.4765	0.41	2.64			5.52	8.5			44.19	0.59				
19/7/0	177.30	6.4811					6.57	10.35			44.19	0.67				
19/7/22	177.52	6.4875	0.41	2.57			5.52	8.94			44.19	0.46				
19cc/0	177.82	6.4962	0.41	2.54			5.52	8.83			44.19	0.58				
20/1/0	177.90	6.4986	0.41	2.46			5.52	8.7			52.56	0.6	44.19	0.6		
20/1/15	178.05	6.5029	0.41	2.48			5.52	9.2			52.56	0.5	44.19	0.5		
20/1/37	178.27	6.5093	0.41	2.58			5.52	8.68	4.65	8.68	44.19	0.54				
20/1/58	178.48	6.5154	0.41	2.57			5.52	8.84			44.19	0.47				
20/1/78	178.68	6.5212	0.41	2.82			4.65	8.58			44.19	0.56				
20/1/97	178.87	6.5267	0.41	2.5	0.35	2.5	5.52	9.04			44.19	0.48				
20/1/118	179.08	6.5328	0.41	2.59			5.52	8.91	4.65	8.91	44.19	0.47				
20/1/137	179.27	6.5384	0.41	2.61			4.65	8.86			44.19	0.46				
20/2/5	179.45	6.5436	0.41	2.53			5.52	9.21			44.19	0.41				
20/2/27	179.67	6.55	0.41	2.55			5.52	9.1			44.19	0.43				
20/2/46	179.86	6.5555	0.41	2.55			5.52	9.3			44.19	0.43				
20/2/77	180.17	6.5645	0.41	2.49			5.52	9.16			44.19	0.55				
20/2/93	180.33	6.5692	0.41	2.49			5.52	9.33			44.19	0.57				
20/2/106	180.46	6.5729	0.41	2.37			5.52	9.43			44.19	0.48				
20/2/133	180.73	6.5808	0.41	2.58			5.52	8.66			44.19	0.51				
20/3/1	180.91	6.586	0.41	2.67			5.52	8.52			44.19	0.52				
20/3/24	181.14	6.5927	0.41	2.6			5.52	8.41			44.19	0.58				
20/3/42	181.32	6.5979	0.41	2.6			5.52	8.79			44.19	0.53				
20/3/67	181.57	6.6052	0.41	2.31			5.52	9.18			44.19	0.51				
20/3/82 avg	181.72	6.6095	0.41	2.58			5.52	8.97			44.19	0.47				
20/3/96	181.86	6.6136	0.41	2.59			5.52	8.8			44.19	0.45				
20/3/116	182.06	6.6194	0.41	2.78			5.52	8.2			44.19	0.54				
20/3/133	182.23	6.6244	0.41	2.69			5.52	8.15			44.19	0.76				
20/4/7	182.47	6.6313	0.41	2.68			5.52	8.34			44.19	0.66				
20/4/28	182.68	6.6374	0.41	2.64			5.52	8.76			44.19	0.57				
20/4/48	182.88	6.6432	0.41	2.61			5.52	8.84			44.19	0.52				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
20/4/68	183.08	6.6491	0.41	2.63			5.52	8.71			44.19	0.53				
20/4/86	183.26	6.6543	0.41	2.58			5.52	8.7			44.19	0.62				
20/4/105	183.45	6.6598	0.41	2.43			5.52	9.05			44.19	0.64				
20/4/132	183.72	6.6677	0.41	2.6			5.52	8.84			44.19	0.56				
20/5/1 avg	183.91	6.6732	0.41	2.56			5.52	9.05			44.19	0.55				
20/5/25	184.15	6.6801	0.41	2.55			5.52	8.64			44.19	0.58				
20/5/42 2nd attempt	184.32	6.6851	0.41	2.47			5.52	9.26			44.19	0.57				
20/5/61	184.51	6.6906	0.41	2.54			5.52	9.02			52.56	0.71				
20/5/82	184.72	6.6967	0.41	2.55			5.52	9.19			44.19	0.58				
20/5/101	184.91	6.7022	0.41	2.49			5.52	9.33			44.19	0.51				
20/5/117	185.07	6.7069	0.41	2.64			5.52	9.33			44.19	0.6				
20/5/137	185.27	6.7127	0.41	2.71			5.52	8.89			44.19	0.66				
20/6/7	185.47	6.7185	0.41	2.52			5.52	9.23			44.19	0.58				
20/6/34	185.74	6.7263	0.41	2.53			5.52	8.97			52.56	0.55	44.19	0.55		
20/6/52	185.92	6.7316	0.41	2.53			5.52	8.83			44.19	0.55				
20/6/68	186.08	6.7362	0.41	2.43			5.52	8.97			52.56	0.55				
20/6/92	186.32	6.7432	0.41	2.53			5.52	8.9			52.56	0.53	44.19	0.53		
20/6/111	186.51	6.7487	0.41	2.58			5.52	8.89			52.56	0.45	44.19	0.45		
20/6/132	186.72	6.7548	0.41	2.61			5.52	8.63			44.19	0.49				
20/7/0	186.90	6.76	0.41	2.9			5.52	8.36			44.19	0.55				
20/7/17	187.07	6.765	0.41	2.88			5.52	8.63			44.19	0.57				
20CC/7	187.22	6.7693	0.41	2.84			5.52	8.26			37.16	0.57				
21/1/1 avg	187.51	6.7778	0.41	3			5.52	8.29			44.19	0.53				
21/1/26	187.76	6.785	0.41	3.08			4.65	8.3			44.19	0.51				
21/1/43	187.93	6.79	0.41	2.74			5.52	8.88			44.19	0.47				
21/1/58	188.08	6.7943	0.41	3.03			4.65	8.59			44.19	0.5				
21/1/82	188.32	6.8013	0.41	2.79			5.52	9			44.19	0.4				
21/1/102	188.52	6.8071	0.49	2.7	0.41	2.7	5.52	9.2			44.19	0.44				
21/1/117	188.67	6.8115	0.41	2.77			5.52	8.75			44.19	0.43				
21/1/142	188.92	6.8187	0.41	2.71			5.52	8.44			44.19	0.47				
21/2/8	189.08	6.8234	0.41	2.69			5.52	9			44.19	0.48				
21/2/33	189.33	6.8306	0.41	2.65			5.52	8.95			44.19	0.43				
21/2/46 avg	189.46	6.8344	0.41	2.67			5.52	8.85			44.19	0.43				
21/2/75	189.75	6.8428	0.41	2.74			5.52	9.08			52.56	0.42	44.19	0.42		
21/2/93	189.93	6.8481	0.41	2.75			5.52	9.06			44.19	0.39				
21/2/117	190.17	6.855	0.41	2.71			5.52	9.02			44.19	0.47				
21/2/142	190.42	6.8623	0.41	2.69			5.52	8.72			44.19	0.56				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
21/3/1	190.51	6.8649	0.41	2.6			5.52	8.74			44.19	0.48				
21/3/16	190.66	6.8693	0.41	2.75			5.52	8.61			44.19	0.51				
21/3/37	190.87	6.8754	0.41	2.81			5.52	8.49			44.19	0.61	37.16	0.61		
21/3/62	191.12	6.8826	0.41	2.72			5.52	8.52			44.19	0.51				
21/3/82	191.32	6.8885	0.41	2.68			5.52	8.42			44.19	0.52				
21/3/102 avg	191.52	6.8943	0.41	2.66			5.52	9.22			44.19	0.47				
21/3/121	191.71	6.8998	0.41	2.83			5.52	8.55			44.19	0.6				
21/3/136	191.86	6.9041	0.41	2.63			5.52	9.22			44.19	0.44				
21/4/7	192.07	6.9102	0.41	2.7			5.52	9.08			44.19	0.49				
21/4/36	192.36	6.9187	0.41	2.74			5.52	8.92			44.19	0.5				
21/4/52	192.52	6.9233	0.41	2.68			5.52	9.76			52.56	0.41	44.19	0.41		
21/4/73	192.73	6.9294	0.41	2.59			5.52	9.73			52.56	0.44	44.19	0.44		
21/4/96	192.96	6.9361	0.41	2.9			5.52	9.31			44.19	0.58				
21/4/112	193.12	6.9408	0.41	2.96			5.52	8.67			44.19	0.58				
21/4/133	193.33	6.9469	0.41	2.73			5.52	8.85			44.19	0.5				
21/5/0 avg	193.50	6.9518	0.41	2.9			5.52	8.66			44.19	0.61				
21/5/22	193.72	6.9582	0.41	2.88			5.52	8.89			44.19	0.53				
21/5/42	193.92	6.964	0.41	3			5.52	8.14			44.19	0.57				
21/5/62	194.12	6.9698	0.41	2.65			5.52	8.98			52.56	0.47	44.19	0.47		
21/5/84	194.34	6.9762	0.41	2.81			5.52	8.19			44.19	0.76				
21/5/102	194.52	6.9814	0.41	2.58			5.52	8.23			52.56	0.74	44.19	0.74		
21/5/122	194.72	6.9872	0.41	2.52			5.52	9.15			52.56	0.62	44.19	0.62		
21/5/140	194.90	6.9925	0.41	2.68			5.52	8.82			44.19	0.69				
21/6/7	195.07	6.9974	0.41	2.65			5.52	8.9			44.19	0.63				
21/6/33	195.33	7.005	0.41	2.79			5.52	8.55			44.19	0.74				
21/6/49 avg	195.49	7.0096	0.41	2.57			5.52	8.52			44.19	0.68				
21/6/66	195.66	7.0145	0.41	2.54			5.52	8.51			44.19	0.72				
21/6/87	195.87	7.0206	0.41	2.59			5.52	8.39			44.19	0.74				
21/6/107	196.07	7.0265	0.41	2.46			5.52	8.82			44.19	0.78				
21/6/134	196.34	7.0343	0.41	2.63			5.52	8.47			44.19	0.74				
21/7/0	196.50	7.039	0.41	2.48			5.52	7.88			44.19	1.03				
21/7/22	196.72	7.0453	0.41	2.56			5.52	8.36			44.19	0.76				
21CC/6	197.00	7.0535	0.41	2.52			5.52	7.95			44.19	1.01				
22/1/1	197.11	7.0567	0.41	2.78			5.52	8.69			44.19	0.67				
22/1/16	197.26	7.061	0.41	2.82			5.52	8.37			44.19	0.59				
22/1/38 avg	197.48	7.0674	0.41	2.71			5.52	8.63			44.19	0.61				
22/1/58	197.68	7.0732	0.41	2.78			5.52	8.77			44.19	0.62				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
22/1/84	197.94	7.0808	0.41	2.58			5.52	8.6			44.19	0.67				
22/1/104	198.14	7.0866	0.41	2.75			5.52	8.62			44.19	0.67				
22/1/122	198.32	7.0918	0.41	2.83			5.52	8.8			44.19	0.58				
22/1/142	198.52	7.0976	0.41	2.89			5.52	8.38			44.19	0.61				
22/2/13	198.73	7.1037	0.41	2.61			5.52	8.11			44.19	0.72				
22/2/32	198.92	7.1093	0.41	2.51			5.52	8.52			52.56	0.74				
22/2/54	199.14	7.1157	0.41	2.4			6.57	8.89			52.56	0.66				
22/2/74	199.34	7.1215	0.41	2.41			5.52	8.57			44.19	0.66				
22/2/93 avg	199.53	7.127	0.41	2.5			5.52	9.01			44.19	0.57				
22/2/112	199.72	7.1325	0.41	2.51			5.52	8.86			52.56	0.58				
22/2/133	199.93	7.1386	0.41	2.43			5.52	8.65			44.19	0.7				
22/3/1	200.11	7.1438	0.41	2.43			5.52	8.51			52.56	0.66	44.19	0.66		
22/3/15	200.25	7.1479	0.41	2.39			5.52	8.71			52.56	0.59				
22/3/42	200.52	7.1557	0.41	2.52			5.52	8.48			44.19	0.72				
22/3/56	200.66	7.1598	0.41	2.32			5.52	8.6			52.56	0.69				
22/3/82	200.92	7.1674	0.41	2.36			5.52	8.86			52.56	0.67	44.19	0.67		
22/3/95	201.05	7.1711	0.41	2.46			5.52	9.04			52.56	0.63	44.19	0.63		
22/3/117	201.27	7.1775	0.41	2.45			5.52	9.17			52.56	0.56				
22/3/132 avg	201.42	7.1819	0.41	2.51			5.52	8.96			44.19	0.57				
22/4/7	201.67	7.1892	0.41	2.76			5.52	8.99			44.19	0.66				
22/4/33	201.93	7.1967	0.41	2.41			5.52	9.11			44.19	0.64				
22/4/73	202.33	7.2083	0.41	2.37			5.52	9.33			44.19	0.65				
22/4/92	202.52	7.2139	0.41	2.49			5.52	8.96			44.19	0.71				
22/4/113	202.73	7.22	0.41	2.26			6.57	9.33			52.56	0.61				
22/4/133	202.93	7.2258	0.41	2.16			6.57	9.34			52.56	0.56				
22CC/7	203.17	7.2327	0.41	3.01			4.65	8.37			44.19	0.77				
23/1/1	206.71	7.3463	0.41	2.51			5.52	8.8			44.19	0.45				
23/1/15	206.85	7.3508	0.41	2.48			5.52	8.93			52.56	0.51				
23/1/43 avg	207.13	7.3599	0.41	2.41			5.52	8.88			52.56	0.59				
23/1/58	207.28	7.3647	0.41	2.47			5.52	8.45			44.19	0.58				
23/1/78	207.48	7.3712	0.41	2.48			5.52	8.55			52.56	0.61	44.19	0.61		
23/1/103	207.73	7.3793	0.41	2.46			5.52	8.77			52.56	0.6	44.19	0.6		
23/1/118	207.88	7.3841	0.41	2.46			5.52	9.05			52.56	0.51				
23/1/142	208.12	7.3919	0.41	2.26			5.52	9.44			52.56	0.43				
23/2/6	208.26	7.3964	0.41	2.41			5.52	9.1			52.56	0.49				
23/2/32	208.52	7.4048	0.41	2.3			5.52	9.37			52.56	0.4	44.19	0.4		
23/2/53	208.73	7.4116	0.41	2.34			5.52	9.26			52.56	0.54				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
23/2/86	209.06	7.4222	0.41	2.28			5.52	9.17			52.56	0.55	44.19	0.55		
23/2/107 avg	209.27	7.429	0.41	2.32			5.52	9.19			52.56	0.43				
23/2/134	209.54	7.4377	0.41	2.41			5.52	8.99			52.56	0.45				
23/3/0	209.70	7.4429	0.41	2.37			5.52	8.92			52.56	0.52				
23/3/15	209.85	7.4477	0.41	2.29			5.52	9.08			52.56	0.48				
23/3/42	210.12	7.4565	0.41	2.47			5.52	8.92			44.19	0.53				
23/3/63	210.33	7.4633					6.57	8.72			44.19	1.1				
23/3/83	210.53	7.4697	0.41	2.48			5.52	8.77			52.56	0.38				
23/3/102	210.72	7.4759	0.41	2.63			5.52	8.61			44.19	0.48				
23/3/117	210.87	7.4807	0.41	2.65			5.52	8.43			44.19	0.52				
23/3/136	211.06	7.4868	0.41	2.42			5.52	8.67			52.56	0.45				
23/4/7 avg	211.27	7.4936	0.41	2.46			5.52	8.27			52.56	0.54				
23/4/32	211.52	7.5017	0.41	2.31			5.52	8.98			52.56	0.49				
23/4/52	211.72	7.5082	0.41	2.37			5.52	8.99			52.56	0.46				
23/4/73	211.93	7.5149	0.41	2.36			5.52	8.99			52.56	0.53				
23/4/93	212.13	7.5214	0.41	2.45			5.52	8.55			44.19	0.69				
23/4/112	212.32	7.5276	0.41	2.34			5.52	8.83			44.19	0.64				
23/4/133	212.53	7.5343	0.41	2.26			6.57	9.17			52.56	0.56	44.19	0.56		
23/5/1	212.71	7.5402	0.41	2.3			6.57	8.47			44.19	0.66				
23/5/24	212.94	7.5476	0.41	2.26			6.57	9.04			52.56	0.62	44.19	0.62		
23/5/42	213.12	7.5534	0.41	2.24			6.57	8.91			44.19	0.68				
23/5/83 avg	213.53	7.5666	0.41	2.3			5.52	8.81			52.56	0.63	44.19	0.63		
23/5/102	213.72	7.5728	0.41	2.3			6.57	8.91			44.19	0.56				
23/5/122	213.92	7.5792	0.41	2.23			6.57	8.93			52.56	0.56				
23/5/142	214.12	7.5857	0.41	2.4			5.52	8.59			52.56	0.51				
23/6/7	214.27	7.5906	0.41	2.32			5.52	8.96			44.19	0.61				
23/6/31	214.51	7.5983	0.41	2.27			6.57	8.95			52.56	0.55				
23/6/52	214.72	7.6051	0.41	2.38			6.57	8.85			52.56	0.56				
23/6/85	215.05	7.6158	0.41	2.37			6.57	9			52.56	0.49				
23/6/111	215.31	7.6242	0.41	2.26			6.57	9.42			52.56	0.49				
23/6/133	215.53	7.6313	0.41	2.18			6.57	9.42			52.56	0.59				
23/7/1 avg	215.71	7.6371	0.41	2.23			6.57	9.32			52.56	0.54				
23/7/23	215.93	7.6442	0.41	2.32			6.57	9.13			52.56	0.57				
23CC/7	216.22	7.6536	0.41	2.16			6.57	9.04			52.56	0.69				
24/1/1	216.31	7.6565	0.41	2.23			5.52	8.61			52.56	0.57				
24/1/27	216.57	7.6649	0.41	2.19			6.57	8.93			52.56	0.5				
24/1/43	216.73	7.67	0.41	2.27			6.57	8.75			52.56	0.57	44.19	0.57		

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
24/1/64	216.94	7.6768	0.41	2.09			6.57	9.16			44.19	0.97				
24/1/82	217.12	7.6826	0.41	2.08	0.35	2.08	6.57	9.35			52.56	0.74				
24/1/104	217.34	7.6897	0.41	2.05			6.57	9.9			44.19	0.68				
24/1/123	217.53	7.6959	0.41	1.94			6.57	10.27			52.56	0.6				
24/1/142 avg	217.72	7.702	0.41	1.95			6.57	10.12			52.56	0.62				
24/2/12	217.92	7.7085	0.41	2.01			6.57	10.1			52.56	0.63				
24/2/28	218.08	7.7136	0.41	1.98			6.57	10.04			52.56	0.59				
24/2/46	218.26	7.7195	0.41	2			6.57	9.91			52.56	0.58				
24/2/72	218.52	7.7279	0.41	2.06			6.57	9.76			52.56	0.47				
24/2/87	218.67	7.7327	0.41	2.09			6.57	9.48			52.56	0.49				
24/2/107	218.87	7.7392	0.41	2.19	0.35	2.19	6.57	9.28			52.56	0.54				
24/2/135	219.15	7.7482	0.41	2.14	0.35	2.14	6.57	9.31			52.56	0.63				
24/3/1	219.31	7.7534	0.41	2.05			6.57	9.88			52.56	0.62				
24/3/23	219.53	7.7605	0.41	1.98			6.57	10.54			52.56	0.46				
24/3/42 avg	219.72	7.7666	0.41	1.96			6.57	10.61			52.56	0.46				
24/3/56	219.86	7.7712	0.41	1.99			6.57	10.46			52.56	0.43				
24/3/82	220.12	7.7796	0.41	1.99			6.57	10.06			52.56	0.59				
24/3/102	220.32	7.786	0.41	1.91			6.57	10.14			52.56	0.62				
24/3/116	220.46	7.7905	0.41	2.06			6.57	9.9			52.56	0.66				
24/3/133	220.63	7.796	0.41	2.05			6.57	9.57			52.56	0.71				
24/4/7	220.87	7.8038	0.41	2.01			6.57	9.77			52.56	0.66				
24/4/32	221.12	7.8119	0.41	2.02			6.57	9.99			52.56	0.52				
24/4/47	221.27	7.8167	0.41	1.94			6.57	10.28			52.56	0.55				
24/4/72	221.52	7.8248	0.41	2.07			6.57	9.54			52.56	0.65	44.19	0.65		
24/4/86 avg	221.66	7.8293	0.41	2.12			6.57	9.97			52.56	0.49				
24/4/112	221.92	7.8377	0.41	2.09			6.57	9.98			52.56	0.54				
24/4/133	222.13	7.8445	0.41	2.07			6.57	9.8			52.56	0.56				
24/5/1	222.31	7.8503	0.41	2.2			6.57	9.68			52.56	0.53				
24/5/15	222.45	7.8548	0.41	2.26			6.57	9.49			52.56	0.5				
24/5/43	222.73	7.8639	0.41	2.27			6.57	9.35			52.56	0.55				
24/5/63	222.93	7.8703	0.41	2.18			6.57	10.19			52.56	0.44				
24/5/84	223.14	7.8771	0.41	2.09			6.57	10.28			52.56	0.4				
24/5/103	223.33	7.8833	0.41	2.15			6.57	9.98			52.56	0.46				
24/5/118	223.48	7.8881	0.41	2.2			6.57	9.78			52.56	0.55				
24/5/142 avg	223.72	7.8959	0.41	2.1			6.57	10.03			52.56	0.53				
24/6/7	223.87	7.9007	0.41	2.14			6.57	9.66			52.56	0.55				
24/6/27	224.07	7.9072	0.41	1.99			6.57	10.04			52.56	0.63				

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24/6/47	224.27	7.9136	0.41	1.98			6.57	10.1			52.56	0.64				
24/6/67	224.47	7.9201	0.41	2.13			6.57	10			52.56	0.57				
24/6/86	224.66	7.9262	0.41	2.03			6.57	9.94			52.56	0.59				
24/6/107	224.87	7.933	0.41	2.01			6.57	10.26			52.56	0.53				
24/6/132	225.12	7.9411	0.41	2.06			6.57	9.58			52.56	0.66				
24CC/9	225.36	7.9489	0.41	2.09			6.57	9.17			52.56	0.78				
25/1/1	225.91	7.9666	0.41	2.08			5.52	9.01			44.19	0.82				
25/1/23	226.13	7.9737	0.41	1.97			6.57	8.99			44.19	0.8				
25/1/42 avg	226.32	7.9799	0.41	1.98			6.57	9.23			44.19	0.84				
25/1/63	226.53	7.9867	0.41	2.07			6.57	8.49			44.19	0.86				
25/1/85	226.75	7.9938	0.41	2.04			5.52	8.61			44.19	0.84				
25/1/103	226.93	7.9996	0.41	2.15			5.52	8.69			52.56	0.78	44.19	0.78		
25/1/125	227.13	8.006	0.41	2.19			5.52	8.72			52.56	0.66				
25/1/144	227.34	8.0128	0.41	2.24	0.35	2.24	6.57	8.25			52.56	0.78				
25/2/5	227.45	8.0164	0.41	2.2			6.57	8.36	5.52	8.36	52.56	0.76	44.19	0.76		
25/2/32	227.72	8.0251	0.41	2.17			6.57	8.42			44.19	0.74				
25/2/53	227.93	8.0319	0.41	2.19			6.57	8.58			44.19	0.76				
25/2/72	228.12	8.038	0.41	2.1			6.57	8.55			52.56	0.77				
25/2/95	228.35	8.0455	0.41	2.03			6.57	8.63			52.56	0.83				
25/2/112 avg	228.52	8.051	0.41	1.99			6.57	9.04			52.56	0.83				
25/2/134	228.74	8.0581	0.41	2.07			6.57	8.6			52.56	0.87				
25/3/0	228.90	8.0632	0.41	2.09			5.52	8.43			52.56	0.87				
25/3/23	229.13	8.0707	0.41	2.14			5.52	8.39			52.56	0.85	44.19	0.85		
25/3/43	229.33	8.0771	0.41	2.1			6.57	8.53	5.52	8.53	52.56	0.8				
25/3/63	229.53	8.0836	0.41	2.02			5.52	8.64			44.19	0.85				
25/3/95	229.85	8.0939	0.41	2.05			6.57	8.81			52.56	0.81				
25/3/118	230.08	8.1014	0.41	2.12			6.57	8.55			52.56	0.76				
25/3/137	230.27	8.1075	0.41	2.03			6.57	8.52			52.56	0.94				
25/4/7	230.47	8.114	0.41	2.16			6.57	8.57			52.56	0.75				
25/4/32	230.72	8.122	0.41	2.2			6.57	8.98			44.19	0.61				
25/4/53 avg	230.93	8.1288	0.41	2.23			6.57	8.71			44.19	0.59				
25/4/74	231.14	8.1356	0.41	2.11			6.57	8.99			52.56	0.62				
25/4/93	231.33	8.1417	0.35	2.04			6.57	9.3			52.56	0.56				
25/4/112	231.52	8.1479	0.41	2.25			6.57	8.67			52.56	0.52				
25/4/133	231.73	8.1547	0.41	2.3	0.35	2.3	6.57	8.42			52.56	0.61				
25/5/1	231.91	8.1605	0.41	2.26			6.57	8.57			52.56	0.49				
25/5/16	232.06	8.1653	0.41	2.26			6.57	8.56			52.56	0.6				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
25/5/38	232.28	8.1724	0.41	2.12			6.57	8.35			52.56	0.71				
25/5/62	232.52	8.1802	0.41	2.18			6.57	8.86			52.56	0.7				
25/5/82	232.72	8.1867	0.41	2.16			5.52	8.58			52.56	0.73	44.19	0.73		
25/5/102 avg	232.92	8.1931	0.41	2.11			6.57	9.07			52.56	0.67				
25/5/117	233.07	8.198	0.41	2.11			6.57	8.74			52.56	0.72				
25/5/137	233.27	8.2044	0.41	2.06			6.57	9.16			52.56	0.68				
25/6/7	233.47	8.2109	0.41	2.07			5.52	9.09			52.56	0.69				
25/6/27	233.67	8.2173	0.41	1.98			6.57	9.33			52.56	0.71				
25/6/48	233.88	8.2241	0.41	2.05			5.52	8.94			52.56	0.63	44.19	0.63		
25/6/75	234.15	8.2329	0.41	1.97			6.57	8.89			52.56	0.87				
25/6/93	234.33	8.2387	0.41	2.04			5.52	8.98			52.56	0.78				
25/6/112	234.52	8.2448	0.41	2.02			5.52	9			52.56	0.72	44.19	0.72		
25/6/133	234.73	8.2516	0.41	2.12			5.52	9.02			52.56	0.67				
25/7/1	234.91	8.2574	0.41	2.03			5.52	8.91			52.56	0.79				
25/7/17 avg	235.07	8.2626	0.41	2.14			5.52	8.34			52.56	0.84				
25cc/10	235.26	8.2687	0.41	2.06			5.52	8.47			52.56	0.74				
26/1/1	235.51	8.2768	0.41	1.86			6.57	8.67			44.19	0.76				
26/1/23	235.73	8.2839	0.41	2.11			6.57	8.45			52.56	0.58				
26/1/58	236.08	8.2952	0.41	2.06	0.35	2.06	6.57	8.6			52.56	0.59				
26/1/82	236.32	8.303	0.41	2.12			6.57	8.34			52.56	0.58				
26/1/102	236.52	8.3094	0.41	2.14			6.57	8.21			52.56	0.58				
26/1/117	236.67	8.3143	0.41	2.1			6.57	8.41			52.56	0.67				
26/1/142	236.92	8.3224	0.41	2.04			6.57	8.36			52.56	0.72	44.19	0.72		
26/2/13	237.13	8.3291	0.41	2.04			6.57	8.12			52.56	0.8				
26/2/32 avg	237.32	8.3353	0.41	2.06			6.57	8.42			44.19	0.72				
26/2/56	237.56	8.343	0.41	2.1			6.57	8.32			52.56	0.67				
26/2/93	237.93	8.355	0.41	1.99			6.57	8.57			52.56	0.73	44.19	0.73		
26/2/112	238.12	8.3611	0.41	1.96			5.52	8.26			44.19	0.97				
26/2/133	238.33	8.3679	0.41	1.89			6.57	8.67			44.19	1.03				
26/3/1	238.51	8.3737	0.41	1.98			5.52	8.57			44.19	0.87				
26/3/22	238.72	8.3805	0.41	1.96			6.57	9.01			44.19	0.78				
26/3/43	238.93	8.3873	0.41	2.02			6.57	8.77			44.19	0.78				
26/3/56	239.06	8.3915	0.41	1.91			6.57	9.28			52.56	0.69	44.19	0.69		
26/3/82	239.32	8.3999	0.41	1.94			6.57	8.82			52.56	0.85				
26/3/102	239.52	8.4064	0.41	2.02			6.57	8.8			52.56	0.86				
26/3/117 avg	239.67	8.4112	0.41	1.96			6.57	8.88			44.19	0.86				
26/3/133	239.83	8.4164	0.41	1.91			6.57	9.04			52.56	0.9	44.19	0.9		

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
26/4/7	240.07	8.4241	0.41	1.94			6.57	8.83			52.56	1.06				
26/4/32	240.32	8.4322	0.41	1.78			6.57	9.3			52.56	0.91				
26/4/52	240.52	8.4387	0.41	1.81			6.57	9.49			52.56	0.61				
26/4/72	240.72	8.4451	0.41	1.88			6.57	9.35			52.56	0.67				
26/4/92	240.92	8.4516	0.41	1.8	0.35	1.8	6.57	9.27			52.56	0.83				
26/4/112	241.12	8.458	0.41	1.77			6.57	9.35			52.56	0.75				
26/4/132	241.32	8.4645	0.41	1.9			6.57	9.08			52.56	0.71				
26/5/0	241.50	8.4703	0.41	1.76			6.57	9.27			52.56	0.88				
26/5/15	241.65	8.4752	0.41	1.86			6.57	9			52.56	0.98				
26/5/42 avg	241.92	8.4839	0.41	1.87			6.57	9.01			52.56	0.94				
26/5/63	242.13	8.4907	0.41	1.88			6.57	9.18			52.56	0.8				
26/5/82	242.32	8.4968	0.41	1.82			6.57	9.38			52.56	0.82				
26/5/102	242.52	8.5033	0.41	1.93			6.57	9.02			52.56	0.75				
26/5/117	242.67	8.5081	0.41	2.16			6.57	8.78			52.56	0.63				
26/5/142	242.92	8.5162	0.41	2.11			6.57	8.77			52.56	0.6				
26/6/7	243.07	8.5211	0.41	2.44			6.57	8.48			44.19	0.71				
26/6/26	243.26	8.5272	0.35	2			6.57	8.63			52.56	0.94				
26/6/47	243.47	8.534	0.35	2.47			6.57	7.45			52.56	0.63				
26/6/63	243.63	8.5391	0.35	2.72			6.57	7.09			52.56	0.5				
26cc/13	243.86	8.5466	0.41	2.53			6.57	7.28			52.56	0.67				
27/1/1 avg	245.11	8.587	0.41	2.65			6.57	7.32			52.56	0.69				
27/1/25	245.35	8.5947	0.35	2.48			6.57	7.33			52.56	0.58				
27/1/43	245.53	8.6005	0.35	2.52			6.57	7.58			52.56	0.84				
27/1/65	245.75	8.6076	0.35	2.78			5.52	6.44			52.56	0.61				
27/1/81	245.91	8.6128	0.35	3.03			5.52	6.87			52.56	0.53	44.19	0.53		
27/1/96	246.06	8.6177	0.35	2.9			5.52	6.27			52.56	0.55				
27/1/117	246.27	8.6244	0.35	3.07			5.52	6.4			44.19	0.55				
27/1/142	246.52	8.6325	0.35	3.1			5.52	6.5			44.19	0.69				
27/2/5	246.65	8.6367	0.35	2.82			6.57	6.66			52.56	0.65				
27/2/27	246.87	8.6438	0.35	2.79			6.57	6.29			52.56	0.6				
27/2/53	247.13	8.6522	0.41	2.39			6.57	7.05			52.56	0.65				
27/2/73 avg	247.33	8.6587	0.41	2.17			6.57	7.84			52.56	1.01				
27/2/93	247.53	8.6651	0.41	2.16			6.57	7.94			52.56	1.07	44.19	1.07		
27/2/107	247.67	8.6697	0.41	2.14			6.57	8.16			52.56	0.98				
27/2/132	247.92	8.6778	0.41	2.29			6.57	7.83			52.56	0.84				
27/3/1	248.11	8.6839	0.41	2.14			6.57	8.04			52.56	1.05				
27/3/16	248.26	8.6887	0.41	2.13			6.57	8.33			52.56	0.9	44.19	0.9		

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
27/3/37	248.47	8.6955	0.41	2.07			6.57	8.22			52.56	1.02				
27/3/56	248.66	8.7017	0.41	2.09			6.57	8.07			52.56	1.17	44.19	1.17		
27/3/83	248.93	8.7104	0.41	2.21			6.57	7.88			52.56	0.98				
27/3/104	249.14	8.7172	0.41	2.3			6.57	7.48			52.56	1.12				
27/3/117	249.27	8.7214	0.41	2.35			6.57	7.53			52.56	1.01				
27/3/142 avg	249.52	8.7294	0.41	2.39			6.57	7.41			52.56	0.97				
27/4/7	249.67	8.7343	0.41	2.37			6.57	7.13			44.19	0.88				
27/4/32	249.92	8.7424	0.41	2.56			6.57	6.92	5.52	6.92	44.19	0.72				
27/4/52	250.12	8.7488	0.41	2.53			6.57	7.12			44.19	0.79				
27/4/67	250.27	8.7537	0.41	2.36			6.57	7.33			44.19	0.89				
27/4/86	250.46	8.7598	0.41	2.61			5.52	6.83			52.56	0.76				
27/4/112	250.72	8.7682	0.41	2.81			5.52	7.6			44.19	0.67				
27/4/132	250.92	8.7747	0.41	2.6			5.52	7.8			44.19	0.68				
27/5/0	251.10	8.7805	0.41	2.53			5.52	8.34			44.19	0.75				
27/5/23	251.33	8.7879	0.41	2.55			5.52	8.38			52.56	0.73				
27/5/38	251.48	8.7928	0.41	2.55			5.52	8.07			44.19	0.79				
27/5/57 avg	251.67	8.7989	0.41	2.6			5.52	8.11			44.19	0.72				
27/5/83	251.93	8.8073	0.41	2.58			5.52	7.69			44.19	0.74				
27/5/105	252.13	8.8138	0.41	2.53			5.52	7.93			44.19	0.78				
27/5/118	252.28	8.8186	0.41	2.64			5.52	7.77			44.19	0.74				
27/5/143	252.53	8.8267	0.41	2.53			5.52	8.01			52.56	0.64				
27/6/7	252.67	8.8312	0.41	2.44			5.52	8.16			44.19	0.77				
27/6/32	252.92	8.8393	0.41	2.51			5.52	7.91			44.19	0.81				
27/6/53	253.13	8.8461	0.41	2.48			6.57	8.39			52.56	0.7				
27/6/73	253.33	8.8525	0.41	2.44			6.57	8.18			52.56	0.59				
27/6/87	253.47	8.8571	0.41	2.37			6.57	8.4			52.56	0.7				
27/6/107	253.67	8.8635	0.41	2.43			6.57	8.45			52.56	0.7				
27/6/132 avg	253.92	8.8716	0.41	2.43			6.57	8.35			52.56	0.55				
27/7/0	254.10	8.8774	0.41	2.14			6.57	8.79			52.56	0.72				
27/7/17	254.27	8.8829	0.41	2.06			6.57	8.89			52.56	0.72				
27CC/10	254.49	8.89	0.41	2.13			6.57	9.07			52.56	0.67				
28/1/4	254.74	8.8995	0.41	2.13			6.57	8.84			52.56	0.56				
28/1/23	254.93	8.9067	0.41	1.95			6.57	9.62			52.56	0.58				
28/1/42	255.12	8.9139	0.41	2.12			5.52	9.29			52.56	0.59	44.19	0.59		
28/1/58	255.28	8.9199	0.41	2.08			6.57	9.25			52.56	0.61				
28/1/83	255.53	8.9294	0.41	2.04			6.57	9.03			52.56	0.69				
28/1/103	255.73	8.937	0.41	2.1			6.57	8.91			52.56	0.63				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
28/1/121 avg	255.91	8.9438	0.41	2.01			6.57	9.12			52.56	0.68				
28/1/141	256.11	8.9513	0.41	2.05			6.57	8.95			52.56	0.64				
28/2/7	256.27	8.9574	0.41	2.05			6.57	8.88			52.56	0.67				
28/2/33	256.53	8.9672	0.41	1.94			6.57	9.07			52.56	0.67				
28/2/54	256.74	8.9752	0.41	1.88			6.57	9.16			52.56	0.67				
28/2/83	257.03	8.9862	0.41	1.93			6.57	9.04			52.56	0.76				
28/2/98	257.18	8.9919	0.41	1.91	0.35	1.91	6.57	9.02			44.19	0.78				
28/2/113	257.33	8.9975	0.41	1.94			6.57	9.17			44.19	0.78				
28/2/133	257.53	9.0051	0.41	1.94	0.35	1.94	6.57	8.97			44.19	0.86				
28/3/1	257.71	9.0119	0.35	1.98			6.57	8.98			52.56	0.76				
28/3/25	257.95	9.021	0.35	1.88			6.57	9.3			52.56	0.7				
28/3/42	258.12	9.0274	0.41	1.8			6.57	9.29			44.19	0.94				
28/3/55	258.25	9.0324	0.41	1.73			6.57	9.42			52.56	0.74				
28/3/84 avg	258.54	9.0433	0.41	1.9			6.57	9.15			52.56	0.65				
28/3/118	258.88	9.0562	0.41	1.95			6.57	9.02			52.56	0.7				
28/3/137	259.07	9.0634	0.41	1.99			6.57	9.03			52.56	0.72				
28/4/6	259.26	9.0706	0.41	1.88			6.57	9.38			52.56	0.68				
28/4/33	259.53	9.0808	0.41	1.93			6.57	9.01			44.19	0.72				
28/4/47	259.67	9.0861	0.41	1.9			6.57	9.19			44.19	0.85				
28/4/66	259.86	9.0933	0.41	1.98			6.57	8.94			52.56	0.74				
28/4/93	260.13	9.1035	0.41	1.89			6.57	9.05			44.19	0.76				
28/4/108	260.28	9.1092	0.41	2.01			6.57	8.97			52.56	0.61				
28/4/134	260.54	9.1191	0.41	2			6.57	8.79			52.56	0.69				
28/5/1	260.71	9.1255	0.41	1.77			6.57	9.65			52.56	0.45				
28/5/16	260.86	9.1312	0.41	2.01			6.57	8.98			52.56	0.61				
28/5/42	261.12	9.141	0.41	1.99			6.57	8.89			52.56	0.71				
28/5/61	261.31	9.1482	0.35	1.95			6.57	8.99			52.56	0.85				
28/5/85	261.55	9.1573	0.41	2.1			6.57	8.75			52.56	0.64				
28/5/102	261.72	9.1637	0.35	1.87			6.57	9.07			44.19	0.88				
28/5/121	261.91	9.1709	0.35	1.86			6.57	9.02			52.56	0.88				
28/5/141	262.11	9.1785	0.35	1.96			6.57	8.89			52.56	0.89				
28/6/8	262.28	9.185	0.35	1.9			6.57	9.13			52.56	0.82				
28cc/8	262.45	9.1914	0.41	2.02	0.35	2.02	6.57	8.97			52.56	0.69				
29/1/0	264.30	9.2614	0.41	2.06			6.57	8.71			52.56	0.82				
29/1/34	264.64	9.2743	0.41	1.92			6.57	9.3			52.56	0.73				
29/1/58	264.88	9.2834	0.35	2.05			6.57	9.3			52.56	0.66				
29/1/80	265.10	9.2917	0.35	2.02			6.57	9.15			52.56	0.85				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
29/1/96 avg	265.26	9.2978	0.35	1.99			6.57	9.27			52.56	0.86				
29/1/117	265.47	9.3057	0.41	1.86	0.35	1.86	6.57	9.2			52.56	0.93	44.19	0.93		
29/1/142	265.72	9.3152	0.41	1.97	0.35	1.97	6.57	9.08			52.56	0.78				
29/2/12	265.92	9.3228	0.41	1.99			6.57	9.19			44.19	0.75				
29/2/32	266.12	9.3303	0.41	1.97			5.52	9.12			52.56	0.78				
29/2/46	266.26	9.3356	0.41	2.09			6.57	8.92			52.56	0.66				
29/2/64	266.44	9.3425	0.41	1.94			6.57	9.04			52.56	0.73	44.19	0.73		
29/2/85	266.65	9.3504	0.41	1.9			6.57	9.3			52.56	0.69				
29/2/107	266.87	9.3587	0.41	1.92			6.57	9.25			52.56	0.61				
29/2/133	267.13	9.3686	0.41	1.94	0.35	1.94	6.57	9			44.19	0.75				
29/3/1	267.31	9.3754	0.41	1.99			6.57	9			44.19	0.66				
29/3/23 avg	267.53	9.3837	0.41	1.92			6.57	9.58			44.19	0.63				
29/3/42	267.72	9.3909	0.35	1.52			6.57	10.01			52.56	0.59				
29/3/57	267.87	9.3966	0.41	1.98			6.57	9.41			52.56	0.59				
29/3/84	268.14	9.4068	0.41	1.86			6.57	9.67			52.56	0.64				
29/3/104	268.34	9.4144	0.41	1.92			6.57	9.78			52.56	0.59				
29/3/117	268.47	9.4193	0.41	1.88			6.57	9.82			52.56	0.54				
29/3/138	268.68	9.4273	0.41	2.08			6.57	9.37			52.56	0.5				
29/4/6	268.86	9.4341	0.41	1.96			6.57	9.36			52.56	0.74				
29/4/48	269.28	9.45	0.41	1.94			5.52	9.23			44.19	0.68				
29/4/72	269.52	9.4783	0.41	2.01			5.52	9.4			52.56	0.6	44.19	0.6		
29/4/95	269.75	9.5055	0.41	2.02			6.57	9.4			52.56	0.68	44.19	0.68		
29/4/107	269.87	9.5197	0.41	1.99			5.52	9.43			52.56	0.55	44.19	0.55		
29/4/135	270.15	9.5527	0.41	1.95			5.52	9.57			52.56	0.52				
29/5/1	270.31	9.5716	0.41	1.97			5.52	9.53			52.56	0.62	44.19	0.62		
29/5/15	270.45	9.5881	0.41	1.86			5.52	9.3			44.19	0.77				
29/5/42 avg	270.72	9.62	0.41	1.97			5.52	9.08			44.19	0.68				
29/5/61	270.91	9.6259	0.35	1.81			6.57	8			37.16	1.39				
29/5/85	271.15	9.6334	0.41	1.81	0.35	1.81	6.57	7.12			44.19	1.94				
29/5/104	271.34	9.6394	0.41	1.66	0.35	1.66	6.57	7.07			31.25	1.77				
29/5/118	271.48	9.6438	0.35	1.66			6.57	7.39			44.19	2.09				
29/5/142	271.72	9.6513	0.41	2.18	0.35	2.18	6.57	8.68			52.56	0.51				
29/6/14	271.94	9.6581	0.35	1.95			6.57	9.07			52.56	0.89				
29cc/17	272.19	9.6659	0.41	1.97			6.57	9.24			52.56	0.55	44.19	0.55		
30/1/1	273.91	9.7197	0.41	2.11	0.58	2.1	6.57	8.74			52.56	0.58				
30/1/14	274.04	9.7238	0.41	2.02			6.57	9.34			44.19	0.55				
30/1/42	274.32	9.7325	0.41	2.07			5.52	9.81			52.56	0.48	44.19	0.48		

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
30/1/58	274.48	9.7375	0.41	2.01			6.57	9.81	5.52	9.81	52.56	0.51	44.19	0.51		
30/1/82	274.72	9.745	0.41	2.1			5.52	9.64			52.56	0.58				
30/1/103	274.93	9.7516	0.41	2.12			5.52	9.32			52.56	0.67				
30/1/122 avg	275.12	9.7575	0.41	2.18			5.52	9.7			44.19	0.49				
30/1/141	275.31	9.7635	0.41	2.19			5.52	9.69			52.56	0.57				
30/2/5	275.45	9.7679	0.41	2.14	0.35	2.14	5.52	9.27			44.19	0.53				
30/2/32	275.72	9.7763	0.41	2.09			6.57	9.32			52.56	0.57				
30/2/53	275.93	9.7829	0.35	1.97			6.57	9.72			52.56	0.66				
30/2/92	276.32	9.795	0.41	1.97	0.35	1.97	6.57	9.61			52.56	0.56	44.19	0.56		
30/2/112	276.52	9.8013	0.41	1.98	0.35	1.98	6.57	9.53			52.56	0.52				
30/2/133	276.73	9.8079	0.41	2.02			6.57	9.49			52.56	0.57				
30/3/1	276.91	9.8135	0.41	1.96			6.57	9.88			52.56	0.57				
30/3/15	277.05	9.8179	0.41	2.13			6.57	9.76			52.56	0.49				
30/3/43	277.33	9.8266	0.41	2.06	0.35	2.06	6.57	9.61			52.56	0.59				
30/3/65	277.55	9.8335	0.41	1.89	0.35	1.89	6.57	9.98			52.56	0.53				
30/3/84	277.74	9.8394	0.35	1.93			6.57	9.76			52.56	0.61				
30/3/103	277.93	9.8454	0.41	2.1			6.57	9.67			52.56	0.55				
30/3/117	278.07	9.8497	0.41	2.09	0.35	2.09	6.57	9.38			52.56	0.58				
30/3/138 avg	278.28	9.8563	0.35	2.07			6.57	9.37			52.56	0.6				
30/4/9	278.49	9.8629	0.41	1.98			6.57	10.01			52.56	0.53				
30/4/32	278.72	9.8701	0.41	2.12	0.35	2.12	6.57	9.43			52.56	0.51				
30/4/48	278.88	9.8751	0.35	2.11			6.57	9.35			52.56	0.63				
30/4/73	279.13	9.8829	0.41	2.17			6.57	9.41			52.56	0.46				
30/4/93	279.33	9.8891	0.41	2.22	0.35	2.22	5.52	9.35			52.56	0.49				
30/4/113	279.53	9.8954	0.41	2.04	0.35	2.04	6.57	9.49			52.56	0.63				
30/4/135	279.75	9.9023	0.41	2.19			5.52	9.41			52.56	0.54				
30/5/6	279.96	9.9088	0.41	2.01			5.52	9.95			44.19	0.56				
30/5/15	280.05	9.9116	0.41	2.18			5.52	9.56			52.56	0.52	44.19	0.52		
30/5/35	280.25	9.9179	0.41	2.19	0.35	2.19	5.52	9.21			52.56	0.53	44.19	0.53		
30/5/84	280.74	9.9332	0.41	2.28			5.52	9.02			52.56	0.53				
30/5/102	280.92	9.9388	0.41	2.24			5.52	9.36			52.56	0.48				
31/1/1	283.51	10.0198	0.41	2.27			5.52	8.73			44.19	0.62				
31/1/17	283.67	10.0248	0.41	2.06			5.52	9.7			52.56	0.62	44.19	0.62		
31/1/44 avg	283.94	10.0332	0.41	2.03			5.52	9.65			44.19	0.67				
31/1/58	284.08	10.0376	0.41	1.98			5.52	10.1			44.19	0.61				
31/1/83	284.33	10.0454	0.41	1.94			5.52	9.89			44.19	0.69				
31/1/105	284.55	10.0523	0.41	2			5.52	9.74			44.19	0.6				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
31/1/118	284.68	10.0564	0.41	2.05			5.52	9.48			44.19	0.67				
31/1/138	284.88	10.0626	0.41	2.1			5.52	9.62			52.56	0.61	44.19	0.61		
31/2/9	285.09	10.0692	0.41	2.04			5.52	9.87			52.56	0.56	44.19	0.56		
31/2/29	285.29	10.0754	0.41	2			5.52	9.7			52.56	0.6				
31/2/48	285.48	10.0814	0.41	2.06			5.52	9.45			44.19	0.66				
31/2/73	285.73	10.0892	0.41	1.98			6.57	9.73			52.56	0.71				
31/2/88 avg	285.88	10.0939	0.41	2.05			6.57	9.81			52.56	0.66				
31/2/110	286.10	10.1007	0.41	2.03			6.57	9.47			52.56	0.68				
31/2/134	286.34	10.1083	0.41	2.04			5.52	9.38			44.19	0.67				
31/3/1	286.51	10.1136	0.41	1.95			5.52	9.67			52.56	0.6				
31/3/23	286.73	10.1204	0.41	2.11			5.52	9.3			52.56	0.64				
31/3/38	286.88	10.1251	0.41	2.09			5.52	9.38			52.56	0.64				
31/3/57	287.04	10.1301	0.41	2.15			5.52	9.36			52.56	0.59				
31/3/82	287.32	10.1389	0.41	2.1			5.52	9			52.56	0.62				
31/3/102	287.52	10.1451	0.41	2.1			5.52	9.3			52.56	0.54				
31/3/117	287.67	10.1498	0.41	2.06			5.52	9.73			52.56	0.49				
31/3/141	287.91	10.1573	0.41	1.98			6.57	9.74			52.56	0.57				
31/4/8	288.08	10.1626	0.41	1.97			6.57	9.59			52.56	0.51				
31/4/30	288.30	10.1695	0.41	2.01			6.57	9.54			52.56	0.53				
31/4/55 avg	288.55	10.1773	0.41	2.03			6.57	9.14			52.56	0.57				
31/4/70	288.70	10.182	0.41	1.89			6.57	9.84			52.56	0.52				
31/4/89	288.89	10.188	0.41	1.98			6.57	9.9			52.56	0.46				
31/4/110	289.10	10.1945	0.35	1.9			6.57	9.69			52.56	0.54				
31/4/134	289.34	10.202	0.41	1.99			6.57	9.65			52.56	0.48				
31/5/0	289.50	10.207	0.41	2.02	0.35	2.02	6.57	9.41			52.56	0.61				
31/5/23	289.73	10.2142	0.41	2.14			6.57	9.52			52.56	0.52				
31/5/43	289.93	10.2205	0.41	2.17	0.35	2.17	6.57	9.15			52.56	0.52				
31/5/62	290.12	10.2264	0.35	2.11			6.57	9.11			52.56	0.59				
31/5/83	290.33	10.233	0.41	2.11			6.57	9.09			52.56	0.53				
31/5/101	290.51	10.2386	0.35	2.14			6.57	9.32			52.56	0.51				
31/5/120	290.70	10.2445	0.41	2.2			5.52	9.65			44.19	0.46				
31cc/0	290.74	10.2458	0.41	1.92	0.35	1.92	6.57	9.39	5.52	9.39	52.56	0.51				
32/1/1	293.11	10.3199	0.41	2.31			5.52	8.75			52.56	0.48	44.19	0.48		
32/1/23	293.33	10.3267	0.41	2.08			6.57	9.25			52.56	0.44				
32/1/41	293.51	10.3324	0.41	2.11			6.57	9.02			52.56	0.42				
32/1/61	293.71	10.3386	0.35	2.12			6.57	8.86			52.56	0.45				
32/1/83	293.93	10.3455	0.35	1.98			6.57	9			52.56	0.53				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
32/1/102 avg	294.12	10.3514	0.35	2.08			6.57	9.16			52.56	0.49				
32/1/121	294.31	10.3574	0.41	2.19			5.52	9.09			52.56	0.46				
32/1/141	294.51	10.3636	0.41	2.21			5.52	9.05			52.56	0.45				
32/2/11	294.71	10.3699	0.41	2.04			5.52	9.45			52.56	0.44				
32/2/30	294.90	10.3758	0.41	2.18			5.52	9.65			52.56	0.3				
32/2/52	295.12	10.3827	0.41	2.19			5.52	9.38			52.56	0.38				
32/2/73	295.33	10.3893	0.41	2.08			5.52	9.2			52.56	0.52				
32/2/93	295.53	10.3955	0.41	2.14			5.52	9.25			52.56	0.45				
32/2/113	295.73	10.4018	0.35	2.12			6.57	8.91			52.56	0.51				
32/2/133	295.93	10.408	0.41	2.03	0.35	2.03	5.52	9.54			52.56	0.59				
32/3/1	296.11	10.4136	0.41	2.04			6.57	10.06			52.56	0.4				
32/3/40	296.50	10.4258	0.41	2.04	0.35	2.04	6.57	9.25			52.56	0.7				
32/3/62	296.72	10.4327	0.41	2.18	0.35	2.18	5.52	9.13			52.56	0.56				
32/3/83	296.93	10.4393	0.41	2.08			5.52	9.13			52.56	0.6	44.19	0.6		
32/3/102 avg	297.12	10.4452	0.41	2.02			6.57	9.8			52.56	0.61				
32/3/123	297.33	10.4518	0.41	1.99			6.57	9.66			52.56	0.65				
32/3/140	297.50	10.4571	0.41	2.11	0.35	2.11	6.57	9.45			52.56	0.63				
32/4/10	297.70	10.4633	0.41	1.96			6.57	10.13			52.56	0.49				
32/4/30	297.90	10.4696	0.41	1.93			6.57	9.84			52.56	0.55				
32/4/48	298.08	10.4752	0.41	2.1			6.57	9.51			52.56	0.49				
32/4/68	298.28	10.4815	0.41	2.07			6.57	9.5			44.19	0.67				
32/4/92	298.52	10.489	0.41	2			6.57	9.53			52.56	0.56				
32/4/110	298.70	10.4946	0.35	1.97			6.57	9.33			52.56	0.66				
32/4/133	298.93	10.5018	0.35	2.09			6.57	9.06			52.56	0.53				
32/5/1	299.11	10.5074	0.41	2.07	0.35	2.07	6.57	9.27			52.56	0.57				
32/5/28	299.38	10.5159	0.41	2.09			6.57	9.59			52.56	0.53				
32/5/40 avg	299.50	10.5196	0.41	2.26	0.35	2.26	5.52	8.81			52.56	0.61				
32cc/2	299.67	10.5249	0.41	2.3			5.52	8.91			52.56	0.45	44.19	0.45		
33/1/1	302.71	10.6199	0.41	2.26			5.52	8.73			52.56	0.47	44.19	0.47		
33/1/27	302.97	10.6281	0.35	2.03			6.57	9.59			52.56	0.5	44.19	0.5		
33/1/40	303.10	10.6321	0.41	2.05	0.35	2.05	6.57	9.52			52.56	0.47				
33/1/59	303.29	10.6381	0.41	2.09			6.57	9.62			52.56	0.46				
33/1/83	303.53	10.6456	0.41	2.12			6.57	9.57			52.56	0.52				
33/1/107	303.77	10.6531	0.41	2.17			6.57	9.58			52.56	0.43				
33/1/121	303.91	10.6575	0.41	2.12			6.57	9.37			52.56	0.55				
33/1/143	304.13	10.6643	0.41	2.04			6.57	9.67			52.56	0.51				
33/2/9	304.29	10.6693	0.41	2.05			6.57	9.52			52.56	0.49				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
33/2/27	304.47	10.675	0.41	2.1			6.57	9.64			52.56	0.49				
33/2/46	304.66	10.6809	0.41	2.02			6.57	9.35			52.56	0.55				
33/2/82	305.02	10.6922	0.41	2.16			6.57	9.06			52.56	0.54				
33/2/95	305.15	10.6962	0.41	2.17			5.52	8.83			52.56	0.57				
33/2/114	305.34	10.7022	0.41	2.14			5.52	8.88			52.56	0.61				
33/2/135	305.55	10.7087	0.41	2.11			5.52	9.08			52.56	0.58				
33/3/1 avg	305.71	10.7137	0.41	2.09			6.57	9.57			52.56	0.46				
33/3/23	305.93	10.7206	0.41	2.13	0.35	2.13	5.52	8.85			52.56	0.57				
33/3/41	306.11	10.7262	0.41	2.07	0.35	2.07	5.52	9.25			52.56	0.63				
33/3/57	306.27	10.7312	0.41	2.1			5.52	9.66			52.56	0.5				
33/3/84	306.54	10.7397	0.41	2.1			5.52	9.26			52.56	0.52				
33/3/105	306.75	10.7462	0.41	2.17			6.57	9.26			52.56	0.41				
33/3/116	306.86	10.7497	0.41	2	0.35	2	6.57	9.49			52.56	0.52				
33/3/138	307.08	10.7565	0.41	2.06	0.35	2.06	5.52	9.26			52.56	0.59				
33/4/10	307.30	10.7634	0.41	2.14			6.57	9.44			52.56	0.47				
33/4/29	307.49	10.7694	0.35	2.01			6.57	9.46			52.56	0.63				
33/4/50	307.70	10.7759	0.41	1.97	0.35	1.97	6.57	9.48			52.56	0.65				
33/4/73	307.93	10.7831	0.41	2			6.57	9.64			52.56	0.55				
33/4/94	308.14	10.7897	0.41	2.05			5.52	9.62			52.56	0.48	44.19	0.48		
33/4/110	308.30	10.7947	0.41	1.96			5.52	9.97			52.56	0.51				
33/4/133	308.53	10.8019	0.41	2.05			5.52	9.47			52.56	0.5				
33/5/1	308.71	10.8075	0.41	1.99			6.57	9.28			52.56	0.56				
33/5/29	308.99	10.8162	0.41	1.96			6.57	9.48			52.56	0.59				
33/5/41	309.11	10.82	0.41	2.08			6.57	9.44			52.56	0.49				
33/5/58	309.28	10.8225	0.41	2.1			6.57	9.39			52.56	0.46				
33/5/84 avg	309.54	10.8264	0.41	2.13			6.57	9.17			52.56	0.49				
33/5/104	309.74	10.8293	0.41	1.86			6.57	9.79			52.56	0.6				
34/1/1	312.31	10.8674	0.41	2.09			6.57	9.23			52.56	0.48				
34/1/24	312.54	10.8708	0.41	1.92	0.35	1.92	6.57	9.73			52.56	0.48				
34/1/37	312.67	10.8727	0.41	1.87			6.57	9.82			52.56	0.53				
34/1/57	312.87	10.8757	0.41	1.86			6.57	9.94			52.56	0.48				
34/1/77	313.07	10.8786	0.41	1.82	0.35	1.82	6.57	9.85			52.56	0.64				
34/1/101	313.31	10.8822	0.41	1.9			6.57	9.69			52.56	0.5				
34/1/123	313.53	10.8854	0.35	1.68			6.57	9.81			52.56	0.58				
34/1/141 avg	313.71	10.8881	0.41	1.85			6.57	9.79			52.56	0.5				
34/2/10	313.90	10.8909	0.41	1.86			6.57	9.61			52.56	0.47				
34/2/29	314.09	10.8937	0.41	1.83			6.57	9.6			52.56	0.59				

Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
34/2/49	314.29	10.8967	0.41	1.83			6.57	9.49			52.56	0.56				
34/2/65	314.45	10.899	0.35	1.88			6.57	9.23			52.56	0.63				
34/2/89	314.69	10.9026	0.41	1.88			6.57	9.76			52.56	0.47				
34/2/110	314.90	10.9057	0.41	1.83			6.57	10.09			52.56	0.43				
34/2/133	315.13	10.9091	0.41	2.01			6.57	9.72			52.56	0.49				
34/3/0	315.30	10.9138	0.41	2.01			6.57	9.59			52.56	0.56				
34/3/22	315.52	10.9213	0.41	1.9			6.57	9.58			52.56	0.65				
34/3/41	315.71	10.9278	0.41	1.99			6.57	9.79			52.56	0.43				
34/3/76	316.06	10.9398	0.41	1.85	0.35	1.85	6.57	9.94			52.56	0.62				
34/3/97	316.27	10.947	0.41	1.96			6.57	9.88			52.56	0.51	44.19	0.51		
34/3/118 avg	316.48	10.9542	0.41	1.99			6.57	9.87			52.56	0.4				
34/3/137	316.67	10.9607	0.41	2.03			6.57	9.84			52.56	0.36	44.19	0.36		
34/4/8	316.88	10.9679	0.41	1.81			6.57	10.45			52.56	0.35				
34/4/30	317.10	10.9755	0.41	1.82			6.57	10.22			52.56	0.48				
34/4/50	317.30	10.9823	0.41	2.01			6.57	9.59			52.56	0.5				
34/4/70	317.50	10.9892	0.41	1.77			6.57	9.96			52.56	0.62				
34/4/88	317.68	10.9953	0.41	1.91			6.57	9.84			52.56	0.47				
34/4/110	317.90	11.0029	0.41	1.86			6.57	9.8			52.56	0.52				
34/4/133	318.13	11.0108	0.41	2.1			6.57	9.74			52.56	0.4				
34/5/5	318.35	11.0183	0.41	1.86			6.57	10.4			52.56	0.48				
34/5/30	318.60	11.0269	0.41	2.03	0.35	2.03	6.57	10.01			52.56	0.54				
35/1/1	321.91	11.1403	0.41	2.11			6.57	9.52			44.19	0.4				
35/1/23	322.13	11.1478	0.41	1.77			6.57	10.6			52.56	0.51				
35/1/43	322.33	11.1547	0.41	1.84			6.57	10.72			52.56	0.38				
35/1/64 avg	322.54	11.1619	0.41	1.87			6.57	10.48			44.19	0.48				
35/1/82	322.72	11.1681	0.41	1.95			6.57	10.25			52.56	0.48				
35/1/100	322.90	11.1742	0.41	1.91	0.35	1.91	6.57	10.18			52.56	0.54				
35/1/119	323.09	11.1807	0.41	1.92	0.35	1.92	6.57	10.14			52.56	0.5				
35/1/141	323.31	11.1883	0.41	1.86			6.57	10.66			52.56	0.47				
35/2/8	323.48	11.1941	0.41	2.06	0.35	2.06	6.57	9.72			52.56	0.47				
35/2/32	323.72	11.2023	0.35	1.98			6.57	9.59			52.56	0.61				
35/2/51	323.91	11.2088	0.41	2.08	0.35	2.08	6.57	9.53			52.56	0.46				
35/2/90	324.30	11.2222	0.41	2.03			6.57	10.12			52.56	0.49				
35/2/110	324.50	11.2291	0.41	1.89			6.57	10.33			52.56	0.45				
35/2/130	324.70	11.2359	0.41	2.01			6.57	9.81			52.56	0.53				
35/3/1	324.91	11.2431	0.41	1.97			6.57	10.07			52.56	0.47				
35/3/22	325.12	11.2503	0.41	1.96			6.57	10.29			52.56	0.42				

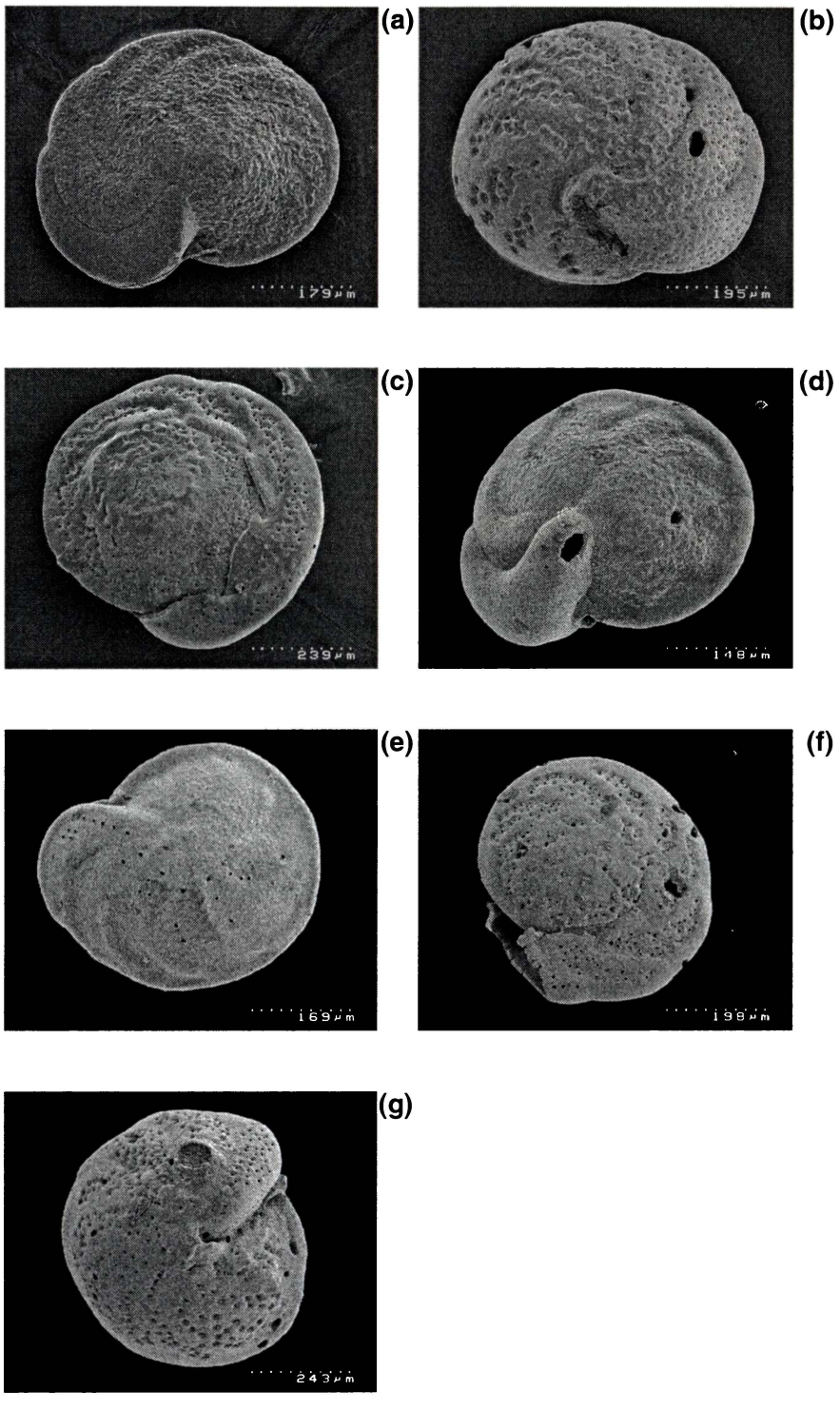
Sample	Depth (mbsf)	Age (Ma)	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode	Mode size	% at mode
35/3/43 avg	325.33	11.2575	0.41	2.1			6.57	10.01			52.56	0.35				
35/3/67	325.57	11.2657	0.41	2.08			6.57	10.06			52.56	0.34				
35/3/81	325.71	11.2705	0.41	2.09			6.57	9.85			52.56	0.34	44.19	0.34		
35/3/104	325.94	11.2784	0.41	2.04			6.57	10.32			52.56	0.32				
35/3/117	326.07	11.2829	0.41	2.1			6.57	9.83			52.56	0.32	44.19	0.32		
35/3/138	326.28	11.2901	0.41	1.91			6.57	10.33			52.56	0.47				
35/4/10	326.50	11.2976	0.41	2.07			6.57	10.07			52.56	0.35				
35/4/30	326.70	11.3045	0.41	2.06			6.57	9.81			52.56	0.41				
35/4/48	326.88	11.3106	0.41	2.09			6.57	9.86			52.56	0.39				
35/4/69	327.09	11.3178	0.41	2.05			6.57	10.15			52.56	0.35				
35/4/88	327.28	11.3243	0.41	2.02			6.57	10.11			52.56	0.34				
35/4/110 avg	327.50	11.3319	0.41	2.08			6.57	9.51			52.56	0.37				
35/4/134	327.74	11.3401	0.41	2			6.57	9.58	5.52	9.58	52.56	0.46	44.19	0.46		
35/5/1	327.91	11.3459	0.41	2.12			5.52	9.47			52.56	0.6	44.19	0.6		
35/5/16	328.06	11.3511	0.41	2.21			5.52	9.61			44.19	0.48				
35/5/37	328.27	11.3583	0.41	2.2			5.52	9.58			44.19	0.48				
35/5/57	328.47	11.3651	0.41	2.31			5.52	9.42			44.19	0.29				
35/5/82	328.72	11.3737	0.41	2.08			5.52	10.82								

Appendix C

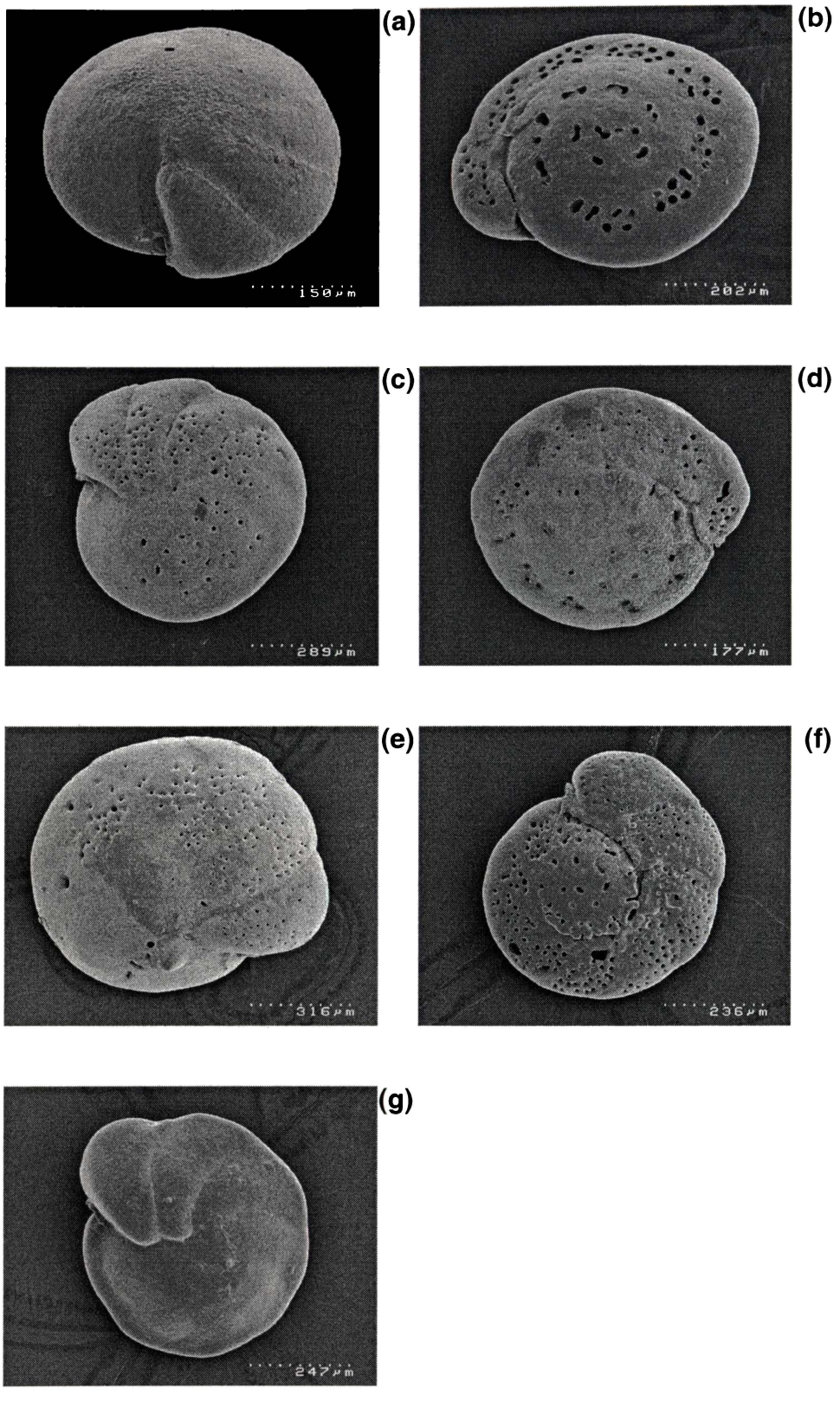
Oxygen And Carbon Isotopic Data And Palaeotemperatures

Appendix C - Oxygen and Carbon isotopic data and palaeotemperature calculations

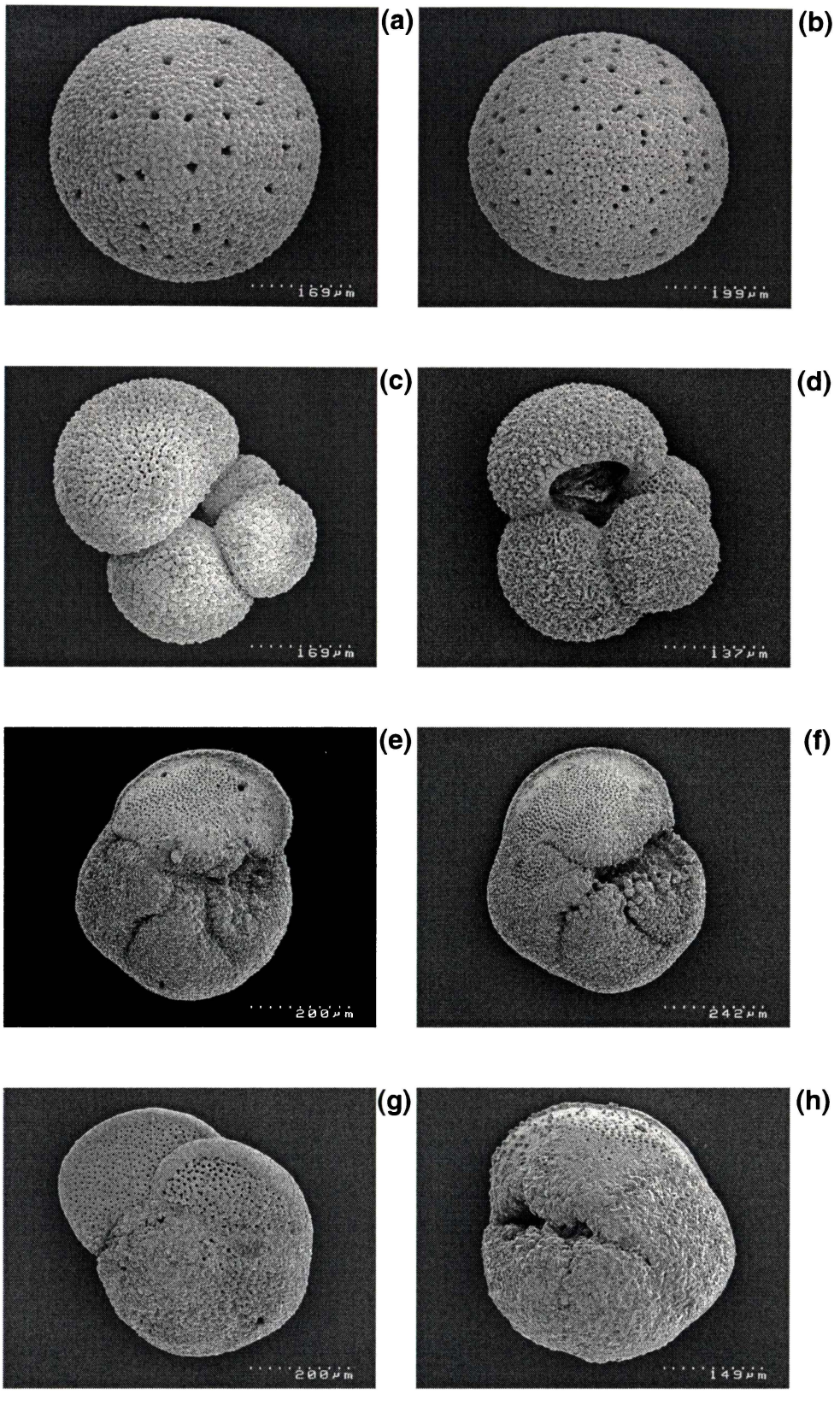
SEM Images



Appendix C Figure 1: Selected images of benthic *Cibicidoides cenop* (Woodruff) used for isotopic analysis. {Note: all SEM images are from specimens rejected for isotopic analysis}.



Appendix C Figure 2 Selected benthic Cibicidoides species used for isotopic analysis: (a-f) *Cibicidoides subhaidingari*, (g) *Cibicidoides* cf. *neoperforatus*.



Appendix C Figure 3: Selected planktic foraminifera used for isotopic analysis: (a-b) *Orbulina universa*; (c-d) *Globigerina bulloides*; (e-g) *Globorotalia (Globoconella) miotumida* (sinistral); (h) *Globorotalia (Globoconella) miotumida* (dextral).

Isotopic Data Tables

Palaeotemperature calculations use equations and $\delta^{18}O_w$ values detailed in Chapter 3.

Appendix C Table 1: DSDP Hole 593 stable isotope data c. 0-197 mbsf. Uvi = *Uvigerina peregrina*, Cib = *Cibicidoides* spp. equivalent -0.64‰, Gb = *Globigerina bulloides*, Ou = *Orbulina universa*, mbsf = metres below sea floor. (After Head and Nelson, 1994; Nelson et al., 1994 - see Chapter 3 for references).

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
1/1/7	0.07	0.0069	3.19	2.55	0.20	1.11	0.84	-0.50	1.26		
1/1/17	0.17	0.0094	2.71	2.07	0.00	0.91	0.89	-0.74	1.02		
1/1/31	0.31	0.0130	3.73	3.09	-0.25	0.66	1.83	-0.26	1.50		
1/1/38	0.38	0.0167	4.38	3.74	-0.14	0.77	1.74	-0.36	1.40		
1/1/57	0.57	0.0269	4.27	3.63	-0.18	0.73	1.97	-0.15	1.61		
1/1/62	0.62	0.0296	3.56	2.92	0.23	1.14	2.19	-0.05	1.71		
1/1/81	0.81	0.0398	4.03	3.39	-0.03	0.88	1.38	-0.17	1.59		
1/1/86	0.86	0.0425	3.58	2.94	-0.17	0.74	0.92	-0.85	0.91		
1-1-103	1.03	0.0516	3.74	3.10	0.03	0.94	1.86	0.22	1.98		
1-1-113	1.13	0.0569	3.68	3.04	-0.07	0.84	1.87	0.07	1.83		
1-1-129	1.29	0.0655	3.34	2.70	0.06	0.97	1.33	-0.36	1.40		
1-1-140	1.40	0.0714	4.35	3.71	0.11	1.02	1.94	0.24	2.00		
1/2/5	1.55	0.0794	3.55	2.91	-0.13	0.78	1.13	-0.19	1.57		
1/2/17	1.67	0.0859	3.02	2.38	0.17	1.08	1.51	0.06	1.82		
1/2/31	1.81	0.0934	3.13	2.49	0.12	1.03	-0.62	-1.44	0.32		
1/2/39	1.89	0.0976	2.76	2.12	0.08	0.99	-0.32	-1.43	0.33		
1/2/57	2.07	0.1073	2.89	2.25	0.46	1.37	-0.51	-1.62	0.14		
1/2/64	2.14	0.1110	3.18	2.54	-0.04	0.87	-0.04	-1.31	0.45		
1/2/81	2.31	0.1201	3.97	3.33	-0.42	0.49	1.66	-0.76	1.00		
1/2/88	2.38	0.1239	3.76	3.12	-0.45	0.46	1.84	-0.45	1.31		
1-2-101	2.51	0.1309	4.04	3.40	-0.46	0.45	1.62	-0.88	0.88		
1-2-114	2.65	0.1384	3.97	3.33	-0.44	0.47	0.96	-1.09	0.67		
1-2-129	2.79	0.1459	3.30	2.66	-0.33	0.58	1.26	-1.18	0.58		
1/2/141	2.92	0.1528	3.68	3.04	-0.39	0.52	1.79	-0.79	0.97		
1/3/10	3.10	0.1625	3.83	3.19	-0.45	0.46	2.13	-0.57	1.19		
1/3/18	3.18	0.1667	4.05	3.41	-0.35	0.56	2.25	-0.23	1.53		
1/3/31	3.31	0.1737	3.42	2.78	-0.31	0.60	2.26	-0.43	1.33		
1/3/41	3.41	0.1791	3.69	3.05	-0.23	0.68	1.80	-0.34	1.42		
1/3/57	3.57	0.1876	2.99	2.35	-0.26	0.65	0.36	-1.70	0.06		
1/3/64	3.64	0.1914	3.30	2.66	-0.58	0.33	-0.13	-1.96	-0.20		
1/3/81	3.81	0.2005	3.23	2.59	-0.62	0.29	0.96	-0.99	0.77		
1/3/86	3.86	0.2032	2.43	1.79	-0.18	0.73	-0.37	-1.55	0.21		
1-3-104	4.03	0.2123	2.71	2.07	0.20	1.11	-0.54	-1.50	0.26		
1-3-114	4.14	0.2182	3.19	2.55	0.17	1.08	-0.05	-1.17	0.59		
1-3-128	4.29	0.2262	3.28	2.64	0.23	1.14	0.55	-1.32	0.44		
1/3/141	4.41	0.2326	3.46	2.82	-0.07	0.84	0.16	-0.87	0.89		
1/4/8	4.59	0.2423	3.21	2.57	0.08	0.99	1.29	-0.54	1.22		
1/4/17	4.68	0.2471	3.50	2.86	-0.55	0.36	2.03	-0.36	1.40		
1/4/30	4.81	0.2541	3.86	3.22	-0.50	0.41	1.77	-0.52	1.24		
1/4/38	4.89	0.2584	3.98	3.34	-0.27	0.64	1.28	-1.14	0.62		
1/4/56	5.07	0.2680	3.75	3.11	-0.11	0.80	1.86	-0.52	1.24		
2/1/10	5.20	0.2727	3.17	2.53	-0.26	0.65	2.18	0.66	2.42		
2/1/18	5.28	0.2762	3.81	3.17	0.03	0.94	0.43	-1.06	0.70		
2/1/40	5.50	0.2849	3.34	2.70	-0.49	0.42	0.53	-0.81	0.95		
2/1/50	5.60	0.2888	2.52	1.88	-0.08	0.83	0.05	-0.28	1.48		
2/1/60	5.70	0.2927	3.01	2.37	0.19	1.10	1.51	-0.88	0.88		
2/1/70	5.80	0.2967	3.99	3.35	-0.55	0.36	2.68	-0.14	1.62		
2/1/81	5.91	0.3010	3.70	3.06	-0.63	0.28	2.16	-0.20	1.56		
2/1/91	6.01	0.3049	3.93	3.29	-0.26	0.65	2.84	0.23	1.99		
2-1-101	6.11	0.3088	3.82	3.18	-0.25	0.66	0.96	-0.72	1.04		
2/1/116	6.27	0.3151	3.76	3.12	-0.34	0.57	2.04	-0.04	1.72		

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
2/2/11	6.71	0.3324	3.40	2.76	-0.14	0.77	1.77	0.15	1.91		
2/2/17	6.77	0.3347	3.53	2.89	-0.10	0.81	1.86	0.18	1.94		
2/2/41	7.01	0.3442	3.47	2.83	-0.46	0.45	-0.14	-0.75	1.01		
2/2/51	7.11	0.3481	3.22	2.58	0.27	1.18	-0.89	-0.99	0.77		
2/2/68	7.28	0.3548	3.44	2.80	-0.03	0.88	0.35	-0.52	1.24		
2-2-101	7.61	0.3677	1.59	0.95	0.06	0.97	-0.97	0.58	2.34		
2/2/115	7.76	0.3736	2.05	1.41	0.60	1.51	-0.25	0.32	2.08		
2/3/11	8.21	0.3913	4.44	3.80	0.10	1.01	2.86	0.37	2.13		
2-3-116	9.26	0.4325	2.95	2.31	-0.76	0.15	1.95	-0.57	1.19		
2/4/21	9.81	0.4399					1.91	-0.44	1.32		
2/4/41	10.01	0.4629	3.94	3.30	-0.05	0.86	2.12	0.06	1.82		
2/4/51	10.11	0.4678	3.50	2.86	-0.81	0.10	1.05	-0.28	1.48		
2/4/61	10.21	0.4728	3.66	3.02	-0.41	0.50	0.67	-1.31	0.45		
2/4/71	10.31	0.4777	1.95	1.31	-2.30	-1.39	0.48	-1.34	0.42		
2/4/81	10.41	0.4826	2.47	1.83	-0.99	-0.08	2.28	0.25	2.01		
2/4/91	10.51	0.4875	3.32	2.68	-0.83	0.08	-0.68	-2.35	-0.59		
2-4-101	10.61	0.4925	3.24	2.60	-0.23	0.68	0.93	-0.79	0.97		
2-4-113	10.73	0.4984	2.28	1.64	-0.73	0.18	0.32	-1.20	0.56		
2/5/11	11.21	0.5220	2.71	2.07	0.24	1.15	-0.25	-1.24	0.52		
2/5/21	11.31	0.5269	2.10	1.46	-0.25	0.66	-0.08	-1.28	0.48		
2/5/42	11.52	0.5373	2.67	2.03	-0.03	0.88	0.36	-0.84	0.92		
2/5/52	11.62	0.5422	2.59	1.95	-0.11	0.80	0.26	-1.26	0.50		
2/5/61	11.71	0.5466	2.36	1.72	-0.23	0.68	0.37	-0.94	0.82		
2/5/80	11.91	0.5565	1.86	1.22	-1.04	-0.13	1.37	0.08	1.84		
2-5-101	12.10	0.5658	2.41	1.77	-0.29	0.62	0.67	-0.49	1.27		
2-5-111	12.26	0.5737					0.61	-0.83	0.93		
2-5-126	12.36	0.5786	2.24	1.60	-0.79	0.12	0.48	-1.20	0.56		
2/6/11	12.71	0.5959	3.37	2.73	-0.68	0.23	1.92	-0.16	1.60		
2/6/21	12.81	0.6008	3.37	2.73	-0.55	0.36	1.92	-0.15	1.61		
2/6/31	12.91	0.6057	2.99	2.35	-0.60	0.31	2.04	-0.01	1.75		
2/6/41	13.01	0.6106	2.84	2.20	-1.26	-0.35	0.30	-1.92	-0.16		
2/6/50	13.10	0.6151	2.75	2.11	-0.80	0.11	-0.61	-2.38	-0.62		
2/6/61	13.21	0.6205	2.88	2.24	-0.56	0.35	1.20	-0.36	1.40		
2/6/71	13.31	0.6254	2.86	2.22	-0.98	-0.07	1.25	-0.04	1.72		
2/6/99	13.59	0.6392	2.87	2.23	-0.45	0.46	1.39	-0.53	1.23		
2-6-113	13.73	0.6461	3.06	2.42	0.15	1.06	1.14	-0.50	1.26		
2-6-129	13.89	0.6540	3.27	2.63	-0.01	0.90	1.52	-0.35	1.41		
3/1/10	14.80	0.6988	3.21	2.57	-0.87	0.04	0.36	-1.70	0.06		
3/1/20	14.90	0.7037	2.58	1.94	-1.27	-0.36	1.24	-0.57	1.19		
3/1/40	15.10	0.7135	3.70	3.06	-0.94	-0.03	1.98	-0.43	1.33		
3/1/63	15.33	0.7249	2.72	2.08	-1.16	-0.25	1.39	-1.04	0.72		
3/1/87	15.57	0.7367	3.10	2.46	-0.74	0.17	1.77	-0.45	1.31		
3/1/98	15.68	0.7421	2.45	1.81	-0.90	0.01	0.87	-0.07	1.69		
3-1-118	15.88	0.7519	2.63	1.99	0.20	1.11	1.45	-0.47	1.29		
3-1-128	15.98	0.7569	3.52	2.88	-0.30	0.61	0.95	-1.00	0.76		
3-1-140	16.10	0.7628	2.77	2.13	0.03	0.94	1.76	-0.91	0.85		
3/2/10	16.30	0.7726	4.27	3.63	-0.13	0.78	2.05	-0.67	1.09		
3/2/20	16.40	0.7775	4.09	3.45	-0.51	0.40	2.04	-0.74	1.02		
3/2/30	16.50	0.7825	4.09	3.45	-0.22	0.69	2.17	-0.38	1.38		
3/2/40	16.60	0.7874	4.32	3.68	-0.24	0.67	2.03	-0.37	1.39		
3/2/60	16.80	0.7973	2.94	2.30	-0.81	0.10	1.69	-0.31	1.45		
3/2/70	16.90	0.8022	3.18	2.54	-0.51	0.40	1.40	-0.25	1.51		
3/2/80	17.00	0.8072	3.16	2.52	0.00	0.91	1.56	-0.55	1.21		
3/2/89	17.09	0.8116	3.10	2.46	-0.37	0.54	1.62	-0.34	1.42		
3-2-106	17.26	0.8200	3.55	2.91	0.22	1.13	0.62	-1.57	0.19		
3-2-130	17.50	0.8319	3.71	3.07	-1.12	-0.21	0.78	-0.58	1.18		
3-2-150	17.70	0.8418	2.80	2.16	0.19	1.10	0.15	-0.24	1.52		
3/3/10	17.80	0.8467	2.84	2.20	0.25	1.16	1.24	-1.05	0.71		
3/3/20	17.90	0.8516	3.51	2.87	-0.76	0.15	1.29	-1.19	0.57		
3/3/30	18.00	0.8566	3.62	2.98	-0.48	0.43	3.06	-0.03	1.73		
3/3/40	18.10	0.8615	3.97	3.33	-0.78	0.13	2.21	-0.62	1.14		
3/3/60	18.30	0.8714	3.56	2.92	-0.50	0.41	2.24	-0.21	1.55		
3/3/70	18.40	0.8764	2.69	2.05	-1.05	-0.14	1.93	-0.22	1.54		

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
3/3/76	18.46	0.8793	3.28	2.64	-0.96	-0.05	1.96	-0.43	1.33		
3/3/86	18.56	0.8843	3.93	3.29	-0.49	0.42	0.70	-1.21	0.55		
3-3-118	18.88	0.9001	3.91	3.27	-1.06	-0.15	1.96	-0.69	1.07		
3-3-130	19.00	0.9060	2.91	2.27	-0.89	0.02	1.04	-0.78	0.98		
3-3-137	19.07	0.9095	3.73	3.09	-0.95	-0.04	0.80	-0.77	0.99		
3-3-150	19.20	0.9159	2.15	1.51	-0.45	0.46	0.09	-0.90	0.86		
3/4/11	19.31	0.9213	2.62	1.98	-0.64	0.27	0.15	-0.51	1.25		
3/4/20	19.40	0.9258	2.92	2.28	-0.51	0.40	0.47	-0.41	1.35		
3/4/30	19.50	0.9307	2.60	1.96	-0.44	0.47	-0.36	-1.01	0.75		
3/4/40	19.60	0.9356	2.48	1.84	-0.16	0.75	1.22	-0.07	1.69		
3/4/56	19.76	0.9436	2.48	1.84	0.01	0.92	0.90	-0.51	1.25		
3/4/70	19.91	0.9510	2.92	2.28	-0.20	0.71	2.26	0.40	2.16		
3/4/80	20.01	0.9559	3.02	2.38	0.15	1.06	1.85	-0.18	1.58		
3/4/91	20.12	0.9613	3.40	2.76	-0.38	0.53	0.63	-1.10	0.66		
3-4-100	20.20	0.9653	3.00	2.36	0.15	1.06	0.53	-1.42	0.34		
3-4-110	20.30	0.9702	2.79	2.15	-0.31	0.60	0.70	-0.75	1.01		
3-4-120	20.40	0.9752	2.53	1.89	-0.39	0.52	0.81	-0.60	1.16		
3-4-128	20.48	0.9791	3.36	2.72	0.10	1.01	0.78	-0.73	1.03		
3-4-140	20.60	0.9851	2.90	2.26	-0.06	0.85	1.22	-0.36	1.40		
3-4-147	20.67	0.9885	2.75	2.11	-0.54	0.37	1.22	-0.23	1.53		
3/5/11	20.81	0.9931	2.05	1.41	-0.58	0.33	0.97	-0.32	1.44		
3/5/20	20.90	0.9957	2.28	1.64	-0.52	0.39	0.62	-0.77	0.99		
3/5/40	21.10	1.0014	3.32	2.68	-0.15	0.76	1.29	-0.22	1.54		
3/5/64	21.34	1.0083	3.42	2.78	-0.08	0.83	1.45	-0.14	1.62		
3/5/84	21.54	1.0140	2.36	1.72	-0.77	0.14	1.08	-0.27	1.49		
3/5/90	21.60	1.0157	3.08	2.44	-0.37	0.54	0.64	-0.40	1.36		
3-5-100	21.70	1.0186	4.17	3.53			0.63	-0.70	1.06		
3-5-110	21.80	1.0214	2.60	1.96	-0.16	0.75	0.82	-0.33	1.43		
3-5-118	21.88	1.0237	3.78	3.14	-0.02	0.89	1.21	-0.06	1.70		
3-5-137	22.07	1.0291	3.12	2.48	-0.26	0.65	0.43	-0.80	0.96		
3/6/10	22.30	1.0357	3.71	3.07	-0.27	0.64	1.70	-0.31	1.45		
3/6/20	22.40	1.0386	3.54	2.90	-0.34	0.57	1.81	-0.20	1.56		
3/6/30	22.50	1.0414	3.74	3.10	-0.47	0.44	2.24	-0.03	1.73		
3/6/40	22.60	1.0443	3.73	3.09	-0.34	0.57	1.99	-0.07	1.69		
3/6/46	22.66	1.0460	4.18	3.54	-0.37	0.54	2.27	-0.12	1.64		
3/6/60	22.80	1.0500	3.45	2.81	-0.69	0.22	1.45	-0.44	1.32		
3-6-100	23.20	1.0614	2.30	1.66	-0.20	0.71	0.99	-0.43	1.33		
3-6-110	23.30	1.0643	2.28	1.64	0.03	0.94	0.98	-0.35	1.41		
3-6-130	23.50	1.0700	2.74	2.10	0.35	1.26	0.90	-0.57	1.19		
3-6-137	23.57	1.0750	2.44	1.80	-0.04	0.87	1.25	-0.55	1.21		
4/1/10	24.40	1.1341	2.12	1.48	-0.10	0.81	1.07	-0.48	1.28		
4/1/20	24.50	1.1412	2.61	1.97	0.05	0.96	1.17	-0.47	1.29		
4/1/31	24.61	1.1490	2.37	1.73	-0.22	0.69	1.29	-0.33	1.43		
4/1/40	24.70	1.1555	3.25	2.61	-0.78	0.13	1.21	-0.32	1.44		
4/1/50	24.80	1.1626	3.63	2.99	0.10	1.01	1.78	-0.20	1.56		
4/1/57	24.87	1.1676	3.07	2.43	-0.40	0.51	1.52	-0.37	1.39		
4/1/70	25.00	1.1768	3.56	2.92	-0.04	0.87	1.74	-0.47	1.29		
4/1/92	25.22	1.1925	3.67	3.03	-0.24	0.67	1.63	-0.60	1.16		
4-1-102	25.32	1.1996	3.67	3.03	0.12	1.03	1.54	-0.32	1.44		
4-1-110	25.40	1.2053	3.76	3.12	-0.03	0.88	1.64	-0.21	1.55		
4-1-120	25.50	1.2124	3.21	2.57	-0.13	0.78	1.21	-0.31	1.45		
4-1-129	25.59	1.2188	2.56	1.92	-0.43	0.48	1.37	-0.17	1.59		
4-1-140	25.70	1.2267	2.84	2.20	0.26	1.17	0.96	-0.12	1.64		
4-1-148	25.78	1.2324	2.64	2.00	-0.48	0.43	1.32	-0.17	1.59		
4/2/10	25.90	1.2409	2.81	2.17	0.22	1.13	1.71	-0.14	1.62		
4/2/21	26.01	1.2487	3.33	2.69	-0.51	0.40	1.56	-0.53	1.23		
4/2/31	26.11	1.2559	3.36	2.72	-0.18	0.73	1.87	-0.18	1.58		
4/2/41	26.21	1.2630	3.37	2.73	-0.13	0.78	1.81	0.27	2.03		
4/2/52	26.32	1.2708	3.02	2.38	0.18	1.09	1.35	-0.29	1.47		
4/2/71	26.51	1.2843	3.11	2.47	0.41	1.32	1.32	0.01	1.77		
4/2/92	26.72	1.2993	2.99	2.35	0.11	1.02	1.09	-0.48	1.28		
4-2-101	26.81	1.3057	2.93	2.29	-0.07	0.84	1.25	-0.67	1.09		
4-2-110	26.90	1.3121	2.86	2.22	-0.16	0.75	1.64	-0.23	1.53		

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
4-2-120	27.00	1.3192	3.47	2.83	0.14	1.05	1.47	-0.17	1.59		
4-2-129	27.09	1.3256	3.14	2.50	0.02	0.93	1.14	-0.29	1.47		
4-2-140	27.21	1.3342	2.52	1.88	-0.52	0.39	1.03	-0.40	1.36		
4-2-148	27.28	1.3392	3.09	2.45	-0.01	0.90	1.48	-0.42	1.34		
4/3/11	27.41	1.3484	3.25	2.61	-0.40	0.51	1.56	-0.51	1.25		
4/3/21	27.51	1.3556	3.21	2.57	-0.24	0.67	1.49	-0.29	1.47		
4/3/31	27.61	1.3627	2.93	2.29	-0.28	0.63	1.77	-0.06	1.70		
4/3/48	27.78	1.3748	3.07	2.43	-0.03	0.88	1.19	-0.50	1.26		
4/3/57	27.87	1.3812	2.90	2.26	-0.31	0.60	1.31	-0.28	1.48		
4/3/71	28.01	1.3912					1.62	-0.24	1.52		
4/3/81	28.11	1.3983	3.24	2.60	-0.19	0.72	0.95	-0.66	1.10		
4/3/90	28.21	1.4054	3.48	2.84	-0.09	0.82	1.57	-0.20	1.56		
4-3-101	28.31	1.4125	3.39	2.75	0.16	1.07	1.22	-0.22	1.54		
4-3-111	28.41	1.4196	2.91	2.27	0.14	1.05	1.21	-0.49	1.27		
4-3-128	28.58	1.4317					0.54	-1.28	0.48		
4/4/11	28.91	1.4552	2.70	2.06	0.16	1.07	1.60	-0.06	1.70		
4/4/41	29.21	1.4766	2.99	2.35	-0.11	0.80	1.41	-0.35	1.41		
4/4/50	29.30	1.4830	3.12	2.48	-0.16	0.75	1.53	0.02	1.78		
4/4/57	29.37	1.4880	3.34	2.70	-0.09	0.82	1.43	-0.34	1.42		
4/4/71	29.51	1.4980	2.57	1.93	-0.04	0.87	1.15	-0.25	1.51		
4/4/91	29.71	1.5122	2.42	1.78	0.01	0.92	1.20	0.31	2.07		
4/4/109	29.90	1.5257	2.67	2.03	-0.26	0.65	0.85	-0.06	1.70		
4/4/119	30.00	1.5329	3.15	2.51	-0.22	0.69	1.33	-0.15	1.61		
4/4/128	30.09	1.5393	3.25	2.61	0.27	1.18	1.13	-0.30	1.46		
4/4/138	30.19	1.5464	2.88	2.24	0.07	0.98	1.03	-0.03	1.73		
4/4/147	30.28	1.5528	2.90	2.26	0.19	1.10	1.06	0.09	1.85		
4/5/10	30.40	1.5614	3.58	2.94	0.03	0.94	1.27	-0.31	1.45		
4/5/21	30.51	1.5692	3.14	2.50	-0.12	0.79	0.76	-0.88	0.88		
4/5/31	30.61	1.5763	2.54	1.90	-1.32	-0.41	1.50	-0.37	1.39		
4/5/41	30.71	1.5834	2.94	2.30	-0.62	0.29	1.00	-0.23	1.53		
4/5/51	30.81	1.5905	3.36	2.72	-0.42	0.49	0.75	-0.74	1.02		
4/5/57	30.87	1.5948	3.23	2.59	-0.18	0.73	0.80	-0.32	1.44		
4/5/71	31.01	1.6048	3.45	2.81	0.32	1.23	1.07	0.02	1.78		
4/5/81	31.11	1.6119	3.25	2.61	0.41	1.32	1.03	0.09	1.85		
4/5/92	31.22	1.6197	2.98	2.34	-0.14	0.77	1.12	-0.11	1.65		
4-5-101	31.31	1.6262	3.21	2.57	0.12	1.03	1.60	0.33	2.09		
4-5-111	31.41	1.6333	2.92	2.28	0.20	1.11	1.07	0.04	1.80		
4-5-121	31.51	1.6404	3.09	2.45	0.19	1.10	0.85	0.09	1.85		
4-5-139	31.69	1.6532	3.07	2.43	0.10	1.01	0.96	-0.17	1.59		
4-5-147	31.78	1.6596	2.86	2.22	-0.29	0.62	0.61	-0.64	1.12		
4/6/11	31.91	1.6689	3.15	2.51	-0.54	0.37	0.88	-0.38	1.38		
4/6/21	32.01	1.6760	3.39	2.75	-0.13	0.78	1.09	-0.57	1.19		
4/6/31	32.11	1.6831	3.60	2.96	-0.26	0.65	0.94	-0.97	0.79		
4/6/41	32.21	1.6902	3.43	2.79	-0.03	0.88	0.98	-0.55	1.21		
4/6/49	32.29	1.6959	3.02	2.38	-0.18	0.73					
4/9/57	32.37	1.7016	2.21	1.57	-0.79	0.12	0.95	-0.56	1.20		
4/6/67	32.47	1.7088	2.90	2.26	0.18	1.09	1.08	-0.45	1.31		
4/6/91	32.71	1.7258	2.29	1.65	-0.60	0.31	0.86	-0.59	1.17		
4-6-101	32.81	1.7330	2.41	1.77	-0.49	0.42	0.81	-0.37	1.39		
4-6-110	32.90	1.7394	2.93	2.29	-0.68	0.23	1.39	-0.23	1.53		
4-6-121	33.01	1.7472	2.84	2.20	0.11	1.02	1.42	-0.01	1.75		
5/1/11	34.01	1.8373	3.10	2.46	-0.26	0.65	1.16	-0.17	1.59		
5/1/23	34.13	1.8491	2.36	1.72	-0.48	0.43	1.17	-0.22	1.54		
5/1/31	34.21	1.8570	2.59	1.95	-0.32	0.59	1.16	0.05	1.81		
5/1/41	34.31	1.8669	2.88	2.24	-0.27	0.64	0.97	-0.37	1.39		
5/1/51	34.41	1.8768	2.85	2.21	-0.05	0.86	1.43	-0.17	1.59		
5/1/57	34.47	1.8827	2.53	1.89	-0.62	0.29	1.38	-0.32	1.44		
5/1/71	34.61	1.8966	2.90	2.26	-0.54	0.37	1.81	0.01	1.77		
5/1/81	34.71	1.9065	3.54	2.90	-0.29	0.62	1.83	-0.12	1.64		
5-1-100	34.90	1.9253	3.37	2.73	-0.21	0.70	1.47	0.10	1.86		
5-1-111	35.01	1.9362	2.97	2.33	-0.32	0.59	1.45	-0.06	1.70		
5-1-121	35.11	1.9460	2.96	2.32	0.12	1.03	1.42	0.02	1.78		
5-1-140	35.30	1.9563	3.06	2.42	-0.68	0.23	1.55	-0.42	1.34		

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
5-1-149	35.39	1.9600	2.89	2.25	-0.34	0.57	1.87	0.60	2.36		
5-1-10A	36.60	2.0105	3.03	2.39	-0.15	0.76	1.87	0.47	2.23	0.96	1.88
5-1-20A	36.70	2.0147	3.20	2.56	-0.06	0.85	1.34	0.29	2.05	1.15	1.92
5-1-30A	36.80	2.0189	3.36	2.72	0.17	1.08	1.31	0.08	1.84	1.20	1.90
5-1-40A	36.90	2.0230	3.07	2.43	-0.13	0.78	1.41	0.26	2.02	0.95	2.06
5-1-50A	37.00	2.0272	2.87	2.23	-0.21	0.70	1.38	0.18	1.94	1.53	2.13
5-1-60A	37.10	2.0314	2.84	2.20	-0.23	0.68	1.56	0.34	2.10	1.26	1.75
5-1-70A	37.20	2.0356	2.91	2.27	-0.15	0.76	1.60	0.34	2.10	1.36	1.94
5-1-80A	37.30	2.0397	2.77	2.13	-0.10	0.81	1.82	0.15	1.91	1.40	1.90
5-1-90A	37.40	2.0439	2.74	2.10	-0.34	0.57	1.04	0.24	2.00	1.48	1.87
5-1-100A	37.50	2.0481	2.65	2.01	0.76	1.67	1.29	0.26	2.02	1.10	1.69
5-1-110A	37.60	2.0522	2.57	1.93	-0.03	0.88	1.06	0.26	2.02	1.21	1.74
5-1-120A	37.70	2.0564	2.61	1.97	0.03	0.94	0.95	0.24	2.00	1.26	1.48
5-1-130A	37.80	2.0606	3.23	2.59	0.39	1.30	1.98	0.38	2.14	1.40	1.59
5-1-140A	37.90	2.0648	2.50	1.86	-0.02	0.89	0.83	0.17	1.93	1.19	1.69
5-1-148A	37.98	2.0681	2.82	2.18	-0.25	0.66	1.29	0.52	2.28	1.56	1.59
5-2-10A	38.10	2.0731	2.55	1.91	-0.01	0.90	1.22	0.60	2.36	1.38	1.43
5-2-20A	38.20	2.0773	2.10	1.46	-0.07	0.84	1.01	0.30	2.06	1.45	1.50
5-2-30A	38.30	2.0815	2.50	1.86	-0.10	0.81	1.32	0.36	2.12	1.58	1.71
5-2-40A	38.40	2.0856	2.82	2.18	-0.05	0.86	1.10	0.24	2.00	1.08	2.01
5-2-50A	38.50	2.0898	2.59	1.95	-0.12	0.79	1.24	0.22	1.98	1.01	1.89
5-2-60A	38.60	2.0940	2.68	2.04	-0.02	0.89	1.35	0.53	2.29	1.12	1.80
5-2-70A	38.70	2.0982	2.26	1.62	-0.33	0.58	0.97	0.20	1.96	1.42	1.69
5-2-80A	38.80	2.1023	2.65	2.01	-0.04	0.87	1.56	0.16	1.92	1.62	1.73
5-2-90A	38.90	2.1065	3.11	2.47	-0.16	0.75	1.55	0.17	1.93	0.55	1.61
5-2-100A	39.00	2.1107	2.95	2.31	-0.20	0.71	1.09	0.14	1.90	0.76	1.66
5-2-110A	39.10	2.1148	2.80	2.16	-0.25	0.66	1.18	0.03	1.79	1.13	1.71
5-2-120A	39.20	2.1190	2.65	2.01	-0.31	0.60	1.78	0.23	1.99	1.54	2.02
5-2-130A	39.30	2.1232	2.73	2.09	-0.20	0.71	1.36	0.36	2.12	1.52	1.83
5-2-140A	39.40	2.1274	2.93	2.29	-0.01	0.90	1.49	0.38	2.14	1.43	2.02
5-2-148A	39.48	2.1307	2.75	2.11	-0.12	0.79	1.60	0.41	2.17	1.46	1.90
5-3-10A	39.60	2.1357	2.23	1.59	-0.22	0.69	1.71	0.52	2.28	1.29	1.90
5-3-20A	39.70	2.1399	2.35	1.71	-0.26	0.65	1.24	0.36	2.12	0.97	1.89
5-3-30A	39.80	2.1441	2.62	1.98	-0.33	0.58	1.36	0.47	2.23	1.46	1.87
5-3-40A	39.90	2.1482	2.24	1.60	-0.21	0.70	1.29	0.43	2.19	1.11	1.83
5-3-50A	40.00	2.1524	2.43	1.79	-0.13	0.78	1.12	0.36	2.12	1.06	1.82
5-3-60A	40.10	2.1566	2.54	1.90	-0.24	0.67	1.41	0.38	2.14	1.31	1.30
5-3-70A	40.20	2.1608	2.79	2.15	-0.35	0.56	0.91	0.35	2.11	0.99	1.69
5-3-80A	40.30	2.1649	2.65	2.01	-0.26	0.65	0.96	0.42	2.18	0.70	2.37
5-3-90A	40.40	2.1691	2.38	1.74	-0.14	0.77	0.99	0.33	2.09	0.95	2.11
5-3-100A	40.50	2.1733	2.43	1.79	0.08	0.99	0.87	0.44	2.20	1.02	1.65
5-3-110A	40.60	2.1774	2.46	1.82	-0.30	0.61	1.24	0.46	2.22	1.74	1.53
5-3-120A	40.70	2.1816	2.57	1.93	-0.02	0.89	1.62	0.25	2.01	1.56	1.68
5-3-130A	40.80	2.1858	2.40	1.76	-0.14	0.77	1.46	0.62	2.38	1.37	1.75
5-3-140A	40.90	2.1900	2.59	1.95	0.25	1.16	1.09	0.55	2.31	0.86	1.82
5-3-148A	40.98	2.1933	2.54	1.90	0.18	1.09	0.66	0.40	2.16	0.90	2.10
5-4-10A	41.10	2.1983	2.59	1.95	0.03	0.94	1.14	0.62	2.38	1.53	1.97
5-4-20A	41.20	2.2025	2.51	1.87	-0.10	0.81	0.80	0.58	2.34	1.25	1.90
5-4-30A	41.30	2.2067	2.42	1.78	0.10	1.01	1.61	0.73	2.49	0.71	2.07
5-4-40A	41.40	2.2108	2.62	1.98	0.15	1.06	1.26	0.44	2.20	0.86	1.80
5-4-50A	41.50	2.2150	2.81	2.17	0.11	1.02	1.34	0.41	2.17	0.99	1.75
5-4-60A	41.60	2.2192	3.07	2.43	0.05	0.96	0.63	0.26	2.02	1.42	2.04
5-4-70A	41.70	2.2234	2.27	1.63	0.06	0.97	1.23	0.38	2.14	1.13	2.03
5-4-80A	41.80	2.2275	2.65	2.01	-0.10	0.81	0.79	0.13	1.89	1.45	1.71
5-4-90A	41.90	2.2317	3.08	2.44	-0.29	0.62	1.29	0.27	2.03	1.36	1.04
5-4-100A	42.00	2.2359	3.10	2.46	-0.22	0.69	1.56	0.11	1.87	1.47	1.93
5-4-110A	42.10	2.2400	2.75	2.11	-0.30	0.61	0.95	0.63	2.39	0.87	1.92
5-4-120A	42.20	2.2442	2.90	2.26	0.07	0.98	0.60	0.22	1.98	1.10	1.73
5-4-130A	42.30	2.2484	3.15	2.51	0.20	1.11	1.47	0.20	1.96	1.22	1.81
5-4-140A	42.40	2.2526	2.95	2.31	0.36	1.27	1.93	0.33	2.09	1.46	2.10
5-4-148A	42.48	2.2559	2.76	2.12	0.57	1.48	1.46	0.25	2.01	1.09	1.87
5-5-10A	42.60	2.2609	2.14	1.50	0.36	1.27	1.71	-0.07	1.69	1.37	1.55
5-5-20A	42.70	2.2651	2.56	1.92	0.10	1.01	1.94	0.14	1.90	1.82	1.60

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
5-5-30A	42.80	2.2693	2.67	2.03	-0.36	0.55	1.16	-0.08	1.68	0.96	1.68
5-5-40A	42.90	2.2734	3.34	2.70	-0.16	0.75	1.67	0.04	1.80	1.48	1.66
5-5-50A	43.00	2.2776	2.89	2.25	-0.24	0.67	1.54	0.19	1.95	1.26	2.08
5-5-60A	43.10	2.2818	3.18	2.54	-0.07	0.84	2.29	0.27	2.03	1.50	1.77
5-5-70A	43.20	2.2859	2.85	2.21	0.02	0.93	2.00	0.10	1.86	1.36	1.90
5-5-80A	43.30	2.2901	2.68	2.04	0.12	1.03	1.52	0.03	1.79	1.25	2.05
5-5-90A	43.40	2.2943	2.78	2.14	0.19	1.10	1.76	0.08	1.84	1.46	1.94
5-5-100A	43.50	2.2985	2.36	1.72	-0.06	0.85	1.26	0.12	1.88	1.36	2.24
5-5-110A	43.60	2.3026	2.84	2.20	0.06	0.97	1.33	0.26	2.02	1.08	2.03
5-5-120A	43.70	2.3068	2.39	1.75	-0.61	0.30	0.95	0.10	1.86	0.70	1.91
5-5-130A	43.80	2.3110	2.04	1.40	-0.36	0.55	1.06	0.40	2.16	0.93	1.96
5-5-140A	43.90	2.3152	2.42	1.78	-0.10	0.81	1.43	0.25	2.01	1.29	2.01
5-5-148A	43.98	2.3185	2.36	1.72	0.10	1.01	1.87	0.52	2.28	1.47	1.86
5-6-10A	44.10	2.3235	2.05	1.41	0.14	1.05	1.01	0.22	1.98	1.62	1.60
5-6-20A	44.20	2.3277	2.29	1.65	0.27	1.18	1.23	-0.11	1.65	1.42	2.00
5-6-30A	44.30	2.3319	2.74	2.10	0.16	1.07	0.78	0.27	2.03	1.44	1.83
5-6-40A	44.40	2.3360	2.42	1.78	0.10	1.01	1.29	0.29	2.05	1.62	1.63
6-1-10A	46.20	2.4111	2.94	2.30	-0.14	0.77	1.42	0.52	2.28	1.76	1.76
6-1-20A	46.30	2.4153	3.17	2.53	0.09	1.00	1.20	0.39	2.15	2.20	1.92
6-1-100A	47.10	2.4487	3.08	2.44	0.28	1.19	1.76	0.40	2.16	1.99	2.01
6-1-110A	47.20	2.4529	2.70	2.06	0.27	1.18	1.71	0.76	2.52	1.82	1.86
6-1-120A	47.30	2.4571	3.27	2.63	0.40	1.31	2.12	0.14	1.90	1.77	1.90
6-1-130A	47.40	2.4612	3.45	2.81	0.32	1.23	2.21	0.09	1.85	2.10	1.85
6-1-140A	47.50	2.4654	3.30	2.66	0.21	1.12	1.64	0.25	2.01	1.85	1.81
6-1-148A	47.58	2.4687	3.14	2.50	0.09	1.00	1.91	0.28	2.04	1.86	1.73
6-2-10A	47.70	2.4737	3.07	2.43	-0.18	0.73	1.75	0.25	2.01	1.63	1.54
6-2-20A	47.80	2.4779	3.02	2.38	-0.04	0.87	1.69	0.21	1.97	1.54	1.73
6-2-30A	47.90	2.4821	2.96	2.32	0.15	1.06	1.51	0.36	2.12	1.16	1.62
6-2-40A	48.00	2.4863	2.74	2.10	0.23	1.14	1.51	0.28	2.04	1.38	1.66
6-2-50A	48.10	2.4904	2.70	2.06	-0.05	0.86	1.80	0.25	2.01	1.69	1.69
6-2-60A	48.20	2.4946	3.16	2.52	-0.33	0.58	1.72	0.36	2.12	1.24	1.57
6-2-70A	48.30	2.4988	3.50	2.86	-0.51	0.40	1.65	0.16	1.92	0.80	1.52
6-2-80A	48.40	2.5030	3.04	2.40	-0.60	0.31	1.51	0.01	1.77	0.90	1.65
6-2-90A	48.50	2.5071	2.79	2.15	-0.49	0.42	1.43	0.09	1.85	1.37	1.37
6-2-100A	48.60	2.5113	3.00	2.36	-0.36	0.55	1.62	0.26	2.02	0.73	1.41
6-2-110A	48.70	2.5155	2.94	2.30	-0.11	0.80	1.34	0.10	1.86	1.33	1.59
6-2-120A	48.80	2.5197	3.30	2.66	-0.22	0.69	1.28	0.26	2.02	1.55	1.73
6-2-140A	49.00	2.5280	3.56	2.92	-0.15	0.76	1.64	0.31	2.07	1.94	1.82
6-2-148A	49.08	2.5318	3.39	2.75	-0.66	0.25	1.52	0.26	2.02	1.36	1.91
6-3-10A	49.20	2.5375	3.07	2.43	-0.45	0.46	1.12	0.31	2.07	1.39	1.82
6-3-20A	49.30	2.5422	2.69	2.05	-0.25	0.66	1.23	0.36	2.12	1.46	1.91
6-3-30A	49.40	2.5469	2.89	2.25	0.10	1.01	1.45	0.41	2.17	1.80	1.94
6-3-40A	49.50	2.5516	2.69	2.05	0.09	1.00	1.23	0.49	2.25	1.10	2.06
6-3-50A	49.60	2.5564	2.52	1.88	0.21	1.12	1.09	0.33	2.09	1.25	1.91
6-3-60A	49.70	2.5611	2.84	2.20	0.10	1.01	1.41	-0.10	1.66	1.16	1.76
6-3-70A	49.80	2.5658	3.04	2.40	-0.32	0.59	1.38	0.21	1.97	1.32	1.70
6-3-80A	49.90	2.5705	2.99	2.35	-0.10	0.81	1.26	0.30	2.06	1.21	1.69
6-3-90A	50.00	2.5753	2.90	2.26	-0.05	0.86	1.06	0.39	2.15	1.16	1.56
6-3-100A	50.10	2.5800	3.10	2.46	0.03	0.94	1.26	0.33	2.09	1.06	1.51
6-3-110A	50.20	2.5906	2.95	2.31	0.20	1.11	1.77	0.53	2.29	1.40	1.46
6-3-120A	50.30	2.6013	3.05	2.41	-0.15	0.76	1.51	0.15	1.91	1.45	1.53
6-3-130A	50.40	2.6119	2.76	2.12	-0.20	0.71	1.47	0.10	1.86	1.20	1.65
6-3-140A	50.50	2.6226	2.80	2.16	-0.11	0.80	1.41	0.25	2.01	1.32	1.75
6-3-148A	50.58	2.6311	2.87	2.23	-0.27	0.64	1.59	0.46	2.22	1.50	1.82
6-4-10A	50.70	2.6438	2.76	2.12	-0.40	0.51	1.59	0.10	1.86	1.29	1.91
6-4-20A	50.80	2.6545	2.62	1.98	-0.43	0.48	1.43	0.23	1.99	1.16	1.81
6-4-30A	50.90	2.6651	2.69	2.05	-0.58	0.33	1.41	0.30	2.06	1.21	1.42
6-4-40A	51.00	2.6757	3.05	2.41	-0.40	0.51	1.37	-0.41	1.35	1.34	1.91
6-4-50A	51.10	2.6864	2.30	1.66	-0.36	0.55	1.29	0.20	1.96	1.24	1.76
6-4-60A	51.20	2.6970	2.56	1.92	-0.31	0.60	1.22	0.16	1.92	1.07	1.54
6-4-70A	51.30	2.7077	2.90	2.26	-0.52	0.39	1.25	0.01	1.77	0.97	1.38
6-4-80A	51.40	2.7183	2.67	2.03	-0.37	0.54	1.41	-0.09	1.67	1.27	1.32
6-4-90A	51.50	2.7289	2.56	1.92	-0.22	0.69	1.44	-0.10	1.66	1.36	1.33

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
6-4-100A	51.60	2.7396	2.50	1.86	-0.19	0.72	1.36	0.11	1.87	1.33	1.49
6-4-110A	51.70	2.7502	2.36	1.72	-0.26	0.65	1.48	0.27	2.03	1.29	1.56
6-4-120A	51.80	2.7609	2.75	2.11	-0.31	0.60	1.42	0.30	2.06	1.24	1.79
6-4-140A	52.00	2.7821	2.72	2.08	-0.22	0.69	1.65	0.36	2.12	1.12	1.82
6-4-148A	52.08	2.7906	2.65	2.01	0.06	0.97	1.45	0.22	1.98	1.09	1.47
6-5-10A	52.20	2.8034	2.46	1.82	-0.13	0.78	1.26	0.19	1.95	1.40	2.06
6-5-20A	52.30	2.8140	2.45	1.81	-0.22	0.69	1.31	0.21	1.97	1.49	1.93
6-5-30A	52.40	2.8247	2.72	2.08	-0.31	0.60	1.16	0.30	2.06	1.07	2.02
6-5-40A	52.50	2.8353	2.46	1.82	-0.29	0.62	1.24	0.26	2.02	1.15	2.06
6-5-50A	52.60	2.8460	2.64	2.00	-0.25	0.66	1.16	0.33	2.09	1.31	1.91
6-5-60A	52.70	2.8566	2.70	2.06	-0.21	0.70	1.36	0.31	2.07	1.13	1.95
6-5-70A	52.80	2.8672	2.56	1.92	-0.12	0.79	1.23	0.26	2.02	1.16	2.06
6-5-80A	52.90	2.8779	2.74	2.10	0.15	1.06	1.39	0.29	2.05	1.13	1.96
6-5-90A	53.00	2.8885	3.10	2.46	0.54	1.45	1.46	0.44	2.20	1.00	1.85
6-5-100A	53.10	2.8991	2.96	2.32	0.20	1.11	1.21	0.33	2.09	1.18	1.96
6-5-110A	53.20	2.9098	2.75	2.11	0.15	1.06	1.23	0.22	1.98	1.15	1.86
6-5-120A	53.30	2.9204	2.90	2.26	0.09	1.00	1.31	0.29	2.05	1.07	1.76
6-5-130A	53.40	2.9311	2.86	2.22	-0.10	0.81	1.21	0.26	2.02	1.16	1.75
6-5-140A	53.50	2.9417	3.11	2.47	-0.18	0.73	0.96	0.24	2.00	0.73	1.36
6-5-148A	53.58	2.9502	2.85	2.21	-0.30	0.61	1.11	0.35	2.11	1.10	1.41
6-6-20A	53.80	2.9736	2.79	2.15	-0.24	0.67	1.23	0.26	2.02	1.44	1.77
6-6-30A	53.90	2.9843	2.72	2.08	-0.07	0.84	1.21	0.21	1.97	0.99	1.57
6-6-40A	54.00	2.9949	3.02	2.38	-0.50	0.41	1.56	0.19	1.95	1.41	1.72
6-6-50A	54.10	3.0055	3.24	2.60	-0.41	0.50	1.49	0.18	1.94	1.14	1.84
6-6-60A	54.20	3.0162	2.42	1.78	-0.44	0.47	1.21	0.27	2.03	1.10	1.72
6-6-70A	54.30	3.0268	2.59	1.95	-0.27	0.64	1.31	0.20	1.96	0.90	1.81
6-6-90A	54.50	3.0481	2.23	1.59	-0.16	0.75	1.10	0.23	1.99		
6-6-100A	54.60	3.0587	3.11	2.47	-0.03	0.88	1.61	0.12	1.88	1.10	1.77
6-6-140A	55.00	3.1013	2.58	1.94	-0.51	0.40	1.21	0.24	2.00	1.02	1.72
6-6-148A	55.08	3.1098	2.70	2.06	-0.75	0.16	1.36	0.26	2.02	0.97	1.70
6-7-10A	55.20	3.1226	3.22	2.58	-0.25	0.66	1.41	0.26	2.02	1.13	1.44
6-7-20A	55.30	3.1332	2.35	1.71	-0.50	0.41	0.79	0.18	1.94	0.53	1.69
6-7-30A	55.40	3.1438	2.83	2.19	-0.43	0.48	1.29	0.17	1.93	0.71	1.69
7-1-20A	55.90	3.1970	2.79	2.15	-0.11	0.80	0.96	0.22	1.98	0.48	1.49
7-1-30A	56.00	3.2077	2.34	1.70	-0.40	0.51	1.31	0.18	1.94	0.93	1.64
7-1-40A	56.10	3.2183	2.39	1.75	-0.56	0.35	1.21	0.23	1.99	1.09	1.55
7-1-60A	56.30	3.2396	2.53	1.89	-0.57	0.34	1.26	0.18	1.94	0.94	1.64
7-1-70A	56.40	3.2502	2.25	1.61	-0.67	0.24	1.05	0.15	1.91		
7-1-80A	56.50	3.2609	2.27	1.63	-0.33	0.58	1.15	0.10	1.86	0.93	1.59
7-1-90A	56.60	3.2715	2.79	2.15	-0.15	0.76	1.20	0.23	1.99	0.94	1.65
7-1-110A	56.80	3.2928	2.06	1.42	-0.44	0.47	0.94	0.33	2.09	0.80	1.68
7-1-120A	56.90	3.3034	2.24	1.60	-0.47	0.44	0.90	0.38	2.14	0.85	1.51
7-1-130A	57.00	3.3140	2.37	1.73	-0.16	0.75	1.25	0.23	1.99	1.54	1.91
7-1-140A	57.10	3.3247	2.84	2.20	-0.63	0.28	1.05	0.18	1.94	1.00	1.52
7-1-148A	57.18	3.3332	2.98	2.34	-0.26	0.65	1.15	0.22	1.98	0.96	1.62
7-2-10A	57.30	3.3460	2.95	2.31	-0.41	0.50	1.20	0.21	1.97	1.33	1.66
7-2-20A	57.40	3.3566	2.95	2.31	-0.21	0.70	1.32	0.24	2.00	1.27	1.57
7-2-30A	57.50	3.3672	3.15	2.51	-0.20	0.71	1.12	0.34	2.10	1.38	1.82
7-2-40A	57.60	3.3779	3.05	2.41	-0.35	0.56	1.41	0.35	2.11	1.29	1.85
7-2-50A	57.70	3.3885	2.95	2.31	-0.04	0.87	1.21	0.49	2.25	1.19	1.86
7-2-60A	57.80	3.3991	2.61	1.97	-0.34	0.57	1.49	0.45	2.21	0.67	1.76
7-2-70A	57.90	3.4098	2.97	2.33	-0.20	0.71	1.26	0.43	2.19	0.95	1.96
7-2-80A	58.00	3.4204	2.61	1.97	-0.22	0.69	1.05	0.45	2.21	0.67	0.97
7-2-90A	58.10	3.4311	2.97	2.33	-0.06	0.85	1.24	0.48	2.24	0.95	1.81
7-2-100A	58.20	3.4417	2.72	2.08	-0.45	0.46	0.72	0.34	2.10	1.06	1.93
7-2-110A	58.30	3.4523	2.86	2.22	-0.25	0.66	0.85	0.35	2.11	1.06	2.01
7-2-120A	58.40	3.4630	2.67	2.03	0.02	0.93	1.29	0.30	2.06	1.43	2.20
7-2-130A	58.50	3.4736	2.92	2.28	-0.36	0.55	1.36	0.45	2.21	1.25	1.88
7-2-140A	58.60	3.4843	3.33	2.69	-0.05	0.86	1.42	0.55	2.31	1.30	1.86
7-2-148A	58.68	3.4928	2.67	2.03	-0.04	0.87	1.56	0.54	2.30	1.39	2.05
7-3-10A	58.80	3.5055	2.60	1.96	-0.02	0.89	1.49	0.52	2.28	1.41	1.88
7-3-18A	58.88	3.5140	2.85	2.21	0.20	1.11	1.32	0.49	2.25	1.50	1.88
7-3-30A	59.00	3.5268	2.87	2.23	-0.34	0.57	1.26	0.48	2.24	1.59	1.97

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
7-3-40A	59.10	3.5374	3.03	2.39	0.20	1.11	1.21	0.60	2.36	1.37	1.75
7-3-50A	59.20	3.5481	2.89	2.25	0.32	1.23	1.12	0.43	2.19	1.08	2.09
7-3-60A	59.30	3.5587	2.34	1.70	0.28	1.19	1.19	0.60	2.36	0.91	1.85
7-3-68A	59.38	3.5672	2.39	1.75	-0.63	0.28	1.10	0.45	2.21	0.82	2.12
7-3-80A	59.60	3.5825	2.53	1.89	0.38	1.29	1.29	0.43	2.19	1.60	2.12
7-3-99A	59.69	3.5848	2.33	1.69	0.27	1.18	0.95	0.53	2.29	0.88	1.91
7-3-108A	59.78	3.5871	2.50	1.86	0.17	1.08	0.82	0.23	1.99	0.78	2.00
7-3-120A	59.90	3.5902	2.54	1.90	0.36	1.27	1.06	0.26	2.02	0.87	2.03
7-3-128A	59.98	3.5922	2.67	2.03	-0.15	0.76	1.19	0.34	2.10	0.86	2.06
7-3-140A	60.10	3.5953	2.43	1.79	-0.16	0.75	1.07	0.45	2.21	0.78	2.30
7-3-148A	60.18	3.5973	2.89	2.25	-0.03	0.88	1.31	0.43	2.19	1.01	1.83
7-4-10A	60.30	3.6004	2.34	1.70	-0.48	0.43	1.39	0.52	2.28	1.08	1.96
7-4-60A	60.80	3.6131	3.22	2.58	0.30	1.21	1.45	0.51	2.27	1.31	1.94
7-4-70A	60.90	3.6156	3.06	2.42	-0.37	0.54	1.37	0.51	2.27	1.30	1.87
7-4-90A	61.10	3.6207	2.77	2.13	0.26	1.17	1.22	0.54	2.30	1.19	1.73
7-4-100A	61.20	3.6233	2.59	1.95	0.21	1.12	1.15	0.48	2.24	1.40	1.80
7-4-108A	61.28	3.6253	2.87	2.23	0.36	1.27	1.26	0.43	2.19	1.29	2.04
7-4-120A	61.40	3.6284	2.28	1.64	0.15	1.06	1.27	0.58	2.34	1.14	2.04
7-4-128A	61.48	3.6304	2.55	1.91	0.26	1.17	1.17	0.56	2.32	1.01	1.54
7-4-140A	61.60	3.6334	2.64	2.00	0.22	1.13	1.28	0.59	2.35	1.47	1.81
7-5-9A	61.79	3.6383	2.36	1.72	0.13	1.04	1.36	0.64	2.40	1.25	1.77
7-5-17A	61.87	3.6403	2.72	2.08	0.07	0.98	1.39	0.66	2.42	1.32	2.10
7-5-29A	61.99	3.6434	2.17	1.53	0.02	0.93	1.42	0.43	2.19	1.32	1.66
7-5-39A	62.09	3.6459	2.95	2.31	0.27	1.18	1.36	0.54	2.30	1.53	1.81
7-5-47A	62.17	3.6479	2.14	1.50	0.20	1.11	1.28	0.46	2.22	1.07	1.54
7-5-60A	62.30	3.6513	2.72	2.08	0.59	1.50	1.27	0.53	2.29	1.32	1.74
7-5-69A	62.39	3.6535	2.17	1.53	-0.06	0.85	1.41	0.50	2.26	1.32	1.65
7-5-88A	62.58	3.6584	3.21	2.57	0.02	0.93	1.36	0.65	2.41	1.30	1.92
7-5-99A	62.69	3.6612	2.81	2.17	0.30	1.21	1.27	0.54	2.30	1.05	1.72
7-5-106A	62.76	3.6630	2.30	1.66	0.03	0.94	1.36	0.59	2.35	1.39	1.91
7-5-119A	62.89	3.6663	2.71	2.07	0.24	1.15	1.45	0.56	2.32	1.29	1.76
7-5-127A	62.97	3.6683	2.10	1.46	0.29	1.20	1.20	0.45	2.21	1.08	1.59
7-5-139A	63.09	3.6714	2.36	1.72	0.38	1.29	1.31	0.56	2.32	1.29	1.87
7-5-148A	63.18	3.6737	3.45	2.81	0.09	1.00	1.42	0.45	2.21	1.10	1.64
7-6-10A	63.30	3.6767	2.72	2.08	-0.09	0.82	1.20	0.47	2.23	1.12	1.69
7-6-20A	63.40	3.6792	2.85	2.21	-0.13	0.78	1.39	0.48	2.24	1.23	1.73
7-6-29A	63.49	3.6815	2.47	1.83	-0.14	0.77	1.10	0.42	2.18	0.99	1.75
7-6-40A	63.60	3.6843	2.32	1.68	-0.11	0.80	1.15	0.57	2.33	1.39	1.95
7-6-50A	63.70	3.6869	2.67	2.03	0.03	0.94	1.31	0.61	2.37	1.28	2.09
7-6-60A	63.80	3.6894	2.50	1.86	0.09	1.00	1.16	0.56	2.32	0.99	1.95
7-6-70A	63.90	3.6920	3.15	2.51	0.06	0.97	1.32	0.64	2.40	1.08	1.95
7-6-80A	64.00	3.6945	2.50	1.86	-0.02	0.89	1.02	0.67	2.43	0.82	1.90
8-1-40A	65.90	3.7429	2.89	2.25	0.27	1.18	1.26	0.65	2.41	1.15	2.06
8-1-80A	66.30	3.7530	2.85	2.21	0.13	1.04	1.29	0.69	2.45	1.08	2.14
8-1-120A	66.70	3.7632	2.81	2.17	-0.05	0.86	1.34	0.56	2.32	1.21	2.09
8-1-148A	66.98	3.7704	2.45	1.81	-0.06	0.85	1.26	0.72	2.48	1.10	2.15
8-2-40A	67.40	3.7810	2.67	2.03	-0.11	0.80	1.47	0.74	2.50	1.64	2.11
8-2-80A	67.80	3.7912	2.46	1.82	0.10	1.01	1.25	0.66	2.42	1.04	2.06
8-2-120A	68.20	3.8014	2.72	2.08	0.17	1.08	1.45	0.69	2.45	0.87	2.04
8-2-148A	68.48	3.8085	2.27	1.63	-0.24	0.67	1.33	0.67	2.43	1.25	1.98
8-3-40A	68.90	3.8192	2.71	2.07	0.10	1.01	1.37	0.70	2.46	1.27	2.13
8-3-80A	69.30	3.8294	2.86	2.22	0.13	1.04	1.15	0.64	2.40	1.31	2.01
8-3-120A	69.70	3.8396	2.38	1.74	0.33	1.24	1.31	0.60	2.36	1.22	1.91
8-3-148A	69.98	3.8467	2.71	2.07	-0.29	0.62	1.20	0.65	2.41	1.27	2.05
8-4-40A	70.40	3.8574	2.49	1.85	-0.43	0.48	1.26	0.63	2.39	1.31	1.84
8-4-77A	70.77	3.8668	2.68	2.04	-0.04	0.87	1.46	0.56	2.32	1.04	1.86
8-4-120A	71.20	3.8777	2.61	1.97	-0.46	0.45	1.31	0.53	2.29	1.58	1.84
8-4-148A	71.48	3.8849	2.57	1.93	-0.01	0.90	1.11	0.44	2.20	0.99	1.64
8-5-40A	71.90	3.8956	2.50	1.86	-0.25	0.66	1.26	0.64	2.40	1.06	1.79
8-5-120A	72.70	3.9159	2.93	2.29	-0.19	0.72	1.39	0.64	2.40	0.96	1.75
8-5-148A	72.98	3.9230	2.69	2.05	-0.06	0.85	1.19	0.45	2.21	1.13	1.77
8-6-40A	73.40	3.9337	2.51	1.87	-0.37	0.54	0.78	0.36	2.12	0.88	1.63
9-1-40A	75.30	3.9821	2.53	1.89	0.01	0.92	1.10	0.37	2.13	1.00	1.83

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
9-1-80A	75.70	3.9923	2.58	1.94	-0.18	0.73	1.21	0.40	2.16	1.09	1.94
9-1-120A	76.10	4.0024	2.52	1.88	-0.13	0.78	1.11	0.48	2.24	0.92	2.02
9-1-148A	76.38	4.0096	2.53	1.89	-0.02	0.89	1.13	0.41	2.17	0.93	2.05
9-2-40A	76.80	4.0203	2.41	1.77	0.04	0.95	0.91	0.40	2.16	0.90	2.15
9-2-80A	77.20	4.0304	2.43	1.79	-0.03	0.88	1.00	0.45	2.21	0.80	1.89
9-2-120A	77.60	4.0406	2.44	1.80	-0.10	0.81	1.25	0.49	2.25	1.20	2.12
9-2-130A	77.70	4.0432	2.39	1.75	-0.26	0.65	1.24	0.62	2.38	1.09	2.07
9-2-148A	77.88	4.0477	2.02	1.38	-0.02	0.89	1.16	0.54	2.30	1.02	1.82
9-3-40A	78.30	4.0584	2.28	1.64	-0.21	0.70	0.92	0.64	2.40	0.74	2.04
9-3-80A	78.70	4.0686	2.14	1.50	-0.30	0.61	1.01	0.66	2.42	0.94	1.85
9-3-120A	79.10	4.0788	2.35	1.71	-0.16	0.75	0.86	0.67	2.43	0.76	1.85
9-3-144A	79.34	4.0849	2.44	1.80	-0.27	0.64	1.10	0.62	2.38	0.94	1.89
9-4-40A	79.80	4.0966	2.60	1.96	-0.08	0.83	1.20	0.58	2.34	0.72	2.03
9-4-80A	80.20	4.1068	2.37	1.73	-0.01	0.90	1.16	0.53	2.29		
9-4-120A	80.60	4.1170	2.41	1.77	-0.16	0.75	1.08	0.64	2.40	1.18	1.94
9-4-148A	80.88	4.1241	2.51	1.87	-0.28	0.63	1.21	0.66	2.42	0.95	1.99
9-5-40A	81.30	4.1348	2.53	1.89	-0.14	0.77	1.08	0.69	2.45	1.18	1.87
9-5-81A	81.71	4.1452	2.75	2.11	-0.07	0.84	1.32	0.56	2.32	1.08	1.95
9-5-130A	82.20	4.1577	2.42	1.78	-0.24	0.67	0.82	0.52	2.28	0.52	1.96
9-5-148A	82.38	4.1623	2.07	1.43	-0.30	0.61	0.92	0.51	2.27	1.10	1.86
9-6-39A	82.79	4.1727	2.63	1.99	-0.24	0.67	1.10	0.53	2.29	0.95	1.77
9-6-81A	83.21	4.1834	1.84	1.20	-0.33	0.58	1.06	0.44	2.20	0.86	2.14
9-6-120A	83.60	4.1933	2.71	2.07	0.00	0.91	1.27	0.46	2.22	0.89	1.96
9-6-130A	83.70	4.1959	2.78	2.14	0.11	1.02	1.33	0.35	2.11	1.06	2.04
9-6-148A	83.80	4.1984	2.45	1.81	0.16	1.07	1.26	0.36	2.12	1.18	2.20
9-7-29A	84.19	4.2083	2.63	1.99	-0.21	0.70	1.12	0.59	2.35	0.82	1.65
10-1-81A	85.31	4.2368	2.87	2.23	-0.11	0.80	1.12	0.65	2.41	1.05	2.35
10-1-130A	85.80	4.2493	2.42	1.78	0.08	0.99	1.21	0.67	2.43		
10-1-148A	85.98	4.2539	2.97	2.33	1.07	1.98	1.54	0.80	2.56	1.68	2.08
10-2-81A	86.81	4.2750	2.43	1.79	0.08	0.99	1.16	0.87	2.63	1.26	2.12
10-2-120A	87.30	4.2875	2.26	1.62	0.14	1.05	1.22	0.90	2.66	1.08	2.28
10-2-148A	87.48	4.2920	2.31	1.67	-0.11	0.80	1.26	0.86	2.62	1.16	2.21
10-3-40A	87.90	4.3027	2.83	2.19	0.31	1.22	1.31	0.74	2.50	1.03	2.06
10-3-80A	88.30	4.3129	2.42	1.78	-0.03	0.88	1.04	0.66	2.42	0.98	1.92
10-3-121A	88.71	4.3234	2.40	1.76	0.01	0.92	1.16	0.62	2.38	1.05	2.02
10-3-141A	88.91	4.3284	2.04	1.40	0.69	1.60	1.10	0.60	2.36		
10-4-40A	89.40	4.3409	2.74	2.10	0.04	0.95	1.24	0.65	2.41	1.01	2.02
10-4-80A	89.80	4.3511	2.85	2.21	-0.07	0.84	1.57	0.55	2.31	1.49	1.85
10-4-120A	90.20	4.3613	2.78	2.14	0.04	0.95	1.15	0.78	2.54	1.22	1.95
10-4-148A	90.48	4.3684	2.23	1.59	-0.12	0.79	1.06	0.73	2.49	1.04	2.05
10-5-40A	90.90	4.3791	2.71	2.07	0.20	1.11	1.16	0.65	2.41	1.26	2.15
10-5-81A	91.31	4.3895	2.17	1.53	-0.35	0.56	1.21	0.55	2.31	0.98	1.89
10-5-121A	91.71	4.3997	2.46	1.82	-0.30	0.61	1.26	0.53	2.29	1.16	1.77
10-5-148A	91.98	4.4066	2.17	1.53	-0.11	0.80	1.10	0.64	2.40	0.89	1.91
10-6-38A	92.30	4.4147	2.54	1.90	0.20	1.11	0.91	0.67	2.43	0.80	2.06
10-6-78A	92.78	4.4269	2.62	1.98	-0.25	0.66	1.15	0.72	2.48	0.96	2.04
10-6-115A	93.15	4.4363	2.08	1.44	-0.26	0.65	0.95	0.75	2.51	1.19	1.94
11-1-40A	94.50	4.4707	2.44	1.80	0.11	1.02	1.17	0.87	2.63	1.27	1.98
11-1-77A	94.87	4.4801	1.99	1.35	-0.07	0.84	0.96	0.83	2.59	0.93	2.04
11-1-121A	95.31	4.4913	2.38	1.74	0.13	1.04	1.21	0.76	2.52	1.37	2.23
11-1-148A	95.58	4.4982	2.85	2.21	0.41	1.32	1.34	0.75	2.51	1.09	2.33
11-2-39A	95.99	4.5086	2.22	1.58	0.26	1.17					
11-2-78A	96.38	4.5185	2.71	2.07	-0.08	0.83	1.41	0.65	2.41	1.49	2.11
11-2-120A	96.80	4.5292	2.85	2.21	0.18	1.09	1.32	0.75	2.51	1.34	1.98
11-2-148A	97.08	4.5364	2.45	1.81	0.22	1.13	1.64	0.90	2.66	1.71	2.25
11-3-40A	97.50	4.5470	3.06	2.42	0.35	1.26	1.51	0.86	2.62	1.43	2.17
11-3-79A	97.89	4.5570	2.54	1.90	0.23	1.14	1.52	0.87	2.63	1.78	2.45
11-3-118A	98.28	4.5669	2.65	2.01	-0.03	0.88	1.38	0.78	2.54	2.23	1.95
11-3-141A	98.51	4.5727	2.87	2.23	0.02	0.93	1.36	0.65	2.41	1.32	1.75
11-4-40A	99.00	4.5852	2.66	2.02	0.36	1.27	1.21	0.57	2.33	1.32	2.17
11-4-79A	99.39	4.5951	2.90	2.26	0.21	1.12	1.40	0.60	2.36	1.54	2.14
11-4-148A	100.08	4.6127	3.02	2.38	-0.17	0.74	1.61	0.54	2.30	2.08	1.72
11-5-41A	100.51	4.6236	2.51	1.87	-0.16	0.75	1.51	0.58	2.34	1.66	1.84

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
11-5-80A	100.90	4.6336	2.39	1.75	-0.23	0.68	1.42	0.53	2.29	1.32	1.85
11-5-120Å	101.30	4.6437	2.35	1.71	0.00	0.91	1.34	0.54	2.30	1.84	2.09
11-5-128A	101.38	4.6458	2.38	1.74	0.05	0.96	1.51	0.50	2.26	1.55	2.09
11-5-148A	101.58	4.6509	2.61	1.97	-0.01	0.90	1.39	0.51	2.27	1.30	2.10
11-6-41A	102.10	4.6641	2.65	2.01	-0.10	0.81	1.45	0.48	2.24	1.38	1.98
11-6-78A	102.38	4.6712	2.20	1.56	0.43	1.34	1.29	0.56	2.32	1.55	2.06
11-6-107A	102.67	4.6786	2.53	1.89	-0.20	0.71	1.41	0.59	2.35	1.75	2.04
12-1-40Å	104.10	4.7150	2.86	2.22	0.22	1.13	1.61	0.63	2.39	1.97	2.22
12-1-80A	104.50	4.7252	2.46	1.82	0.40	1.31	1.47	0.62	2.38	1.48	2.00
12-1-120Å	104.90	4.7354	2.40	1.76	0.06	0.97	1.36	0.56	2.32	1.13	1.82
12-1-140A	105.10	4.7405	2.71	2.07	-0.02	0.89	1.41	0.60	2.36		
12-2-40A	105.60	4.7532	2.45	1.81	-0.05	0.86	1.29	0.70	2.46	1.03	1.93
12-2-120A	106.40	4.7735	1.88	1.24	0.07	0.98	0.99	0.69	2.45		
12-2-148A	106.68	4.7807	1.94	1.30	-0.24	0.67	1.10	0.64	2.40		
12-3-40A	107.10	4.7913	2.58	1.94	-0.15	0.76	1.57	0.67	2.43	1.51	1.79
12-3-80A	107.50	4.8015	2.60	1.96	-0.13	0.78	1.26	0.64	2.40	1.09	1.78
12-3-120A	107.90	4.8117	2.08	1.44	-0.19	0.72	1.06	0.62	2.38	0.99	2.00
12-3-148A	108.18	4.8188	2.34	1.70	-0.11	0.80	1.27	0.66	2.42	1.04	2.18
12-4-40A	108.60	4.8295	2.25	1.61	0.00	0.91	1.36	0.69	2.45	1.16	1.96
12-4-80A	109.00	4.8397	2.04	1.40	0.57	1.48	1.26	0.69	2.45	1.39	1.88
12-4-120A	109.40	4.8499	2.22	1.58	0.47	1.38	1.48	0.56	2.32	1.71	1.79
12-4-148A	109.68	4.8570	1.84	1.20	0.23	1.14	1.32	0.71	2.47	1.35	2.12
12-5-40A	110.10	4.8677	2.16	1.52	0.14	1.05	1.48	0.74	2.50	1.70	2.12
12-5-80A	110.50	4.8779	2.27	1.63	-0.11	0.80	1.26	0.69	2.45	0.94	2.03
12-5-120A	110.90	4.8881	2.86	2.22	0.18	1.09	1.19	0.64	2.40	0.79	2.06
12-5-148A	111.18	4.8952	2.50	1.86	0.55	1.46	1.37	0.63	2.39	1.74	2.07
12-6-40A	111.40	4.9008	2.33	1.69	0.01	0.92	1.56	0.68	2.44	1.40	2.03
12-6-80Å	111.80	4.9110	2.77	2.13	-0.12	0.79	1.63	0.61	2.37	1.81	1.88
13-1-80A	114.10	4.9695	2.14	1.50	0.44	1.35	1.16	0.65	2.41		
13-1-120A	114.50	4.9797	2.18	1.54	0.83	1.74	1.56	0.75	2.51	1.94	2.21
13-1-148A	114.78	4.9868	2.32	1.68	0.70	1.61	1.36	0.72	2.48	1.00	2.19
13-2-40A	115.20	4.9975	2.24	1.60	0.75	1.66	1.47	0.80	2.56	1.23	2.32
13-2-80A	115.60	5.0077	2.90	2.26	0.59	1.50	1.60	0.89	2.65	1.48	2.07
13-2-120A	116.00	5.0178	2.26	1.62	0.95	1.86	1.26	0.78	2.54	1.08	2.26
13-2-148A	116.28	5.0250	2.43	1.79	1.02	1.93	1.19	0.83	2.59	0.89	2.28
13-3-40A	116.70	5.0357	2.04	1.40	1.20	2.11	1.27	0.81	2.57	1.07	2.24
13-3-80A	117.10	5.0458	2.09	1.45	0.60	1.51	1.19	0.85	2.61	0.99	2.11
13-3-120A	117.50	5.0560	2.43	1.79	0.55	1.46	0.96	0.87	2.63	0.89	2.30
13-3-148A	117.78	5.0631	2.27	1.63	0.19	1.10	1.21	0.76	2.52	1.24	2.25
13-4-40A	118.20	5.0738	2.40	1.76	0.59	1.50	1.32	0.90	2.66	1.11	1.95
13-4-80A	118.60	5.0840	2.69	2.05	0.21	1.12	1.56	0.91	2.67	1.44	2.19
13-4-120A	119.00	5.0942	2.42	1.78	0.58	1.49	1.48	0.87	2.63	1.21	2.05
13-4-148A	119.28	5.1013	2.57	1.93	0.23	1.14	1.69	1.04	2.80	1.80	2.42
13-5-40A	119.70	5.1120	2.48	1.84	0.39	1.30	1.46	0.98	2.74	1.63	2.20
13-5-80A	120.10	5.1222	2.84	2.20	0.72	1.63	1.41	0.87	2.63	1.38	2.20
13-5-120A	120.50	5.1324	2.38	1.74	0.61	1.52	1.36	0.78	2.54	1.14	2.20
13-5-148A	120.78	5.1395	3.01	2.37	0.60	1.51	1.31	0.70	2.46	1.23	2.13
13-6-40A	121.20	5.1502	2.37	1.73	-0.04	0.87	1.35	0.76	2.52	1.39	2.15
13-6-80A	121.60	5.1604	2.92	2.28	-0.07	0.84	1.46	0.70	2.46	1.20	1.92
13-6-118A	121.98	5.1700	2.47	1.83	0.41	1.32	1.27	0.71	2.47	1.78	2.17
14-1-40A	123.30	5.2009	2.54	1.90	0.60	1.51	1.71	0.67	2.43	1.52	2.22
14-1-80A	123.70	5.2070	2.32	1.68	-0.05	0.86	1.21	0.68	2.44	1.04	1.89
14-1-120A	124.10	5.2131	2.49	1.85	0.34	1.25	1.34	0.63	2.39	1.18	2.14
14-1-148A	124.38	5.2173	2.29	1.65	0.59	1.50	1.19	0.67	2.43	1.05	2.20
14-2-40A	124.80	5.2237	2.46	1.82	0.91	1.82	1.27	0.78	2.54	1.17	2.26
14-2-120A	125.60	5.2359	2.11	1.47	0.69	1.60	1.41	1.21	2.97	1.30	2.14
14-2-148A	125.88	5.2401	2.25	1.61	0.06	0.97	1.26	0.80	2.56	1.01	2.12
14-3-40A	126.30	5.2465	2.28	1.64	0.17	1.08	1.55	0.64	2.40	1.13	2.07
14-3-80A	126.70	5.2526	2.04	1.40	-0.03	0.88	1.27	0.66	2.42	1.17	2.00
14-3-120A	127.10	5.2586	2.67	2.03	0.58	1.49	1.32	0.78	2.54	1.43	2.29
14-3-148A	127.38	5.2629	2.94	2.30	-0.06	0.85	1.19	0.79	2.55	1.12	1.87
14-4-120A	128.60	5.2814	3.04	2.40	0.24	1.15	1.59	0.47	2.23	1.72	2.22
14-4-148Å	128.88	5.2857	3.11	2.47	0.04	0.95	1.66	0.55	2.31	1.98	2.07

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
14-5-40A	129.30	5.2921	3.04	2.40	0.12	1.03	1.43	1.02	2.78		
14-5-80Å	129.70	5.2981	3.04	2.40	0.44	1.35	1.70	1.37	3.13	2.00	2.27
14-5-120A	130.10	5.3042	3.06	2.42	0.12	1.03	1.48	1.05	2.81	1.73	2.50
14-5-148A	130.38	5.3084	2.56	1.92	-0.02	0.89	1.56	1.12	2.88	1.55	2.20
14-6-40A	130.88	5.3160	3.33	2.69	0.50	1.41	1.69	1.32	3.08	1.85	2.30
14-6-80A	131.20	5.3209	2.44	1.80	-0.10	0.81	1.65	0.81	2.57		
15-1-40A	132.90	5.3467	2.53	1.89	0.18	1.09	1.56	1.01	2.77	1.62	2.05
15-1-80A	133.30	5.3528	2.50	1.86	0.41	1.32	1.29	1.10	2.86	0.97	2.26
15-1-120A	133.70	5.3589	2.53	1.89	0.11	1.02	1.24	1.20	2.96	1.33	2.30
15-1-148A	133.98	5.3631	2.04	1.40	0.18	1.09	1.49	1.03	2.79	1.29	2.37
15-2-40A	134.40	5.3695	2.16	1.52	0.41	1.32	1.31	0.99	2.75	0.91	2.24
15-2-80A	134.80	5.3756	2.30	1.66	0.31	1.22	1.50	0.87	2.63	1.39	2.25
15-2-120A	135.20	5.3816	2.07	1.43	1.20	2.11	1.49	0.78	2.54	1.56	1.98
15-2-148A	135.48	5.3859	2.42	1.78	0.28	1.19	1.64	0.97	2.73	1.52	2.23
15-3-40A	135.90	5.3923	2.57	1.93	0.43	1.34	1.69	0.90	2.66	1.82	2.13
15-3-80A	136.30	5.3983	2.92	2.28	1.23	2.14	1.72	0.76	2.52	2.17	1.75
15-3-148A	137.40	5.4150	2.21	1.57	0.82	1.73	1.36	0.67	2.43		
15-4-80A	137.80	5.4211	2.94	2.30	0.30	1.21	1.96	0.89	2.65	1.59	2.41
15-4-120A	138.20	5.4272	3.11	2.47	0.29	1.20	1.36	0.63	2.39	1.85	1.69
15-4-148A	138.48	5.4314	2.74	2.10	0.04	0.95	1.41	0.62	2.38	1.35	2.90
15-5-40A	138.90	5.4378	2.72	2.08	0.26	1.17	1.52	0.70	2.46	1.64	2.05
15-5-80A	139.30	5.4439	2.85	2.21	0.17	1.08	1.11	0.65	2.41		
15-5-120Å	139.70	5.4500	3.28	2.64	0.60	1.51	0.92	0.76	2.52	0.97	1.80
15-5-147A	139.97	5.4541	2.43	1.79	0.44	1.35	1.19	0.80	2.56	1.01	1.92
15-6-40Å	140.40	5.4606	2.22	1.58	0.22	1.13	1.36	0.86	2.62	0.96	1.87
15-6-80A	140.80	5.4667	2.26	1.62	0.78	1.69	1.29	0.77	2.53	1.13	1.95
15-6-114A	141.14	5.4718	3.05	2.41	0.62	1.53	1.47	0.75	2.51	1.24	2.07
16-1-40Å	142.50	5.4925	3.12	2.48	1.12	2.03	1.51	0.71	2.47	1.52	2.09
16-1-80A	142.90	5.4986	2.77	2.13	0.30	1.21	1.48	0.86	2.62	1.81	2.30
16-1-120Å	143.30	5.5046	2.81	2.17	0.05	0.96	1.36	0.64	2.40	1.11	1.80
16-1-148A	143.58	5.5089	2.84	2.20	0.27	1.18	1.44	0.64	2.40	1.28	1.89
16-2-80A	144.40	5.5307	2.53	1.89	0.15	1.06	1.36	0.69	2.45	1.14	1.90
16-2-148A	145.08	5.5504	2.76	2.12	0.26	1.17	1.56	0.72	2.48	1.94	2.25
16-3-40A	145.50	5.5626	2.37	1.73	0.31	1.22	1.49	0.71	2.47	1.30	1.89
16-3-80A	145.90	5.5741	2.33	1.69	0.51	1.42	1.26	0.67	2.43	1.47	1.70
16-3-120A	146.30	5.5857	2.28	1.64	0.40	1.31	1.37	0.54	2.30	1.51	1.95
16-3-148A	146.58	5.5938	2.16	1.52	0.25	1.16	1.48	0.52	2.28	1.31	2.10
16-4-40A	147.00	5.6060	2.24	1.60	0.11	1.02	1.36	0.47	2.23	1.11	1.92
16-4-80A	147.40	5.6176	2.46	1.82	-0.17	0.74	1.41	0.42	2.18	0.90	1.80
16-4-120A	147.80	5.6292	3.06	2.42	-0.07	0.84	1.52	0.45	2.21	1.08	1.69
16-5-40A	148.50	5.6494	2.00	1.36	0.12	1.03	1.65	0.58	2.34	1.42	2.04
16-5-80A	148.90	5.6610	2.56	1.92	0.21	1.12	1.39	0.67	2.43	0.89	2.10
16-5-120A	149.30	5.6726	1.77	1.13	0.35	1.26	1.30	0.76	2.52	1.10	2.30
16-5-148A	149.58	5.6807	2.87	2.23	0.10	1.01	1.25	0.72	2.48	0.67	1.89
16-6-40A	150.00	5.6929	1.93	1.29	0.15	1.06	1.36	0.87	2.63	0.91	2.32
16-6-120A	150.80	5.7160	2.31	1.67	0.09	1.00	1.47	0.76	2.52	1.11	1.98
16-6-148A	151.08	5.7242	2.66	2.02	-0.16	0.75	1.26	0.73	2.49	0.80	1.70
17-1-40A	152.10	5.7537	2.57	1.93	0.48	1.39	1.61	0.60	2.36	1.48	1.57
17-1-80A	152.50	5.7653	2.30	1.66	-0.31	0.60	1.58	0.67	2.43	1.43	2.02
17-1-120A	152.90	5.7769	2.93	2.29	0.42	1.33	1.61	0.62	2.38	1.76	1.94
17-1-148A	153.18	5.7850	2.17	1.53	0.24	1.15	1.29	0.63	2.39	0.96	2.38
17-2-80A	154.00	5.8087	2.31	1.67	0.01	0.92	1.38	0.76	2.52	1.16	2.25
17-2-120A	154.40	5.8203	2.12	1.48	0.13	1.04	1.48	0.89	2.65	1.31	2.35
17-2-148A	154.68	5.8284	2.54	1.90	0.02	0.93	1.30	1.08	2.84	1.26	2.31
17-3-40A	155.10	5.8406	2.19	1.55	0.16	1.07	1.21	1.21	2.97	1.05	2.02
17-3-80A	155.50	5.8522	2.29	1.65	0.29	1.20	1.00	0.98	2.74	0.88	2.24
17-3-120A	155.90	5.8638	2.41	1.77	0.33	1.24	0.96	0.87	2.63	0.87	2.00
17-3-148A	156.18	5.8719	2.79	2.15	0.16	1.07	1.26	1.07	2.83	1.75	2.35
17-4-40A	156.60	5.8840	2.45	1.81	0.09	1.00	1.10	0.95	2.71	0.56	1.70
17-4-80A	157.00	5.8956	2.24	1.60	0.01	0.92	1.30	0.83	2.59	0.92	2.19
17-4-120A	157.40	5.9072	2.23	1.59	0.13	1.04	1.26	0.80	2.56	1.39	2.13
17-4-148A	157.68	5.9153	2.23	1.59	-0.15	0.76	1.41	0.75	2.51	1.67	1.84
18/1/9	158.79	5.9474	1.71	1.07	-0.48	0.43	1.06	0.71	2.47	0.81	2.47

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
18/1/29	158.99	5.9532	1.97	1.33	0.12	1.03	1.24	0.60	2.36	0.90	1.90
18/1/50	159.20	5.9593	2.54	1.90	0.05	0.96	1.11	0.65	2.41	0.78	1.91
18/1/69	159.39	5.9648	2.41	1.77	0.19	1.10	1.26	0.72	2.48	1.13	2.26
18-1-100	159.70	5.9738	2.24	1.60	0.27	1.18	1.39	0.78	2.54	1.68	2.43
18-1-121	159.91	5.9799	2.17	1.53	-0.09	0.82	1.28	0.81	2.57	0.88	1.32
18-1-140	160.10	5.9854	1.99	1.35	-0.24	0.67	0.92	0.95	2.71	0.21	1.99
18/2/10	160.30	5.9912	2.36	1.72	-0.14	0.77	0.87	0.73	2.49	0.59	1.92
18/2/29	160.49	5.9967	2.16	1.52	-0.06	0.85	0.91	0.65	2.41	0.51	1.80
18/2/50	160.70	6.0028	2.30	1.66	0.05	0.96	1.12	0.56	2.32	0.86	2.10
18/2/68	160.88	6.0080	2.27	1.63	-0.06	0.85	1.25	0.44	2.20	0.97	1.71
18/2/80	161.00	6.0115	2.39	1.75	-0.16	0.75	1.36	0.41	2.17	1.24	1.85
18-2-100	161.20	6.0172	2.56	1.92	-0.05	0.86	1.24	0.30	2.06	1.39	1.62
18-2-120	161.40	6.0230	2.63	1.99	-0.35	0.56	1.31	0.38	2.14	1.64	1.45
18-2-139	161.59	6.0285	2.34	1.70	-0.16	0.75	1.26	0.49	2.25	1.15	2.23
18/3/10	161.80	6.0346	2.87	2.23	-0.21	0.70	1.14	0.92	2.68	1.24	2.33
18/3/30	162.00	6.0404	3.17	2.53	0.32	1.23	1.24	0.81	2.57	0.88	2.29
18/3/50	162.20	6.0462	2.36	1.72	0.20	1.11	1.32	0.79	2.55	1.31	2.49
18/3/70	162.40	6.0520	2.19	1.55	-0.12	0.79	1.25	0.75	2.51	1.16	2.43
18/3/80	162.50	6.0549	2.29	1.65	-0.18	0.73	1.16	0.85	2.61	1.09	2.12
18-3-101	162.71	6.0610	2.77	2.13	0.11	1.02	1.41	1.02	2.78	1.26	2.31
18-3-120	162.90	6.0665	2.46	1.82	0.05	0.96	1.31	0.96	2.72	1.11	2.12
18/4/9	163.29	6.0778	1.95	1.31	0.00	0.91	1.06	0.91	2.67	0.97	2.15
18/4/30	163.50	6.0839	1.71	1.07	-0.15	0.76	1.21	0.71	2.47	1.06	2.34
18/4/50	163.70	6.0897	2.29	1.65	0.12	1.03	1.11	0.65	2.41	0.88	2.25
18/4/69	163.89	6.0952	2.64	2.00	-0.07	0.84	1.34	0.59	2.35	0.93	2.26
18/4/80	164.00	6.0983	2.75	2.11	0.05	0.96	1.26	0.56	2.32	0.92	2.39
18-4-100	164.20	6.1041	2.85	2.21	0.11	1.02	1.27	0.61	2.37	1.32	2.51
18-4-120	164.40	6.1099	2.49	1.85	0.05	0.96	1.31	0.66	2.42	1.11	2.16
18-4-140	164.60	6.1157	2.85	2.21	0.24	1.15	1.21	0.73	2.49	1.05	2.46
18/5/10	164.80	6.1215	2.45	1.81	0.19	1.10	0.87	0.81	2.57	0.67	2.05
18/5/30	165.00	6.1273	2.91	2.27	0.13	1.04	1.35	0.91	2.67	1.15	2.23
18/5/50	165.20	6.1331	2.36	1.72	-0.03	0.88	1.15	1.05	2.81	0.91	2.08
18/5/70	165.40	6.1389	2.08	1.44	-0.60	0.31	0.99	0.96	2.72	0.88	1.93
18/5/80	165.50	6.1418	2.26	1.62	0.35	1.26	1.32	0.85	2.61	1.03	2.04
18-5-100	165.70	6.1476	2.95	2.31	-0.15	0.76	1.42	0.72	2.48	1.23	1.82
18-5-120	165.90	6.1534	2.53	1.89	0.38	1.29	1.41	0.83	2.59	1.53	2.32
18-5-140	166.10	6.1592	2.35	1.71	-0.36	0.55	1.26	0.91	2.67	1.36	2.28
18/6/10	166.30	6.1650	2.52	1.88	0.01	0.92	1.36	0.96	2.72	1.14	2.22
18/6/30	166.50	6.1707	2.21	1.57	0.11	1.02	1.16	1.04	2.80	0.95	2.26
18/6/50	166.70	6.1765	2.46	1.82	0.06	0.97	1.26	1.12	2.88	1.02	2.03
18/6/69	166.89	6.1820	3.04	2.40	0.64	1.55	1.07	1.03	2.79	1.00	2.02
18/6/80	167.00	6.1852	3.06	2.42	0.33	1.24	0.91	0.90	2.66	0.77	2.11
18-6-100	167.20	6.1910	2.37	1.73	0.02	0.93	1.26	0.81	2.57	0.99	2.16
18-6-120	167.40	6.1968	2.98	2.34	0.48	1.39	1.01	0.69	2.45	0.67	2.04
19/1/10	168.40	6.2258	2.02	1.38	0.06	0.97	1.21	0.51	2.27	0.81	2.06
19/1/30	168.60	6.2316	1.93	1.29	0.22	1.13	1.16	0.60	2.36	1.06	2.48
19/1/69	168.99	6.2429	2.85	2.21	0.34	1.25	1.34	0.72	2.48	1.91	2.49
19/1/80	169.10	6.2460	2.67	2.03	0.15	1.06	1.41	0.80	2.56	1.26	2.41
19/1/99	169.29	6.2515	2.82	2.18	0.16	1.07	1.51	0.85	2.61	1.30	2.16
19-1-120	169.50	6.2576	3.36	2.72	0.42	1.33	0.99	0.91	2.67	0.76	2.17
19-1-140	169.70	6.2634	2.52	1.88	0.05	0.96	1.04	0.77	2.53	0.80	2.20
19/2/10	169.90	6.2692	2.61	1.97	0.03	0.94	1.21	0.60	2.36	0.91	1.85
19/2/30	170.10	6.2750	2.96	2.32	0.02	0.93	1.01	0.41	2.17	0.62	2.01
19/2/47	170.27	6.2799	2.99	2.35	0.19	1.10	1.31	0.50	2.26	1.20	2.34
19/2/70	170.50	6.2866	1.92	1.28	-0.38	0.53	0.85	0.60	2.36	0.79	2.15
19-2-100	170.80	6.2953	2.28	1.64	0.24	1.15	1.12	0.65	2.41	1.59	2.28
19-2-120	171.00	6.3011	2.63	1.99	0.06	0.97	1.41	0.72	2.48	1.22	2.01
19-2-140	171.20	6.3069	2.11	1.47	0.09	1.00	1.53	0.63	2.39	1.40	2.02
19/3/09	171.39	6.3124	3.06	2.42	0.15	1.06	1.66	0.53	2.29	1.86	2.02
19/3/30	171.60	6.3184	2.38	1.74	0.29	1.20	1.99	0.42	2.18	1.65	2.04
19/3/50	171.80	6.3242	2.25	1.61	0.32	1.23	1.33	0.54	2.30	1.44	1.83
19/3/70	172.00	6.3300	2.21	1.57	-0.25	0.66	1.29	0.63	2.39	1.05	1.62
19/3/97	172.27	6.3379	3.39	2.75	0.01	0.92	1.78	0.73	2.49	1.31	2.26

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
19-3-120	172.50	6.3445	3.35	2.71	0.12	1.03	1.61	0.51	2.27	1.42	2.35
19-3-139	172.69	6.3500	3.17	2.53	0.17	1.08	1.72	0.63	2.39	1.36	2.42
19/4/10	172.90	6.3561	2.89	2.25	0.29	1.20	1.92	0.77	2.53	1.57	2.58
19/4/30	173.10	6.3619	3.20	2.56	0.02	0.93	1.04	0.91	2.67	1.40	2.25
19/4/50	173.30	6.3677	3.59	2.95	0.11	1.02	1.65	1.12	2.88	1.88	2.20
19/4/70	173.50	6.3735	3.58	2.94	-0.08	0.83	1.11	1.03	2.79	1.45	2.22
19-4-100	173.80	6.3822	2.97	2.33	0.08	0.99	1.36	0.94	2.70	1.66	2.07
19-4-120	174.00	6.3880	3.15	2.51	0.08	0.99	1.78	0.80	2.56	1.69	1.86
19-4-140	174.20	6.3937	3.44	2.80	0.06	0.97	1.76	0.99	2.75	2.39	2.51
19/5/10	174.40	6.3995	2.79	2.15	0.10	1.01	1.72	0.73	2.49	1.60	2.14
19/5/30	174.60	6.4053	2.12	1.48	0.01	0.92	1.52	0.63	2.39	1.11	2.64
19/5/50	174.81	6.4114	2.26	1.62	-0.12	0.79	1.36	0.36	2.12	1.25	2.25
19/5/70	175.00	6.4169	2.34	1.70	-0.27	0.64				1.01	1.77
19-5-100	175.30	6.4256	3.29	2.65	0.26	1.17	1.42	0.96	2.72	1.58	2.07
19-5-120	175.50	6.4314	2.67	2.03	0.17	1.08	1.36	0.80	2.56	1.46	1.92
19/5/140	175.70	6.4372	2.35	1.71	-0.28	0.63	1.41	0.76	2.52	1.35	1.81
19/6/10	175.90	6.4430	3.67	3.03	0.14	1.05	1.72	0.85	2.61	1.68	2.16
19/6/30	176.10	6.4488	3.45	2.81	0.27	1.18	1.71	0.73	2.49	1.86	1.82
19/6/50	176.30	6.4546	3.29	2.65	0.11	1.02	1.56	0.63	2.39	1.58	2.02
19/6/70	176.50	6.4604	3.46	2.82	0.07	0.98	1.74	0.51	2.27	1.31	1.84
19-6-100	176.80	6.4690	3.24	2.60	-0.01	0.90	1.63	0.89	2.65	1.75	1.73
19-6-120	177.00	6.4748	2.61	1.97	0.03	0.94	1.59	0.87	2.63	1.45	1.39
19-6-148	177.28	6.4829	3.05	2.41	-0.08	0.83	1.31	0.71	2.47	1.05	1.27
19/7/10	177.40	6.4864	2.53	1.89	-0.30	0.61	1.28	0.66	2.42	1.21	2.01
19/7/30	177.60	6.4922	3.31	2.67	0.11	1.02	1.65	0.42	2.18	1.49	1.75
19/7/50	177.80	6.4980	3.23	2.59	-0.40	0.51	1.00	0.56	2.32	1.06	2.11
20/1/20	178.10	6.5067	3.23	2.59	-0.40	0.51	1.51	0.69	2.45	1.06	2.15
20/1/60	178.50	6.5183	2.26	1.62	-0.18	0.73	1.26	1.03	2.79	1.16	2.06
20/1/92	178.82	6.5275	3.32	2.68	0.32	1.23	1.39	1.25	3.01	1.69	2.02
20-1-112	179.02	6.5333	3.70	3.06	0.53	1.44	1.46	1.31	3.07	1.97	2.46
20-1-127	179.17	6.5377	2.83	2.19	-0.62	0.29	1.20	1.23	2.99	1.16	1.62
20/2/30	179.70	6.5530	2.44	1.80	-0.42	0.49	0.51	0.44	2.20	1.13	1.83
20/2/52	179.92	6.5594	2.29	1.65	0.03	0.94	0.28	0.51	2.27	0.76	1.92
20/2/71	180.11	6.5649	1.89	1.25	-0.08	0.83	0.82	0.59	2.35	0.50	2.09
20-2-100	180.40	6.5733	2.02	1.38	-0.44	0.47	0.19	0.65	2.41	0.79	1.82
20-2-120	180.60	6.5791	2.93	2.29	-0.15	0.76	1.46	0.71	2.47	1.06	2.02
20-2-140	180.80	6.5849	3.37	2.73	0.04	0.95	1.71	0.79	2.55	1.96	1.95
20/3/10	181.00	6.5907	2.31	1.67	-0.54	0.37	1.24	0.96	2.72	0.65	1.85
20/3/29	181.19	6.5962	1.94	1.30	-0.49	0.42	1.29	1.01	2.77	0.80	1.95
20/3/52	181.40	6.6023	1.75	1.11	-0.12	0.79	1.10	1.08	2.84	0.84	1.96
20/3/70	181.60	6.6081	2.30	1.66	-0.19	0.72	1.67	1.12	2.88	1.37	1.21
20-3-102	181.92	6.6173	2.12	1.48	-0.16	0.75	1.01	0.89	2.65	0.71	2.41
20-3-120	182.10	6.6225	2.12	1.48	-0.06	0.85	1.26	1.11	2.87	1.08	2.29
20/4/10	182.50	6.6341	2.59	1.95	0.04	0.95	1.39	1.21	2.97	1.52	1.93
20/4/31	182.70	6.6399	2.26	1.62	-0.39	0.52	1.41	1.26	3.02	1.25	1.73
20/4/50	182.90	6.6457	1.96	1.32	0.14	1.05	1.03	1.10	2.86	1.23	2.32
20/4/70	183.10	6.6515	2.61	1.97	0.23	1.14	1.50	1.29	3.05	1.40	2.30
20-4-100	183.40	6.6602	2.69	2.05	0.24	1.15	1.60	1.21	2.97	1.55	2.26
20-4-120	183.60	6.6660	2.21	1.57	0.32	1.23	0.76	1.18	2.94	1.17	2.34
20-4-140	183.80	6.6718	3.17	2.53	0.60	1.51	0.80	1.13	2.89	1.23	2.03
20/5/10	184.00	6.6776	3.44	2.80	-0.05	0.86	0.96	1.31	3.07	1.45	2.09
20/5/30	184.20	6.6834	2.83	2.19	0.28	1.19	1.27	1.09	2.85	1.55	2.50
20/5/51	184.41	6.6894	2.03	1.39	0.10	1.01	1.65	0.96	2.72	1.72	2.56
20/5/71	184.61	6.6952	2.48	1.84	-0.19	0.72	1.46	1.02	2.78	1.03	2.39
20-5-100	184.90	6.7036	3.01	2.37	0.27	1.18	1.62	1.10	2.86	1.52	2.27
20-5-120	185.10	6.7094	2.82	2.18	-0.04	0.87	1.59	1.21	2.97	1.46	2.15
20-5-140	185.30	6.7152	3.45	2.81	0.71	1.62	1.36	1.43	3.19	1.85	2.08
20/6/10	185.50	6.7210	2.95	2.31	0.43	1.34	1.26	1.13	2.89	1.61	2.13
20/6/29	185.69	6.7265	2.60	1.96	0.02	0.93	1.00	1.01	2.77	0.80	2.27
20/6/50	185.90	6.7326	2.38	1.74	0.10	1.01	1.31	1.45	3.21	1.11	2.05
20/6/70	186.10	6.7384	1.91	1.27	0.05	0.96	1.13	1.30	3.06	0.99	2.40
20-6-100	186.40	6.7471	2.54	1.90	0.05	0.96	1.74	1.00	2.76	1.31	2.04
20-6-120	186.60	6.7529	2.57	1.93	0.13	1.04	0.96	0.93	2.69	0.76	2.27

DSDP Site 593 Sample No.	Depth (mbsf)	Age (Ma)	Uvi 18O	U to Cib 18O	Uvi 13C	U to Cib 13C	Gb 18O	Gb 13C	Gb13C +1.76	Ou 18O	Ou 13C
20-6-140	186.80	6.7587	2.74	2.10	0.29	1.20	1.20	0.80	2.56	1.45	2.00
20/7/10	187.00	6.7645	2.47	1.83	-0.36	0.55	0.80	0.90	2.66	0.60	1.89
21/1/10	187.60	6.7818	2.36	1.72	-0.15	0.76	1.24	0.97	2.73	0.96	1.62
21/1/29	187.79	6.7873	2.23	1.59	-0.29	0.62	1.55	1.25	3.01	1.27	1.85
21/1/50	188.00	6.7934	2.33	1.69	-0.40	0.51	0.73	0.96	2.72	1.78	1.96
21/1/69	188.19	6.7989	3.28	2.64	0.31	1.22	1.51	0.99	2.75	0.78	1.71
21/1/99	188.49	6.8076	2.28	1.64	0.11	1.02	1.29	1.09	2.85	0.68	2.30
21-1-120	188.70	6.8137	3.48	2.84	0.16	1.07	1.64	1.53	3.29	1.40	2.27
21-1-139	188.89	6.8192	2.36	1.72	-0.22	0.69	1.51	1.44	3.20	1.07	2.39
21/2/10	189.10	6.8253	2.48	1.84	-0.32	0.59	1.59	1.38	3.14	1.13	1.94
21/2/20	189.20	6.8282	2.35	1.71	0.11	1.02	1.57	1.32	3.08	1.76	2.35
21/2/52	189.52	6.8374	2.49	1.85	-0.38	0.53	1.46	1.21	2.97	1.20	2.22
21/2/70	189.70	6.8426	2.29	1.65	-0.12	0.79	1.37	1.03	2.79	1.14	2.14
21-2-100	190.00	6.8513	2.73	2.09	-0.15	0.76	0.99	1.32	3.08	0.54	2.15
21-2-120	190.20	6.8571	2.85	2.21	0.10	1.01	1.06	1.12	2.88	0.85	2.28
21-2-140	190.40	6.8629	2.59	1.95	0.14	1.05	1.30	0.94	2.70	0.70	2.23
21/3/10	190.60	6.8687	2.36	1.72	0.08	0.99	1.21	0.83	2.59	1.45	2.45
21/3/30	190.80	6.8745	2.48	1.84	0.05	0.96	1.16	1.05	2.81	1.30	2.25
21/3/50	191.00	6.8803	2.54	1.90	0.01	0.92	1.38	1.20	2.96	1.73	1.97
21/3/69	191.19	6.8858	2.75	2.11	-0.10	0.81	1.69	1.32	3.08	1.92	2.17
21/3/98	191.48	6.8942	2.65	2.01	-0.15	0.76	1.72	1.37	3.13	1.65	2.36
21-3-120	191.70	6.9006	3.10	2.46	-0.09	0.82	1.65	1.46	3.22	1.20	2.20
21-3-140	191.90	6.9064	3.58	2.94	0.47	1.38	1.71	1.38	3.14	1.85	2.04
21/4/10	192.10	6.9122	2.58	1.94	-0.18	0.73	1.66	1.32	3.08	1.45	2.63
21/4/30	192.30	6.9179	2.50	1.86	0.11	1.02	1.40	1.28	3.04	1.00	2.23
21/4/50	192.50	6.9237	2.44	1.80	0.23	1.14	1.21	1.26	3.02	1.04	2.59
21/4/70	192.70	6.9295	2.40	1.76	0.34	1.25	1.29	1.34	3.10	1.09	2.69
21-4-100	193.00	6.9382	2.76	2.12	0.16	1.07	1.36	1.41	3.17	1.56	2.57
21-4-120	193.20	6.9440	2.22	1.58	0.33	1.24	1.49	1.46	3.22	1.58	2.41
21-4-140	193.50	6.9527	2.35	1.71	0.24	1.15	1.61	1.51	3.27	1.75	2.35
21/5/10	193.60	6.9556	2.26	1.62	0.36	1.27	1.38	1.56	3.32	1.07	2.21
21/5/30	193.80	6.9614	2.60	1.96	0.48	1.39	1.42	1.41	3.17	1.24	2.47
21/5/45	193.98	6.9666	2.36	1.72	0.20	1.11	1.56	1.30	3.06	1.46	2.17
21/5/69	194.19	6.9727	2.65	2.01	0.40	1.31	1.71	1.15	2.91	1.62	2.26
21-5-100	194.50	6.9817	2.31	1.67	0.35	1.26	1.25	1.25	3.01	1.35	2.35
21-5-120	194.70	6.9875	2.12	1.48	0.30	1.21	1.36	1.30	3.06	1.09	2.44
21-5-138	194.88	6.9927	3.12	2.48	0.51	1.42	1.40	1.46	3.22	1.01	2.38
21/6/10	195.10	6.9990	2.82	2.18	0.62	1.53	1.54	1.64	3.40	1.60	2.75
21/6/50	195.50	7.0106	3.05	2.41	0.67	1.58	1.71	1.41	3.17	1.31	2.41
21/6/70	195.70	7.0164	2.71	2.07	0.24	1.15	1.50	1.52	3.28	1.28	2.22
21-6-100	196.00	7.0251	3.30	2.66	0.43	1.34	1.59	1.46	3.22	1.67	2.64
21-6-120	196.20	7.0309	2.94	2.30	0.56	1.47	1.60	1.38	3.14	1.45	2.10
21-6-140	196.40	7.0367	2.61	1.97	0.65	1.56	1.37	1.33	3.09	1.26	2.23

Appendix C Table 2: DSDP Hole 593 calculated palaeotemperatures for c. 0-120 mbsf.

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
0.07	0.0069	3.19	3.83	2.55	5.99	0.84	14.97		
0.17	0.0094	2.71	5.44	2.07	7.68	0.89	14.75		
0.31	0.0130	3.73	2.09	3.09	4.16	1.83	10.55		
0.38	0.0167	4.38	0.09	3.74	2.05	1.74	10.95		
0.57	0.0269	4.27	0.42	3.63	2.40	1.97	9.93		
0.62	0.0296	3.56	2.62	2.92	4.72	2.19	8.95		
0.81	0.0398	4.03	1.15	3.39	3.17	1.38	12.55		
0.86	0.0425	3.58	2.56	2.94	4.66	0.92	14.61		
1.03	0.0516	3.74	2.05	3.10	4.12	1.86	10.41		
1.13	0.0569	3.68	2.24	3.04	4.32	1.87	10.37		

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
1.29	0.0655	3.34	3.33	2.70	5.47	1.33	12.77		
1.40	0.0714	4.35	0.18	3.71	2.15	1.94	10.06		
1.55	0.0794	3.55	2.66	2.91	4.76	1.13	13.67		
1.67	0.0859	3.02	4.39	2.38	6.58	1.51	11.97		
1.81	0.0934	3.13	4.02	2.49	6.19	-0.62	21.59		
1.89	0.0976	2.76	5.27	2.12	7.50	-0.32	20.22		
2.07	0.1073	2.89	4.82	2.25	7.04	-0.51	21.09		
2.14	0.1110	3.18	3.86	2.54	6.02	-0.04	18.95		
2.31	0.1201	3.97	1.34	3.33	3.37	1.66	11.30		
2.38	0.1239	3.76	1.99	3.12	4.06	1.84	10.50		
2.51	0.1309	4.04	1.12	3.40	3.14	1.62	11.48		
2.65	0.1384	3.97	1.34	3.33	3.37	0.96	14.43		
2.79	0.1459	3.30	3.46	2.66	5.61	1.26	13.09		
2.92	0.1528	3.68	2.24	3.04	4.32	1.79	10.72		
3.10	0.1625	3.83	1.77	3.19	3.83	2.13	9.22		
3.18	0.1667	4.05	1.09	3.41	3.11	2.25	8.69		
3.31	0.1737	3.42	3.07	2.78	5.20	2.26	8.64		
3.41	0.1791	3.69	2.21	3.05	4.29	1.80	10.68		
3.57	0.1876	2.99	4.49	2.35	6.68	0.36	17.13		
3.64	0.1914	3.30	3.46	2.66	5.61	-0.13	19.36		
3.81	0.2005	3.23	3.69	2.59	5.85	0.96	14.43		
3.86	0.2032	2.43	6.40	1.79	8.69	-0.37	20.45		
4.03	0.2123	2.71	5.44	2.07	7.68	-0.54	21.23		
4.14	0.2182	3.19	3.83	2.55	5.99	-0.05	18.99		
4.29	0.2262	3.28	3.53	2.64	5.68	0.55	16.28		
4.41	0.2326	3.46	2.95	2.82	5.06	0.16	18.04		
4.59	0.2423	3.21	3.76	2.57	5.92	1.29	12.95		
4.68	0.2471	3.50	2.82	2.86	4.93	2.03	9.66		
4.81	0.2541	3.86	1.68	3.22	3.73	1.77	10.81		
4.89	0.2584	3.98	1.31	3.34	3.33	1.28	13.00		
5.07	0.2680	3.75	2.02	3.11	4.09	1.86	10.41		
5.20	0.2727	3.17	3.89	2.53	6.06	2.18	9.00		
5.28	0.2762	3.81	1.83	3.17	3.89	0.43	16.82		
5.50	0.2849	3.34	3.33	2.70	5.47	0.53	16.37		
5.60	0.2888	2.52	6.09	1.88	8.36	0.05	18.54		
5.70	0.2927	3.01	4.42	2.37	6.61	1.51	11.97		
5.80	0.2967	3.99	1.27	3.35	3.30	2.68	6.79		
5.91	0.3010	3.70	2.18	3.06	4.26	2.16	9.09		
6.01	0.3049	3.93	1.46	3.29	3.50	2.84	6.09		
6.11	0.3088	3.82	1.80	3.18	3.86	0.96	14.43		
6.27	0.3151	3.76	1.99	3.12	4.06	2.04	9.62		
6.71	0.3324	3.40	3.14	2.76	5.27	1.77	10.81		
6.77	0.3347	3.53	2.72	2.89	4.82	1.86	10.41		
7.01	0.3442	3.47	2.91	2.83	5.03	-0.14	19.40		
7.11	0.3481	3.22	3.73	2.58	5.88	-0.89	22.83		
7.28	0.3548	3.44	3.01	2.80	5.13	0.35	17.18		
7.61	0.3677	1.59	9.43	0.95	11.85	-0.97	23.20		
7.76	0.3736	2.05	7.75	1.41	10.10	-0.25	19.90		
8.21	0.3913	4.44	-0.09	3.80	1.87	2.86	6.00		
9.26	0.4325	2.95	4.62	2.31	6.82	1.95	10.01		
9.81	0.4399					1.91	10.19		
10.01	0.4629	3.94	1.43	3.30	3.46	2.12	9.26		
10.11	0.4678	3.50	2.82	2.86	4.93	1.05	14.03		
10.21	0.4728	3.66	2.31	3.02	4.39	0.67	15.73		
10.31	0.4777	1.95	8.11	1.31	10.47	0.48	16.59		
10.41	0.4826	2.47	6.26	1.83	8.54	2.28	8.56		
10.51	0.4875	3.32	3.40	2.68	5.54	-0.68	21.87		
10.61	0.4925	3.24	3.66	2.60	5.81	0.93	14.57		
10.73	0.4984	2.28	6.93	1.64	9.24	0.32	17.31		
11.21	0.5220	2.71	5.44	2.07	7.68	-0.25	19.90		
11.31	0.5269	2.10	7.57	1.46	9.91	-0.08	19.13		
11.52	0.5373	2.67	5.57	2.03	7.82	0.36	17.13		
11.62	0.5422	2.59	5.85	1.95	8.11	0.26	17.59		

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
11.71	0.5466	2.36	6.65	1.72	8.95	0.37	17.09		
11.91	0.5565	1.86	8.43	1.22	10.82	1.37	12.60		
12.10	0.5658	2.41	6.47	1.77	8.76	0.67	15.73		
12.26	0.5737					0.61	16.00		
12.36	0.5786	2.24	7.07	1.60	9.39	0.48	16.59		
12.71	0.5959	3.37	3.24	2.73	5.37	1.92	10.15		
12.81	0.6008	3.37	3.24	2.73	5.37	1.92	10.15		
12.91	0.6057	2.99	4.49	2.35	6.68	2.04	9.62		
13.01	0.6106	2.84	4.99	2.20	7.21	0.30	17.41		
13.10	0.6151	2.75	5.30	2.11	7.53	-0.61	21.55		
13.21	0.6205	2.88	4.86	2.24	7.07	1.20	13.36		
13.31	0.6254	2.86	4.93	2.22	7.14	1.25	13.13		
13.59	0.6392	2.87	4.89	2.23	7.11	1.39	12.51		
13.73	0.6461	3.06	4.26	2.42	6.44	1.14	13.62		
13.89	0.6540	3.27	3.56	2.63	5.71	1.52	11.93		
14.80	0.6988	3.21	3.76	2.57	5.92	0.36	17.13		
14.90	0.7037	2.58	5.88	1.94	8.14	1.24	13.18		
15.10	0.7135	3.70	2.18	3.06	4.26	1.98	9.88		
15.33	0.7249	2.72	5.40	2.08	7.64	1.39	12.51		
15.57	0.7367	3.10	4.12	2.46	6.30	1.77	10.81		
15.68	0.7421	2.45	6.33	1.81	8.62	0.87	14.83		
15.88	0.7519	2.63	5.71	1.99	7.96	1.45	12.24		
15.98	0.7569	3.52	2.75	2.88	4.86	0.95	14.48		
16.10	0.7628	2.77	5.23	2.13	7.46	1.76	10.86		
16.30	0.7726	4.27	0.42	3.63	2.40	2.05	9.57		
16.40	0.7775	4.09	0.97	3.45	2.98	2.04	9.62		
16.50	0.7825	4.09	0.97	3.45	2.98	2.17	9.04		
16.60	0.7874	4.32	0.27	3.68	2.24	2.03	9.66		
16.80	0.7973	2.94	4.66	2.30	6.86	1.69	11.17		
16.90	0.8022	3.18	3.86	2.54	6.02	1.40	12.46		
17.00	0.8072	3.16	3.92	2.52	6.09	1.56	11.75		
17.09	0.8116	3.10	4.12	2.46	6.30	1.62	11.48		
17.26	0.8200	3.55	2.66	2.91	4.76	0.62	15.96		
17.50	0.8319	3.71	2.15	3.07	4.22	0.78	15.24		
17.70	0.8418	2.80	5.13	2.16	7.35	0.15	18.08		
17.80	0.8467	2.84	4.99	2.20	7.21	1.24	13.18		
17.90	0.8516	3.51	2.79	2.87	4.89	1.29	12.95		
18.00	0.8566	3.62	2.43	2.98	4.52	3.06	5.13		
18.10	0.8615	3.97	1.34	3.33	3.37	2.21	8.86		
18.30	0.8714	3.56	2.62	2.92	4.72	2.24	8.73		
18.40	0.8764	2.69	5.50	2.05	7.75	1.93	10.10		
18.46	0.8793	3.28	3.53	2.64	5.68	1.96	9.97		
18.56	0.8843	3.93	1.46	3.29	3.50	0.70	15.60		
18.88	0.9001	3.91	1.52	3.27	3.56	1.96	9.97		
19.00	0.9060	2.91	4.76	2.27	6.96	1.04	14.07		
19.07	0.9095	3.73	2.09	3.09	4.16	0.80	15.15		
19.20	0.9159	2.15	7.39	1.51	9.72	0.09	18.36		
19.31	0.9213	2.62	5.74	1.98	8.00	0.15	18.08		
19.40	0.9258	2.92	4.72	2.28	6.93	0.47	16.64		
19.50	0.9307	2.60	5.81	1.96	8.07	-0.36	20.40		
19.60	0.9356	2.48	6.23	1.84	8.51	1.22	13.27		
19.76	0.9436	2.48	6.23	1.84	8.51	0.90	14.70		
19.91	0.9510	2.92	4.72	2.28	6.93	2.26	8.64		
20.01	0.9559	3.02	4.39	2.38	6.58	1.85	10.46		
20.12	0.9613	3.40	3.14	2.76	5.27	0.63	15.91		
20.20	0.9653	3.00	4.46	2.36	6.65	0.53	16.37		
20.30	0.9702	2.79	5.16	2.15	7.39	0.70	15.60		
20.40	0.9752	2.53	6.06	1.89	8.33	0.81	15.10		
20.48	0.9791	3.36	3.27	2.72	5.40	0.78	15.24		
20.60	0.9851	2.90	4.79	2.26	7.00	1.22	13.27		
20.67	0.9885	2.75	5.30	2.11	7.53	1.22	13.27		
20.81	0.9931	2.05	7.75	1.41	10.10	0.97	14.39		
20.90	0.9957	2.28	6.93	1.64	9.24	0.62	15.96		

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
21.10	1.0014	3.32	3.40	2.68	5.54	1.29	12.95		
21.34	1.0083	3.42	3.07	2.78	5.20	1.45	12.24		
21.54	1.0140	2.36	6.65	1.72	8.95	1.08	13.89		
21.60	1.0157	3.08	4.19	2.44	6.37	0.64	15.87		
21.70	1.0186	4.17	0.72	3.53	2.72	0.63	15.91		
21.80	1.0214	2.60	5.81	1.96	8.07	0.82	15.06		
21.88	1.0237	3.78	1.93	3.14	3.99	1.21	13.31		
22.07	1.0291	3.12	4.06	2.48	6.23	0.43	16.82		
22.30	1.0357	3.71	2.15	3.07	4.22	1.70	11.12		
22.40	1.0386	3.54	2.69	2.90	4.79	1.81	10.64		
22.50	1.0414	3.74	2.05	3.10	4.12	2.24	8.73		
22.60	1.0443	3.73	2.09	3.09	4.16	1.99	9.84		
22.66	1.0460	4.18	0.69	3.54	2.69	2.27	8.60		
22.80	1.0500	3.45	2.98	2.81	5.10	1.45	12.24		
23.20	1.0614	2.30	6.86	1.66	9.17	0.99	14.30		
23.30	1.0643	2.28	6.93	1.64	9.24	0.98	14.34		
23.50	1.0700	2.74	5.33	2.10	7.57	0.90	14.70		
23.57	1.0750	2.44	6.37	1.80	8.65	1.25	13.13		
24.40	1.1341	2.12	7.50	1.48	9.84	1.07	13.94		
24.50	1.1412	2.61	5.78	1.97	8.04	1.17	13.49		
24.61	1.1490	2.37	6.61	1.73	8.91	1.29	12.95		
24.70	1.1555	3.25	3.63	2.61	5.78	1.21	13.31		
24.80	1.1626	3.63	2.40	2.99	4.49	1.78	10.77		
24.87	1.1676	3.07	4.22	2.43	6.40	1.52	11.93		
25.00	1.1768	3.56	2.62	2.92	4.72	1.74	10.95		
25.22	1.1925	3.67	2.27	3.03	4.36	1.63	11.44		
25.32	1.1996	3.67	2.27	3.03	4.36	1.54	11.84		
25.40	1.2053	3.76	1.99	3.12	4.06	1.64	11.39		
25.50	1.2124	3.21	3.76	2.57	5.92	1.21	13.31		
25.59	1.2188	2.56	5.95	1.92	8.22	1.37	12.60		
25.70	1.2267	2.84	4.99	2.20	7.21	0.96	14.43		
25.78	1.2324	2.64	5.68	2.00	7.93	1.32	12.82		
25.90	1.2409	2.81	5.10	2.17	7.32	1.71	11.08		
26.01	1.2487	3.33	3.37	2.69	5.50	1.56	11.75		
26.11	1.2559	3.36	3.27	2.72	5.40	1.87	10.37		
26.21	1.2630	3.37	3.24	2.73	5.37	1.81	10.64		
26.32	1.2708	3.02	4.39	2.38	6.58	1.35	12.68		
26.51	1.2843	3.11	4.09	2.47	6.26	1.32	12.82		
26.72	1.2993	2.99	4.49	2.35	6.68	1.09	13.85		
26.81	1.3057	2.93	4.69	2.29	6.89	1.25	13.13		
26.90	1.3121	2.86	4.93	2.22	7.14	1.64	11.39		
27.00	1.3192	3.47	2.91	2.83	5.03	1.47	12.15		
27.09	1.3256	3.14	3.99	2.50	6.16	1.14	13.62		
27.21	1.3342	2.52	6.09	1.88	8.36	1.03	14.12		
27.28	1.3392	3.09	4.16	2.45	6.33	1.48	12.10		
27.41	1.3484	3.25	3.63	2.61	5.78	1.56	11.75		
27.51	1.3556	3.21	3.76	2.57	5.92	1.49	12.06		
27.61	1.3627	2.93	4.69	2.29	6.89	1.77	10.81		
27.78	1.3748	3.07	4.22	2.43	6.40	1.19	13.40		
27.87	1.3812	2.90	4.79	2.26	7.00	1.31	12.86		
28.01	1.3912					1.62	11.48		
28.11	1.3983	3.24	3.66	2.60	5.81	0.95	14.48		
28.21	1.4054	3.48	2.88	2.84	4.99	1.57	11.70		
28.31	1.4125	3.39	3.17	2.75	5.30	1.22	13.27		
28.41	1.4196	2.91	4.76	2.27	6.96	1.21	13.31		
28.58	1.4317					0.54	16.32		
28.91	1.4552	2.70	5.47	2.06	7.71	1.60	11.57		
29.21	1.4766	2.99	4.49	2.35	6.68	1.41	12.42		
29.30	1.4830	3.12	4.06	2.48	6.23	1.53	11.88		
29.37	1.4880	3.34	3.33	2.70	5.47	1.43	12.33		
29.51	1.4980	2.57	5.92	1.93	8.18	1.15	13.58		
29.71	1.5122	2.42	6.44	1.78	8.73	1.20	13.36		
29.90	1.5257	2.67	5.57	2.03	7.82	0.85	14.92		

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
30.00	1.5329	3.15	3.96	2.51	6.12	1.33	12.77		
30.09	1.5393	3.25	3.63	2.61	5.78	1.13	13.67		
30.19	1.5464	2.88	4.86	2.24	7.07	1.03	14.12		
30.28	1.5528	2.90	4.79	2.26	7.00	1.06	13.98		
30.40	1.5614	3.58	2.56	2.94	4.66	1.27	13.04		
30.51	1.5692	3.14	3.99	2.50	6.16	0.76	15.33		
30.61	1.5763	2.54	6.02	1.90	8.29	1.50	12.02		
30.71	1.5834	2.94	4.66	2.30	6.86	1.00	14.25		
30.81	1.5905	3.36	3.27	2.72	5.40	0.75	15.37		
30.87	1.5948	3.23	3.69	2.59	5.85	0.80	15.15		
31.01	1.6048	3.45	2.98	2.81	5.10	1.07	13.02		
31.11	1.6119	3.25	3.63	2.61	5.78	1.03	13.20		
31.22	1.6197	2.98	4.52	2.34	6.72	1.12	12.80		
31.31	1.6262	3.21	3.76	2.57	5.92	1.60	10.66		
31.41	1.6333	2.92	4.72	2.28	6.93	1.07	13.02		
31.51	1.6404	3.09	4.16	2.45	6.33	0.85	14.00		
31.69	1.6532	3.07	4.22	2.43	6.40	0.96	13.51		
31.78	1.6596	2.86	4.93	2.22	7.14	0.61	15.08		
31.91	1.6689	3.15	3.96	2.51	6.12	0.88	13.87		
32.01	1.6760	3.39	3.17	2.75	5.30	1.09	12.93		
32.11	1.6831	3.60	2.50	2.96	4.59	0.94	13.60		
32.21	1.6902	3.43	3.04	2.79	5.16	0.98	13.42		
32.29	1.6959	3.02	4.39	2.38	6.58				
32.37	1.7016	2.21	7.18	1.57	9.50	0.95	13.56		
32.47	1.7088	2.90	4.79	2.26	7.00	1.08	12.98		
32.71	1.7258	2.29	6.89	1.65	9.20	0.86	13.96		
32.81	1.7330	2.41	6.47	1.77	8.76	0.81	14.18		
32.90	1.7394	2.93	4.69	2.29	6.89	1.39	11.59		
33.01	1.7472	2.84	4.99	2.20	7.21	1.42	11.46		
34.01	1.8373	3.10	4.12	2.46	6.30	1.16	12.62		
34.13	1.8491	2.36	6.65	1.72	8.95	1.17	12.57		
34.21	1.8570	2.59	5.85	1.95	8.11	1.16	12.62		
34.31	1.8669	2.88	4.86	2.24	7.07	0.97	13.47		
34.41	1.8768	2.85	4.96	2.21	7.18	1.43	11.41		
34.47	1.8827	2.53	6.06	1.89	8.33	1.38	11.64		
34.61	1.8966	2.90	4.79	2.26	7.00	1.81	9.73		
34.71	1.9065	3.54	2.69	2.90	4.79	1.83	9.64		
34.90	1.9253	3.37	3.24	2.73	5.37	1.47	11.24		
35.01	1.9362	2.97	4.56	2.33	6.75	1.45	11.33		
35.11	1.9460	2.96	4.59	2.32	6.79	1.42	11.46		
35.30	1.9563	3.06	4.26	2.42	6.44	1.55	10.88		
35.39	1.9600	2.89	4.82	2.25	7.04	1.87	9.46		
36.60	2.0105	3.03	4.36	2.39	6.54	1.87	9.46	0.96	13.51
36.70	2.0147	3.20	3.79	2.56	5.95	1.34	11.81	1.15	12.66
36.80	2.0189	3.36	3.27	2.72	5.40	1.31	11.95	1.20	12.44
36.90	2.0230	3.07	4.22	2.43	6.40	1.41	11.50	0.95	13.56
37.00	2.0272	2.87	4.89	2.23	7.11	1.38	11.64	1.53	10.97
37.10	2.0314	2.84	4.99	2.20	7.21	1.56	10.84	1.26	12.17
37.20	2.0356	2.91	4.76	2.27	6.96	1.60	10.66	1.36	11.73
37.30	2.0397	2.77	5.23	2.13	7.46	1.82	9.68	1.40	11.55
37.40	2.0439	2.74	5.33	2.10	7.57	1.04	13.15	1.48	11.19
37.50	2.0481	2.65	5.64	2.01	7.89	1.29	12.04	1.10	12.89
37.60	2.0522	2.57	5.92	1.93	8.18	1.06	13.06	1.21	12.39
37.70	2.0564	2.61	5.78	1.97	8.04	0.95	13.56	1.26	12.17
37.80	2.0606	3.23	3.69	2.59	5.85	1.98	8.97	1.40	11.55
37.90	2.0648	2.50	6.16	1.86	8.43	0.83	14.09	1.19	12.48
37.98	2.0681	2.82	5.06	2.18	7.28	1.29	12.04	1.56	10.84
38.10	2.0731	2.55	5.99	1.91	8.25	1.22	12.35	1.38	11.64
38.20	2.0773	2.10	7.57	1.46	9.91	1.01	13.29	1.45	11.33
38.30	2.0815	2.50	6.16	1.86	8.43	1.32	11.90	1.58	10.75
38.40	2.0856	2.82	5.06	2.18	7.28	1.10	12.89	1.08	12.98
38.50	2.0898	2.59	5.85	1.95	8.11	1.24	12.26	1.01	13.29
38.60	2.0940	2.68	5.54	2.04	7.78	1.35	11.77	1.12	12.80

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
38.70	2.0982	2.26	7.00	1.62	9.32	0.97	13.47	1.42	11.46
38.80	2.1023	2.65	5.64	2.01	7.89	1.56	10.84	1.62	10.57
38.90	2.1065	3.11	4.09	2.47	6.26	1.55	10.88	0.55	15.35
39.00	2.1107	2.95	4.62	2.31	6.82	1.09	12.93	0.76	14.41
39.10	2.1148	2.80	5.13	2.16	7.35	1.18	12.53	1.13	12.75
39.20	2.1190	2.65	5.64	2.01	7.89	1.78	9.86	1.54	10.92
39.30	2.1232	2.73	5.37	2.09	7.60	1.36	11.73	1.52	11.01
39.40	2.1274	2.93	4.69	2.29	6.89	1.49	11.15	1.43	11.41
39.48	2.1307	2.75	5.30	2.11	7.53	1.60	10.66	1.46	11.28
39.60	2.1357	2.23	7.11	1.59	9.43	1.71	10.17	1.29	12.04
39.70	2.1399	2.35	6.68	1.71	8.98	1.24	12.26	0.97	13.47
39.80	2.1441	2.62	5.74	1.98	8.00	1.36	11.73	1.46	11.28
39.90	2.1482	2.24	7.07	1.60	9.39	1.29	12.04	1.11	12.84
40.00	2.1524	2.43	6.40	1.79	8.69	1.12	12.80	1.06	13.06
40.10	2.1566	2.54	6.02	1.90	8.29	1.41	11.50	1.31	11.95
40.20	2.1608	2.79	5.16	2.15	7.39	0.91	13.74	0.99	13.38
40.30	2.1649	2.65	5.64	2.01	7.89	0.96	13.51	0.70	14.68
40.40	2.1691	2.38	6.58	1.74	8.87	0.99	13.38	0.95	13.56
40.50	2.1733	2.43	6.40	1.79	8.69	0.87	13.91	1.02	13.24
40.60	2.1774	2.46	6.30	1.82	8.58	1.24	12.26	1.74	10.04
40.70	2.1816	2.57	5.92	1.93	8.18	1.62	10.57	1.56	10.84
40.80	2.1858	2.40	6.51	1.76	8.80	1.46	11.28	1.37	11.68
40.90	2.1900	2.59	5.85	1.95	8.11	1.09	12.93	0.86	13.96
40.98	2.1933	2.54	6.02	1.90	8.29	0.66	14.86	0.90	13.78
41.10	2.1983	2.59	5.85	1.95	8.11	1.14	12.71	1.53	10.97
41.20	2.2025	2.51	6.12	1.87	8.40	0.80	14.23	1.25	12.22
41.30	2.2067	2.42	6.44	1.78	8.73	1.61	10.61	0.71	14.63
41.40	2.2108	2.62	5.74	1.98	8.00	1.26	12.17	0.86	13.96
41.50	2.2150	2.81	5.10	2.17	7.32	1.34	11.81	0.99	13.38
41.60	2.2192	3.07	4.22	2.43	6.40	0.63	14.99	1.42	11.46
41.70	2.2234	2.27	6.96	1.63	9.28	1.23	12.31	1.13	12.75
41.80	2.2275	2.65	5.64	2.01	7.89	0.79	14.27	1.45	11.33
41.90	2.2317	3.08	4.19	2.44	6.37	1.29	12.04	1.36	11.73
42.00	2.2359	3.10	4.12	2.46	6.30	1.56	10.84	1.47	11.24
42.10	2.2400	2.75	5.30	2.11	7.53	0.95	13.56	0.87	13.91
42.20	2.2442	2.90	4.79	2.26	7.00	0.60	15.13	1.10	12.89
42.30	2.2484	3.15	3.96	2.51	6.12	1.47	11.24	1.22	12.35
42.40	2.2526	2.95	4.62	2.31	6.82	1.93	9.20	1.46	11.28
42.48	2.2559	2.76	5.27	2.12	7.50	1.46	11.28	1.09	12.93
42.60	2.2609	2.14	7.43	1.50	9.76	1.71	10.17	1.37	11.68
42.70	2.2651	2.56	5.95	1.92	8.22	1.94	9.15	1.82	9.68
42.80	2.2693	2.67	5.57	2.03	7.82	1.16	12.62	0.96	13.51
42.90	2.2734	3.34	3.33	2.70	5.47	1.67	10.35	1.48	11.19
43.00	2.2776	2.89	4.82	2.25	7.04	1.54	10.92	1.26	12.17
43.10	2.2818	3.18	3.86	2.54	6.02	2.29	7.61	1.50	11.10
43.20	2.2859	2.85	4.96	2.21	7.18	2.00	8.89	1.36	11.73
43.30	2.2901	2.68	5.54	2.04	7.78	1.52	11.01	1.25	12.22
43.40	2.2943	2.78	5.20	2.14	7.43	1.76	9.95	1.46	11.28
43.50	2.2985	2.36	6.65	1.72	8.95	1.26	12.17	1.36	11.73
43.60	2.3026	2.84	4.99	2.20	7.21	1.33	11.86	1.08	12.98
43.70	2.3068	2.39	6.54	1.75	8.84	0.95	13.56	0.70	14.68
43.80	2.3110	2.04	7.78	1.40	10.14	1.06	13.06	0.93	13.65
43.90	2.3152	2.42	6.44	1.78	8.73	1.43	11.41	1.29	12.04
43.98	2.3185	2.36	6.65	1.72	8.95	1.87	9.46	1.47	11.24
44.10	2.3235	2.05	7.75	1.41	10.10	1.01	13.29	1.62	10.57
44.20	2.3277	2.29	6.89	1.65	9.20	1.23	12.31	1.42	11.46
44.30	2.3319	2.74	5.33	2.10	7.57	0.78	14.32	1.44	11.37
44.40	2.3360	2.42	6.44	1.78	8.73	1.29	12.04	1.62	10.57
46.20	2.4111	2.94	4.66	2.30	6.86	1.42	11.46	1.76	9.95
46.30	2.4153	3.17	3.89	2.53	6.06	1.20	12.44	2.20	8.00
47.10	2.4487	3.08	4.19	2.44	6.37	1.76	9.95	1.99	8.93
47.20	2.4529	2.70	5.47	2.06	7.71	1.71	10.17	1.82	9.68
47.30	2.4571	3.27	3.56	2.63	5.71	2.12	8.36	1.77	9.90

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
47.40	2.4612	3.45	2.98	2.81	5.10	2.21	7.96	2.10	8.44
47.50	2.4654	3.30	3.46	2.66	5.61	1.64	10.48	1.85	9.55
47.58	2.4687	3.14	3.99	2.50	6.16	1.91	9.28	1.86	9.51
47.70	2.4737	3.07	4.22	2.43	6.40	1.75	9.99	1.63	10.53
47.80	2.4779	3.02	4.39	2.38	6.58	1.69	10.26	1.54	10.92
47.90	2.4821	2.96	4.59	2.32	6.79	1.51	11.06	1.16	12.62
48.00	2.4863	2.74	5.33	2.10	7.57	1.51	11.06	1.38	11.64
48.10	2.4904	2.70	5.47	2.06	7.71	1.80	9.77	1.69	10.26
48.20	2.4946	3.16	3.92	2.52	6.09	1.72	10.13	1.24	12.26
48.30	2.4988	3.50	2.82	2.86	4.93	1.65	10.44	0.80	14.23
48.40	2.5030	3.04	4.32	2.40	6.51	1.51	11.06	0.90	13.78
48.50	2.5071	2.79	5.16	2.15	7.39	1.43	11.41	1.37	11.68
48.60	2.5113	3.00	4.46	2.36	6.65	1.62	10.57	0.73	14.54
48.70	2.5155	2.94	4.66	2.30	6.86	1.34	11.81	1.33	11.86
48.80	2.5197	3.30	3.46	2.66	5.61	1.28	12.08	1.55	10.88
49.00	2.5280	3.56	2.62	2.92	4.72	1.64	10.48	1.94	9.15
49.08	2.5318	3.39	3.17	2.75	5.30	1.52	11.01	1.36	11.73
49.20	2.5375	3.07	4.22	2.43	6.40	1.12	12.80	1.39	11.59
49.30	2.5422	2.69	5.50	2.05	7.75	1.23	12.31	1.46	11.28
49.40	2.5469	2.89	4.82	2.25	7.04	1.45	11.33	1.80	9.77
49.50	2.5516	2.69	5.50	2.05	7.75	1.23	12.31	1.10	12.89
49.60	2.5564	2.52	6.09	1.88	8.36	1.09	12.93	1.25	12.22
49.70	2.5611	2.84	4.99	2.20	7.21	1.41	11.50	1.16	12.62
49.80	2.5658	3.04	4.32	2.40	6.51	1.38	11.64	1.32	11.90
49.90	2.5705	2.99	4.49	2.35	6.68	1.26	12.17	1.21	12.39
50.00	2.5753	2.90	4.79	2.26	7.00	1.06	13.06	1.16	12.62
50.10	2.5800	3.10	4.12	2.46	6.30	1.26	12.17	1.06	13.06
50.20	2.5906	2.95	4.62	2.31	6.82	1.77	9.90	1.40	11.55
50.30	2.6013	3.05	4.29	2.41	6.47	1.51	11.06	1.45	11.33
50.40	2.6119	2.76	5.27	2.12	7.50	1.47	11.24	1.20	12.44
50.50	2.6226	2.80	5.13	2.16	7.35	1.41	11.50	1.32	11.90
50.58	2.6311	2.87	4.89	2.23	7.11	1.59	10.70	1.50	11.10
50.70	2.6438	2.76	5.27	2.12	7.50	1.59	10.70	1.29	12.04
50.80	2.6545	2.62	5.74	1.98	8.00	1.43	11.41	1.16	12.62
50.90	2.6651	2.69	5.50	2.05	7.75	1.41	11.50	1.21	12.39
51.00	2.6757	3.05	4.29	2.41	6.47	1.37	11.68	1.34	11.81
51.10	2.6864	2.30	6.86	1.66	9.17	1.29	12.04	1.24	12.26
51.20	2.6970	2.56	5.95	1.92	8.22	1.22	12.35	1.07	13.02
51.30	2.7077	2.90	4.79	2.26	7.00	1.25	12.22	0.97	13.47
51.40	2.7183	2.67	5.57	2.03	7.82	1.41	11.50	1.27	12.13
51.50	2.7289	2.56	5.95	1.92	8.22	1.44	11.37	1.36	11.73
51.60	2.7396	2.50	6.16	1.86	8.43	1.36	11.73	1.33	11.86
51.70	2.7502	2.36	6.65	1.72	8.95	1.48	11.19	1.29	12.04
51.80	2.7609	2.75	5.30	2.11	7.53	1.42	11.46	1.24	12.26
52.00	2.7821	2.72	5.40	2.08	7.64	1.65	10.44	1.12	12.80
52.08	2.7906	2.65	5.64	2.01	7.89	1.45	11.33	1.09	12.93
52.20	2.8034	2.46	6.30	1.82	8.58	1.26	12.17	1.40	11.55
52.30	2.8140	2.45	6.33	1.81	8.62	1.31	11.95	1.49	11.15
52.40	2.8247	2.72	5.40	2.08	7.64	1.16	12.62	1.07	13.02
52.50	2.8353	2.46	6.30	1.82	8.58	1.24	12.26	1.15	12.66
52.60	2.8460	2.64	5.68	2.00	7.93	1.16	12.62	1.31	11.95
52.70	2.8566	2.70	5.47	2.06	7.71	1.36	11.73	1.13	12.75
52.80	2.8672	2.56	5.95	1.92	8.22	1.23	12.31	1.16	12.62
52.90	2.8779	2.74	5.33	2.10	7.57	1.39	11.59	1.13	12.75
53.00	2.8885	3.10	4.12	2.46	6.30	1.46	11.28	1.00	13.33
53.10	2.8991	2.96	4.59	2.32	6.79	1.21	12.39	1.18	12.53
53.20	2.9098	2.75	5.30	2.11	7.53	1.23	12.31	1.15	12.66
53.30	2.9204	2.90	4.79	2.26	7.00	1.31	11.95	1.07	13.02
53.40	2.9311	2.86	4.93	2.22	7.14	1.21	12.39	1.16	12.62
53.50	2.9417	3.11	4.09	2.47	6.26	0.96	13.51	0.73	14.54
53.58	2.9502	2.85	4.96	2.21	7.18	1.11	12.84	1.10	12.89
53.80	2.9736	2.79	5.16	2.15	7.39	1.23	12.31	1.44	11.37
53.90	2.9843	2.72	5.40	2.08	7.64	1.21	12.39	0.99	13.38

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
54.00	2.9949	3.02	4.39	2.38	6.58	1.56	10.84	1.41	11.50
54.10	3.0055	3.24	3.66	2.60	5.81	1.49	11.15	1.14	12.71
54.20	3.0162	2.42	6.44	1.78	8.73	1.21	12.39	1.10	12.89
54.30	3.0268	2.59	5.85	1.95	8.11	1.31	11.95	0.90	13.78
54.50	3.0481	2.23	7.11	1.59	9.43	1.10	12.89		
54.60	3.0587	3.11	4.09	2.47	6.26	1.61	10.61	1.10	12.89
55.00	3.1013	2.58	5.88	1.94	8.14	1.21	12.39	1.02	13.24
55.08	3.1098	2.70	5.47	2.06	7.71	1.36	11.73	0.97	13.47
55.20	3.1226	3.22	3.73	2.58	5.88	1.41	11.50	1.13	12.75
55.30	3.1332	2.35	6.68	1.71	8.98	0.79	14.27	0.53	15.44
55.40	3.1438	2.83	5.03	2.19	7.25	1.29	12.04	0.71	14.63
55.90	3.1970	2.79	5.16	2.15	7.39	0.96	13.51	0.48	15.67
56.00	3.2077	2.34	6.72	1.70	9.02	1.31	11.95	0.93	13.65
56.10	3.2183	2.39	6.54	1.75	8.84	1.21	12.39	1.09	12.93
56.30	3.2396	2.53	6.06	1.89	8.33	1.26	12.17	0.94	13.60
56.40	3.2502	2.25	7.04	1.61	9.35	1.05	13.11		
56.50	3.2609	2.27	6.96	1.63	9.28	1.15	12.66	0.93	13.65
56.60	3.2715	2.79	5.16	2.15	7.39	1.20	12.44	0.94	13.60
56.80	3.2928	2.06	7.71	1.42	10.06	0.94	13.60	0.80	14.23
56.90	3.3034	2.24	7.07	1.60	9.39	0.90	13.78	0.85	14.00
57.00	3.3140	2.37	6.61	1.73	8.91	1.25	12.22	1.54	10.92
57.10	3.3247	2.84	4.99	2.20	7.21	1.05	13.11	1.00	13.33
57.18	3.3332	2.98	4.52	2.34	6.72	1.15	12.66	0.96	13.51
57.30	3.3460	2.95	4.62	2.31	6.82	1.20	12.44	1.33	11.86
57.40	3.3566	2.95	4.62	2.31	6.82	1.32	11.90	1.27	12.13
57.50	3.3672	3.15	3.96	2.51	6.12	1.12	12.80	1.38	11.64
57.60	3.3779	3.05	4.29	2.41	6.47	1.41	11.50	1.29	12.04
57.70	3.3885	2.95	4.62	2.31	6.82	1.21	12.39	1.19	12.48
57.80	3.3991	2.61	5.78	1.97	8.04	1.49	11.15	0.67	14.81
57.90	3.4098	2.97	4.56	2.33	6.75	1.26	11.26	0.95	12.64
58.00	3.4204	2.61	5.78	1.97	8.04	1.05	12.19	0.67	13.89
58.10	3.4311	2.97	4.56	2.33	6.75	1.24	11.35	0.95	12.64
58.20	3.4417	2.72	5.40	2.08	7.64	0.72	13.67	1.06	12.15
58.30	3.4523	2.86	4.93	2.22	7.14	0.85	13.09	1.06	12.15
58.40	3.4630	2.67	5.57	2.03	7.82	1.29	11.12	1.43	10.50
58.50	3.4736	2.92	4.72	2.28	6.93	1.36	10.81	1.25	11.30
58.60	3.4843	3.33	3.37	2.69	5.50	1.42	10.55	1.30	11.08
58.68	3.4928	2.67	5.57	2.03	7.82	1.56	9.93	1.39	10.68
58.80	3.5055	2.60	5.81	1.96	8.07	1.49	10.24	1.41	10.59
58.88	3.5140	2.85	4.96	2.21	7.18	1.32	10.99	1.50	10.19
59.00	3.5268	2.87	4.89	2.23	7.11	1.26	11.26	1.59	9.79
59.10	3.5374	3.03	4.36	2.39	6.54	1.21	11.48	1.37	10.77
59.20	3.5481	2.89	4.82	2.25	7.04	1.12	11.88	1.08	12.06
59.30	3.5587	2.34	6.72	1.70	9.02	1.19	11.57	0.91	12.82
59.38	3.5672	2.39	6.54	1.75	8.84	1.10	11.97	0.82	13.22
59.60	3.5825	2.53	6.06	1.89	8.33	1.29	11.12	1.60	9.75
59.69	3.5848	2.33	6.75	1.69	9.06	0.95	12.64	0.88	12.95
59.78	3.5871	2.50	6.16	1.86	8.43	0.82	13.22	0.78	13.40
59.90	3.5902	2.54	6.02	1.90	8.29	1.06	12.15	0.87	13.00
59.98	3.5922	2.67	5.57	2.03	7.82	1.19	11.57	0.86	13.04
60.10	3.5953	2.43	6.40	1.79	8.69	1.07	12.10	0.78	13.40
60.18	3.5973	2.89	4.82	2.25	7.04	1.31	11.04	1.01	12.37
60.30	3.6004	2.34	6.72	1.70	9.02	1.39	10.68	1.08	12.06
60.80	3.6131	3.22	3.73	2.58	5.88	1.45	10.41	1.31	11.04
60.90	3.6156	3.06	4.26	2.42	6.44	1.37	10.77	1.30	11.08
61.10	3.6207	2.77	5.23	2.13	7.46	1.22	11.44	1.19	11.57
61.20	3.6233	2.59	5.85	1.95	8.11	1.15	11.75	1.40	10.64
61.28	3.6253	2.87	4.89	2.23	7.11	1.26	11.26	1.29	11.12
61.40	3.6284	2.28	6.93	1.64	9.24	1.27	11.21	1.14	11.79
61.48	3.6304	2.55	5.99	1.91	8.25	1.17	11.66	1.01	12.37
61.60	3.6334	2.64	5.68	2.00	7.93	1.28	11.17	1.47	10.33
61.79	3.6383	2.36	6.65	1.72	8.95	1.36	10.81	1.25	11.30
61.87	3.6403	2.72	5.40	2.08	7.64	1.39	10.68	1.32	10.99

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
61.99	3.6434	2.17	7.32	1.53	9.65	1.42	10.55	1.32	10.99
62.09	3.6459	2.95	4.62	2.31	6.82	1.36	10.81	1.53	10.06
62.17	3.6479	2.14	7.43	1.50	9.76	1.28	11.17	1.07	12.10
62.30	3.6513	2.72	5.40	2.08	7.64	1.27	11.21	1.32	10.99
62.39	3.6535	2.17	7.32	1.53	9.65	1.41	10.59	1.32	10.99
62.58	3.6584	3.21	3.76	2.57	5.92	1.36	10.81	1.30	11.08
62.69	3.6612	2.81	5.10	2.17	7.32	1.27	11.21	1.05	12.19
62.76	3.6630	2.30	6.86	1.66	9.17	1.36	10.81	1.39	10.68
62.89	3.6663	2.71	5.44	2.07	7.68	1.45	10.41	1.29	11.12
62.97	3.6683	2.10	7.57	1.46	9.91	1.20	11.53	1.08	12.06
63.09	3.6714	2.36	6.65	1.72	8.95	1.31	11.04	1.29	11.12
63.18	3.6737	3.45	2.98	2.81	5.10	1.42	10.55	1.10	11.97
63.30	3.6767	2.72	5.40	2.08	7.64	1.20	11.53	1.12	11.88
63.40	3.6792	2.85	4.96	2.21	7.18	1.39	10.68	1.23	11.39
63.49	3.6815	2.47	6.26	1.83	8.54	1.10	11.97	0.99	12.46
63.60	3.6843	2.32	6.79	1.68	9.09	1.15	11.75	1.39	10.68
63.70	3.6869	2.67	5.57	2.03	7.82	1.31	11.04	1.28	11.17
63.80	3.6894	2.50	6.16	1.86	8.43	1.16	11.70	0.99	12.46
63.90	3.6920	3.15	3.96	2.51	6.12	1.32	10.99	1.08	12.06
64.00	3.6945	2.50	6.16	1.86	8.43	1.02	12.33	0.82	13.22
65.90	3.7429	2.89	4.82	2.25	7.04	1.26	11.26	1.15	11.75
66.30	3.7530	2.85	4.96	2.21	7.18	1.29	11.12	1.08	12.06
66.70	3.7632	2.81	5.10	2.17	7.32	1.34	10.90	1.21	11.48
66.98	3.7704	2.45	6.33	1.81	8.62	1.26	11.26	1.10	11.97
67.40	3.7810	2.67	5.57	2.03	7.82	1.47	10.33	1.64	9.57
67.80	3.7912	2.46	6.30	1.82	8.58	1.25	11.30	1.04	12.24
68.20	3.8014	2.72	5.40	2.08	7.64	1.45	10.41	0.87	13.00
68.48	3.8085	2.27	6.96	1.63	9.28	1.33	10.95	1.25	11.30
68.90	3.8192	2.71	5.44	2.07	7.68	1.37	10.77	1.27	11.21
69.30	3.8294	2.86	4.93	2.22	7.14	1.15	11.75	1.31	11.04
69.70	3.8396	2.38	6.58	1.74	8.87	1.31	11.04	1.22	11.44
69.98	3.8467	2.71	5.44	2.07	7.68	1.20	11.53	1.27	11.21
70.40	3.8574	2.49	6.19	1.85	8.47	1.26	11.26	1.31	11.04
70.77	3.8668	2.68	5.54	2.04	7.78	1.46	10.37	1.04	12.24
71.20	3.8777	2.61	5.78	1.97	8.04	1.31	11.04	1.58	9.84
71.48	3.8849	2.57	5.92	1.93	8.18	1.11	11.93	0.99	12.46
71.90	3.8956	2.50	6.16	1.86	8.43	1.26	11.26	1.06	12.15
72.70	3.9159	2.93	4.69	2.29	6.89	1.39	10.68	0.96	12.60
72.98	3.9230	2.69	5.50	2.05	7.75	1.19	11.57	1.13	11.84
73.40	3.9337	2.51	6.12	1.87	8.40	0.78	13.40	0.88	12.95
75.30	3.9821	2.53	6.06	1.89	8.33	1.10	11.97	1.00	12.42
75.70	3.9923	2.58	5.88	1.94	8.14	1.21	11.48	1.09	12.02
76.10	4.0024	2.52	6.09	1.88	8.36	1.11	11.93	0.92	12.77
76.38	4.0096	2.53	6.06	1.89	8.33	1.13	11.84	0.93	12.73
76.80	4.0203	2.41	6.47	1.77	8.76	0.91	12.82	0.90	12.86
77.20	4.0304	2.43	6.40	1.79	8.69	1.00	12.42	0.80	13.31
77.60	4.0406	2.44	6.37	1.80	8.65	1.25	11.30	1.20	11.53
77.70	4.0432	2.39	6.54	1.75	8.84	1.24	11.35	1.09	12.02
77.88	4.0477	2.02	7.86	1.38	10.21	1.16	11.70	1.02	12.33
78.30	4.0584	2.28	6.93	1.64	9.24	0.92	12.77	0.74	13.58
78.70	4.0686	2.14	7.43	1.50	9.76	1.01	12.37	0.94	12.68
79.10	4.0788	2.35	6.68	1.71	8.98	0.86	13.04	0.76	13.49
79.34	4.0849	2.44	6.37	1.80	8.65	1.10	11.97	0.94	12.68
79.80	4.0966	2.60	5.81	1.96	8.07	1.20	11.53	0.72	13.67
80.20	4.1068	2.37	6.61	1.73	8.91	1.16	11.70		
80.60	4.1170	2.41	6.47	1.77	8.76	1.08	12.06	1.18	11.61
80.88	4.1241	2.51	6.12	1.87	8.40	1.21	11.48	0.95	12.64
81.30	4.1348	2.53	6.06	1.89	8.33	1.08	12.06	1.18	11.61
81.71	4.1452	2.75	5.30	2.11	7.53	1.32	10.99	1.08	12.06
82.20	4.1577	2.42	6.44	1.78	8.73	0.82	13.22	0.52	14.57
82.38	4.1623	2.07	7.68	1.43	10.02	0.92	12.77	1.10	11.97
82.79	4.1727	2.63	5.71	1.99	7.96	1.10	11.97	0.95	12.64
83.21	4.1834	1.84	8.51	1.20	10.89	1.06	12.15	0.86	13.04

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
83.60	4.1933	2.71	5.44	2.07	7.68	1.27	11.21	0.89	12.91
83.70	4.1959	2.78	5.20	2.14	7.43	1.33	10.95	1.06	12.15
83.80	4.1984	2.45	6.33	1.81	8.62	1.26	11.26	1.18	11.61
84.19	4.2083	2.63	5.71	1.99	7.96	1.12	11.88	0.82	13.22
85.31	4.2368	2.87	4.89	2.23	7.11	1.12	11.88	1.05	12.19
85.80	4.2493	2.42	6.44	1.78	8.73	1.21	11.48		
85.98	4.2539	2.97	4.56	2.33	6.75	1.54	10.01	1.68	9.39
86.81	4.2750	2.43	6.40	1.79	8.69	1.16	11.70	1.26	11.26
87.30	4.2875	2.26	7.00	1.62	9.32	1.22	11.44	1.08	12.06
87.48	4.2920	2.31	6.82	1.67	9.13	1.26	11.26	1.16	11.70
87.90	4.3027	2.83	5.03	2.19	7.00	1.31	10.13	1.03	11.37
88.30	4.3129	2.42	6.19	1.78	8.47	1.04	11.33	0.98	11.59
88.71	4.3234	2.40	6.26	1.76	8.54	1.16	10.79	1.05	11.28
88.91	4.3284	2.04	7.53	1.40	9.87	1.10	11.06		
89.40	4.3409	2.74	5.10	2.10	7.32	1.24	10.44	1.01	11.46
89.80	4.3511	2.85	4.72	2.21	6.93	1.57	8.97	1.49	9.33
90.20	4.3613	2.78	4.96	2.14	7.18	1.15	10.84	1.22	10.53
90.48	4.3684	2.23	6.86	1.59	9.17	1.06	11.24	1.04	11.33
90.90	4.3791	2.71	5.20	2.07	7.43	1.16	10.79	1.26	10.35
91.31	4.3895	2.17	7.07	1.53	9.39	1.21	10.57	0.98	11.59
91.71	4.3997	2.46	6.06	1.82	8.33	1.26	10.35	1.16	10.79
91.98	4.4066	2.17	7.07	1.53	9.39	1.10	11.06	0.89	11.99
92.30	4.4147	2.54	5.78	1.90	8.04	0.91	11.90	0.80	12.39
92.78	4.4269	2.62	5.50	1.98	7.75	1.15	10.84	0.96	11.68
93.15	4.4363	2.08	7.39	1.44	9.72	0.95	11.73	1.19	10.66
94.50	4.4707	2.44	6.12	1.80	8.40	1.17	10.75	1.27	10.30
94.87	4.4801	1.99	7.71	1.35	10.06	0.96	11.68	0.93	11.81
95.31	4.4913	2.38	6.33	1.74	8.62	1.21	10.57	1.37	9.86
95.58	4.4982	2.85	4.72	2.21	6.93	1.34	9.99	1.09	11.10
95.99	4.5086	2.22	6.89	1.58	9.20				
96.38	4.5185	2.71	5.20	2.07	7.43	1.41	9.68	1.49	9.33
96.80	4.5292	2.85	4.72	2.21	6.93	1.32	10.08	1.34	9.99
97.08	4.5364	2.45	6.09	1.81	8.36	1.64	8.67	1.71	8.36
97.50	4.5470	3.06	4.02	2.42	6.19	1.51	9.24	1.43	9.59
97.89	4.5570	2.54	5.78	1.90	8.04	1.52	9.20	1.78	8.05
98.28	4.5669	2.65	5.40	2.01	7.64	1.38	9.82	2.23	6.07
98.51	4.5727	2.87	4.66	2.23	6.86	1.36	9.90	1.32	10.08
99.00	4.5852	2.66	5.37	2.02	7.60	1.21	10.57	1.32	10.08
99.39	4.5951	2.90	4.56	2.26	6.75	1.40	9.73	1.54	9.11
100.08	4.6127	3.02	4.16	2.38	6.33	1.61	8.80	2.08	6.73
100.51	4.6236	2.51	5.88	1.87	8.14	1.51	9.24	1.66	8.58
100.90	4.6336	2.39	6.30	1.75	8.58	1.42	9.64	1.32	10.08
101.30	4.6437	2.35	6.44	1.71	8.73	1.34	9.99	1.84	7.78
101.38	4.6458	2.38	6.33	1.74	8.62	1.51	9.24	1.55	9.06
101.58	4.6509	2.61	5.54	1.97	7.78	1.39	9.77	1.30	10.17
102.10	4.6641	2.65	5.40	2.01	7.64	1.45	9.51	1.38	9.82
102.38	4.6712	2.20	6.96	1.56	9.28	1.29	10.21	1.55	9.06
102.67	4.6786	2.53	5.81	1.89	8.07	1.41	9.68	1.75	8.18
104.10	4.7150	2.86	4.69	2.22	6.89	1.61	8.80	1.97	7.21
104.50	4.7252	2.46	6.06	1.82	8.33	1.47	9.42	1.48	9.37
104.90	4.7354	2.40	6.26	1.76	8.54	1.36	9.90	1.13	10.92
105.10	4.7405	2.71	5.20	2.07	7.43	1.41	9.68		
105.60	4.7532	2.45	6.09	1.81	8.36	1.29	10.21	1.03	11.37
106.40	4.7735	1.88	8.11	1.24	10.47	0.99	11.55		
106.68	4.7807	1.94	7.89	1.30	10.25	1.10	11.06		
107.10	4.7913	2.58	5.64	1.94	7.89	1.57	8.97	1.51	9.24
107.50	4.8015	2.60	5.57	1.96	7.82	1.26	10.35	1.09	11.10
107.90	4.8117	2.08	7.39	1.44	9.72	1.06	11.24	0.99	11.55
108.18	4.8188	2.34	6.47	1.70	8.76	1.27	10.30	1.04	11.33
108.60	4.8295	2.25	6.79	1.61	9.09	1.36	9.90	1.16	10.79
109.00	4.8397	2.04	7.53	1.40	9.87	1.26	10.35	1.39	9.77
109.40	4.8499	2.22	6.89	1.58	9.20	1.48	9.37	1.71	8.36
109.68	4.8570	1.84	8.25	1.20	10.63	1.32	10.08	1.35	9.95

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
110.10	4.8677	2.16	7.11	1.52	9.43	1.48	9.37	1.70	8.40
110.50	4.8779	2.27	6.72	1.63	9.02	1.26	10.35	0.94	11.77
110.90	4.8881	2.86	4.69	2.22	6.89	1.19	10.66	0.79	12.44
111.18	4.8952	2.50	5.92	1.86	8.18	1.37	9.86	1.74	8.22
111.40	4.9008	2.33	6.51	1.69	8.80	1.56	9.02	1.40	9.73
111.80	4.9110	2.77	4.99	2.13	7.21	1.63	8.71	1.81	7.92
114.10	4.9695	2.14	7.18	1.50	9.50	1.16	10.79		
114.50	4.9797	2.18	7.04	1.54	9.35	1.56	9.02	1.94	7.34
114.78	4.9868	2.32	5.54	1.68	8.84	1.36	9.90	1.00	11.50
115.20	4.9975	2.24	6.82	1.60	9.13	1.47	9.42	1.23	10.48
115.60	5.0077	2.90	4.56	2.26	6.75	1.60	8.84	1.48	9.37
116.00	5.0178	2.26	6.75	1.62	9.06	1.26	10.35	1.08	11.15
116.28	5.0250	2.43	6.16	1.79	8.43	1.19	10.66	0.89	11.99
116.70	5.0357	2.04	7.53	1.40	9.87	1.27	10.30	1.07	11.19
117.10	5.0458	2.09	7.35	1.45	9.69	1.19	10.66	0.99	11.55
117.50	5.0560	2.43	6.16	1.79	8.43	0.96	11.68	0.89	11.99
117.78	5.0631	2.27	6.72	1.63	9.02	1.21	10.57	1.24	10.44
118.20	5.0738	2.40	6.26	1.76	8.54	1.32	10.08	1.11	11.01
118.60	5.0840	2.69	5.27	2.05	7.50	1.56	9.02	1.44	9.55
119.00	5.0942	2.42	6.19	1.78	8.47	1.48	9.37	1.21	10.57
119.28	5.1013	2.57	5.68	1.93	7.93	1.69	8.44	1.80	7.96
119.70	5.1120	2.48	5.99	1.84	8.25	1.46	9.46	1.63	8.71
120.10	5.1222	2.84	4.76	2.20	6.96	1.41	9.68	1.38	9.82
120.50	5.1324	2.38	6.33	1.74	8.62	1.36	9.90	1.14	10.88
120.78	5.1395	3.01	4.19	2.37	6.37	1.31	10.13	1.23	10.48
121.20	5.1502	2.37	6.37	1.73	8.65	1.35	9.95	1.39	9.77
121.60	5.1604	2.92	4.49	2.28	6.68	1.46	9.46	1.20	10.61
121.98	5.1700	2.47	6.02	1.83	8.29	1.27	10.30	1.78	8.05
123.30	5.2009	2.54	5.57	1.90	7.82	1.71	8.36	1.52	9.20
123.70	5.2070	2.32	6.33	1.68	8.62	1.21	10.57	1.04	11.33
124.10	5.2131	2.49	5.74	1.85	8.00	1.34	9.99	1.18	10.70
124.38	5.2173	2.29	6.44	1.65	8.73	1.19	10.66	1.05	11.28
124.80	5.2237	2.46	5.85	1.82	8.11	1.27	10.30	1.17	10.75
125.60	5.2359	2.11	7.07	1.47	9.39	1.41	9.68	1.30	10.17
125.88	5.2401	2.25	6.58	1.61	8.87	1.26	10.35	1.01	11.46
126.30	5.2465	2.28	6.47	1.64	8.76	1.55	9.06	1.13	10.92
126.70	5.2526	2.04	7.32	1.40	9.65	1.27	10.30	1.17	10.75
127.10	5.2586	2.67	5.13	2.03	7.35	1.32	10.08	1.43	9.59
127.38	5.2629	2.94	4.22	2.30	6.40	1.19	10.66	1.12	10.97
128.60	5.2814	3.04	3.89	2.40	6.06	1.59	8.89	1.72	8.31
128.88	5.2857	3.11	3.66	2.47	5.81	1.66	8.58	1.98	7.17
129.30	5.2921	3.04	3.89	2.40	6.06	1.43	9.59		
129.70	5.2981	3.04	3.89	2.40	6.06	1.70	8.40	2.00	7.08
130.10	5.3042	3.06	3.83	2.42	5.99	1.48	9.37	1.73	8.27
130.38	5.3084	2.56	5.50	1.92	7.75	1.56	9.02	1.55	9.06
130.88	5.3160	3.33	2.95	2.69	5.06	1.69	8.44	1.85	7.74
131.20	5.3209	2.44	5.92	1.80	8.18	1.65	8.62		
132.90	5.3467	2.53	5.61	1.89	7.86	1.56	9.02	1.62	8.75
133.30	5.3528	2.50	5.71	1.86	7.96	1.29	10.21	0.97	11.64
133.70	5.3589	2.53	5.61	1.89	7.86	1.24	10.44	1.33	10.04
133.98	5.3631	2.04	7.32	1.40	9.65	1.49	9.33	1.29	10.21
134.40	5.3695	2.16	6.89	1.52	9.20	1.31	10.13	0.91	11.90
134.80	5.3756	2.30	6.40	1.66	8.69	1.50	9.28	1.39	9.77
135.20	5.3816	2.07	7.21	1.43	9.54	1.49	9.33	1.56	9.02
135.48	5.3859	2.42	5.99	1.78	8.25	1.64	8.67	1.52	9.20
135.90	5.3923	2.57	5.47	1.93	7.71	1.69	8.44	1.82	7.87
136.30	5.3983	2.92	4.29	2.28	6.47	1.72	8.31	2.17	6.33
137.40	5.4150	2.21	6.72	1.57	9.02	1.36	9.90		
137.80	5.4211	2.94	4.22	2.30	6.40	1.96	7.26	1.59	8.89
138.20	5.4272	3.11	3.66	2.47	5.81	1.36	9.90	1.85	7.74
138.48	5.4314	2.74	4.89	2.10	7.11	1.41	9.68	1.35	9.95
138.90	5.4378	2.72	4.96	2.08	7.18	1.52	9.20	1.64	8.67
139.30	5.4439	2.85	4.52	2.21	6.72	1.11	11.01		

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
139.70	5.4500	3.28	3.11	2.64	5.23	0.92	11.86	0.97	11.64
139.97	5.4541	2.43	5.95	1.79	8.22	1.19	10.66	1.01	11.46
140.40	5.4606	2.22	6.68	1.58	8.98	1.36	9.90	0.96	11.68
140.80	5.4667	2.26	6.54	1.62	8.84	1.29	10.21	1.13	10.92
141.14	5.4718	3.05	3.86	2.41	6.02	1.47	9.42	1.24	10.44
142.50	5.4925	3.12	3.63	2.48	5.78	1.51	9.24	1.52	9.20
142.90	5.4986	2.77	4.79	2.13	7.00	1.48	9.37	1.81	7.92
143.30	5.5046	2.81	4.66	2.17	6.86	1.36	9.90	1.11	11.01
143.58	5.5089	2.84	4.56	2.20	6.75	1.44	9.55	1.28	10.26
144.40	5.5307	2.53	5.61	1.89	7.86	1.36	9.90	1.14	10.88
145.08	5.5504	2.76	4.82	2.12	7.04	1.56	9.02	1.94	7.34
145.50	5.5626	2.37	6.16	1.73	8.43	1.49	9.33	1.30	10.17
145.90	5.5741	2.33	6.30	1.69	8.58	1.26	10.35	1.47	9.42
146.30	5.5857	2.28	6.47	1.64	8.76	1.37	9.86	1.51	9.24
146.58	5.5938	2.16	6.89	1.52	9.20	1.48	9.37	1.31	10.13
147.00	5.6060	2.24	6.61	1.60	8.91	1.36	9.90	1.11	11.01
147.40	5.6176	2.46	5.85	1.82	8.11	1.41	9.68	0.90	11.95
147.80	5.6292	3.06	3.83	2.42	5.99	1.52	9.20	1.08	11.15
148.50	5.6494	2.00	7.46	1.36	9.80	1.65	8.62	1.42	9.64
148.90	5.6610	2.56	5.50	1.92	7.75	1.39	9.77	0.89	11.99
149.30	5.6726	1.77	8.29	1.13	10.66	1.30	10.17	1.10	11.06
149.58	5.6807	2.87	4.46	2.23	6.65	1.25	10.39	0.67	12.98
150.00	5.6929	1.93	7.71	1.29	10.06	1.36	9.90	0.91	11.90
150.80	5.7160	2.31	6.37	1.67	8.65	1.47	9.42	1.11	11.01
151.08	5.7242	2.66	5.16	2.02	7.39	1.26	10.35	0.80	12.39
152.10	5.7537	2.57	5.47	1.93	7.71	1.61	8.80	1.48	9.37
152.50	5.7653	2.30	6.40	1.66	8.69	1.58	8.93	1.43	9.59
152.90	5.7769	2.93	4.26	2.29	6.44	1.61	8.80	1.76	8.14
153.18	5.7850	2.17	6.86	1.53	9.17	1.29	10.21	0.96	11.68
154.00	5.8087	2.31	6.37	1.67	8.65	1.38	9.82	1.16	10.79
154.40	5.8203	2.12	7.04	1.48	9.35	1.48	9.37	1.31	10.13
154.68	5.8284	2.54	5.57	1.90	7.82	1.30	10.17	1.26	10.35
155.10	5.8406	2.19	6.79	1.55	9.09	1.21	10.57	1.05	11.28
155.50	5.8522	2.29	6.44	1.65	8.73	1.00	11.50	0.88	12.04
155.90	5.8638	2.41	6.02	1.77	8.29	0.96	11.68	0.87	12.08
156.18	5.8719	2.79	4.72	2.15	6.93	1.26	10.35	1.75	8.18
156.60	5.8840	2.45	5.88	1.81	8.14	1.10	11.06	0.56	13.47
157.00	5.8956	2.24	6.61	1.60	8.91	1.30	10.17	0.92	11.86
157.40	5.9072	2.23	6.65	1.59	8.95	1.26	10.35	1.39	9.77
157.68	5.9153	2.23	6.65	1.59	8.95	1.41	9.68	1.67	8.53
158.79	5.9474	1.71	8.51	1.07	10.89	1.06	11.24	0.81	12.35
158.99	5.9532	1.97	7.57	1.33	9.91	1.24	10.44	0.90	11.95
159.20	5.9593	2.54	5.57	1.90	7.82	1.11	11.01	0.78	12.48
159.39	5.9648	2.41	6.02	1.77	8.29	1.26	10.35	1.13	10.92
159.70	5.9738	2.24	6.61	1.60	8.91	1.39	9.77	1.68	8.49
159.91	5.9799	2.17	6.86	1.53	9.17	1.28	10.26	0.88	12.04
160.10	5.9854	1.99	7.50	1.35	9.84	0.92	11.86	0.21	15.04
160.30	5.9912	2.36	6.19	1.72	8.47	0.87	12.08	0.59	13.33
160.49	5.9967	2.16	6.89	1.52	9.20	0.91	11.90	0.51	13.69
160.70	6.0028	2.30	6.40	1.66	8.69	1.12	10.97	0.86	12.13
160.88	6.0080	2.27	6.51	1.63	8.80	1.25	10.39	0.97	11.64
161.00	6.0115	2.39	6.09	1.75	8.36	1.36	9.90	1.24	10.44
161.20	6.0172	2.56	5.50	1.92	7.75	1.24	10.44	1.39	9.77
161.40	6.0230	2.63	5.27	1.99	7.50	1.31	10.13	1.64	8.67
161.59	6.0285	2.34	6.26	1.70	8.54	1.26	10.35	1.15	10.84
161.80	6.0346	2.87	4.46	2.23	6.65	1.14	10.88	1.24	10.44
162.00	6.0404	3.17	3.46	2.53	5.61	1.24	10.44	0.88	12.04
162.20	6.0462	2.36	6.19	1.72	8.47	1.32	10.08	1.31	10.13
162.40	6.0520	2.19	6.79	1.55	9.09	1.25	10.39	1.16	10.79
162.50	6.0549	2.29	6.44	1.65	8.73	1.16	10.79	1.09	11.10
162.71	6.0610	2.77	4.79	2.13	7.00	1.41	9.68	1.26	10.35
162.90	6.0665	2.46	5.85	1.82	8.11	1.31	10.13	1.11	11.01
163.29	6.0778	1.95	7.64	1.31	9.99	1.06	11.24	0.97	11.64

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
163.50	6.0839	1.71	8.51	1.07	10.89	1.21	10.57	1.06	11.24
163.70	6.0897	2.29	6.44	1.65	8.73	1.11	11.01	0.88	12.04
163.89	6.0952	2.64	5.23	2.00	7.46	1.34	9.99	0.93	11.81
164.00	6.0983	2.75	4.86	2.11	7.07	1.26	10.35	0.92	11.86
164.20	6.1041	2.85	4.52	2.21	6.72	1.27	10.30	1.32	10.08
164.40	6.1099	2.49	5.74	1.85	8.00	1.31	10.13	1.11	11.01
164.60	6.1157	2.85	4.52	2.21	6.72	1.21	10.57	1.05	11.28
164.80	6.1215	2.45	5.88	1.81	8.14	0.87	12.08	0.67	12.98
165.00	6.1273	2.91	4.32	2.27	6.51	1.35	9.95	1.15	10.84
165.20	6.1331	2.36	6.19	1.72	8.47	1.15	10.84	0.91	11.90
165.40	6.1389	2.08	7.18	1.44	9.50	0.99	11.55	0.88	12.04
165.50	6.1418	2.26	6.54	1.62	8.84	1.32	10.08	1.03	11.37
165.70	6.1476	2.95	4.19	2.31	6.37	1.42	9.64	1.23	10.48
165.90	6.1534	2.53	5.61	1.89	7.86	1.41	9.68	1.53	9.15
166.10	6.1592	2.35	6.23	1.71	8.51	1.26	10.35	1.36	9.90
166.30	6.1650	2.52	5.64	1.88	7.89	1.36	9.90	1.14	10.88
166.50	6.1707	2.21	6.72	1.57	9.02	1.16	10.79	0.95	11.73
166.70	6.1765	2.46	5.85	1.82	8.11	1.26	10.35	1.02	11.41
166.89	6.1820	3.04	3.89	2.40	6.06	1.07	11.19	1.00	11.50
167.00	6.1852	3.06	3.83	2.42	5.99	0.91	11.90	0.77	12.53
167.20	6.1910	2.37	6.16	1.73	8.43	1.26	10.35	0.99	11.55
167.40	6.1968	2.98	4.09	2.34	6.26	1.01	11.46	0.67	12.98
168.40	6.2258	2.02	7.39	1.38	9.72	1.21	9.66	0.81	11.44
168.60	6.2316	1.93	7.71	1.29	10.06	1.16	9.88	1.06	10.33
168.99	6.2429	2.85	4.52	2.21	6.72	1.34	9.09	1.91	6.57
169.10	6.2460	2.67	5.13	2.03	7.35	1.41	8.78	1.26	9.44
169.29	6.2515	2.82	4.62	2.18	6.82	1.51	8.33	1.30	9.26
169.50	6.2576	3.36	2.85	2.72	4.96	0.99	10.64	0.76	11.66
169.70	6.2634	2.52	5.64	1.88	7.89	1.04	10.41	0.80	11.48
169.90	6.2692	2.61	5.33	1.97	7.57	1.21	9.66	0.91	10.99
170.10	6.2750	2.96	4.16	2.32	6.33	1.01	10.55	0.62	12.28
170.27	6.2799	2.99	4.06	2.35	6.23	1.31	9.22	1.20	9.70
170.50	6.2866	1.92	7.75	1.28	10.10	0.85	11.26	0.79	11.53
170.80	6.2953	2.28	6.47	1.64	8.76	1.12	10.06	1.59	7.98
171.00	6.3011	2.63	5.27	1.99	7.50	1.41	8.78	1.22	9.62
171.20	6.3069	2.11	7.07	1.47	9.39	1.53	8.25	1.40	8.82
171.39	6.3124	3.06	3.83	2.42	5.99	1.66	7.67	1.86	6.79
171.60	6.3184	2.38	6.12	1.74	8.40	1.99	6.22	1.65	7.72
171.80	6.3242	2.25	6.58	1.61	8.87	1.33	9.13	1.44	8.64
172.00	6.3300	2.21	6.72	1.57	9.02	1.29	9.31	1.05	10.37
172.27	6.3379	3.39	2.75	2.75	4.86	1.78	7.15	1.31	9.22
172.50	6.3445	3.35	2.88	2.71	4.99	1.61	7.89	1.42	8.73
172.69	6.3500	3.17	3.46	2.53	5.61	1.72	7.41	1.36	9.00
172.90	6.3561	2.89	4.39	2.25	6.58	1.92	6.53	1.57	8.07
173.10	6.3619	3.20	3.37	2.56	5.50	1.04	10.41	1.40	8.82
173.30	6.3677	3.59	2.12	2.95	4.19	1.65	7.72	1.88	6.71
173.50	6.3735	3.58	2.15	2.94	4.22	1.11	10.10	1.45	8.60
173.80	6.3822	2.97	4.12	2.33	6.30	1.36	9.00	1.66	7.67
174.00	6.3880	3.15	3.53	2.51	5.68	1.78	7.15	1.69	7.54
174.20	6.3937	3.44	2.59	2.80	4.69	1.76	7.23	2.39	4.47
174.40	6.3995	2.79	4.72	2.15	6.93	1.72	7.41	1.60	7.94
174.60	6.4053	2.12	7.04	1.48	9.35	1.52	8.29	1.11	10.10
174.81	6.4114	2.26	6.54	1.62	8.84	1.36	9.00	1.25	9.48
175.00	6.4169	2.34	6.26	1.70	8.54			1.01	10.55
175.30	6.4256	3.29	3.07	2.65	5.20	1.42	8.73	1.58	8.03
175.50	6.4314	2.67	5.13	2.03	7.35	1.36	9.00	1.46	8.56
175.70	6.4372	2.35	6.23	1.71	8.51	1.41	8.78	1.35	9.04
175.90	6.4430	3.67	1.87	3.03	3.92	1.72	7.41	1.68	7.59
176.10	6.4488	3.45	2.56	2.81	4.66	1.71	7.45	1.86	6.79
176.30	6.4546	3.29	3.07	2.65	5.20	1.56	8.11	1.58	8.03
176.50	6.4604	3.46	2.53	2.82	4.62	1.74	7.32	1.31	9.22
176.80	6.4690	3.24	3.24	2.60	5.37	1.63	7.81	1.75	7.28
177.00	6.4748	2.61	5.33	1.97	7.57	1.59	7.98	1.45	8.60

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
177.28	6.4829	3.05	3.86	2.41	6.02	1.31	9.22	1.05	10.37
177.40	6.4864	2.53	5.61	1.89	7.86	1.28	9.35	1.21	9.66
177.60	6.4922	3.31	3.01	2.67	5.13	1.65	7.72	1.49	8.42
177.80	6.4980	3.23	3.27	2.59	5.40	1.00	10.59	1.06	10.33
178.10	6.5067	3.23	3.27	2.59	5.40	1.51	8.33	1.06	10.33
178.50	6.5183	2.26	6.54	1.62	8.84	1.26	9.44	1.16	9.88
178.82	6.5275	3.32	2.98	2.68	5.10	1.39	8.86	1.69	7.54
179.02	6.5333	3.70	1.77	3.06	3.83	1.46	8.56	1.97	6.31
179.17	6.5377	2.83	4.59	2.19	6.79	1.20	9.70	1.16	9.88
179.70	6.5530	2.44	5.92	1.80	8.18	0.51	12.77	1.13	10.01
179.92	6.5594	2.29	6.44	1.65	8.73	0.28	13.80	0.76	11.66
180.11	6.5649	1.89	7.86	1.25	10.21	0.82	11.39	0.50	12.82
180.40	6.5733	2.02	7.39	1.38	9.72	0.19	14.21	0.79	11.53
180.60	6.5791	2.93	4.26	2.29	6.44	1.46	8.56	1.06	10.33
180.80	6.5849	3.37	2.82	2.73	4.93	1.71	7.45	1.96	6.36
181.00	6.5907	2.31	6.37	1.67	8.65	1.24	9.53	0.65	12.15
181.19	6.5962	1.94	7.68	1.30	10.02	1.29	9.31	0.80	11.48
181.40	6.6023	1.75	8.36	1.11	10.74	1.10	10.15	0.84	11.30
181.60	6.6081	2.30	6.40	1.66	8.69	1.67	7.63	1.37	8.95
181.92	6.6173	2.12	7.04	1.48	9.35	1.01	10.55	0.71	11.88
182.10	6.6225	2.12	7.04	1.48	9.35	1.26	9.44	1.08	10.24
182.50	6.6341	2.59	5.40	1.95	7.64	1.39	8.86	1.52	8.29
182.70	6.6399	2.26	6.54	1.62	8.84	1.41	8.78	1.25	9.48
182.90	6.6457	1.96	7.60	1.32	9.95	1.03	10.46	1.23	9.57
183.10	6.6515	2.61	5.33	1.97	7.57	1.50	8.38	1.40	8.82
183.40	6.6602	2.69	5.06	2.05	7.28	1.60	7.94	1.55	8.16
183.60	6.6660	2.21	6.72	1.57	9.02	0.76	11.66	1.17	9.84
183.80	6.6718	3.17	3.46	2.53	5.61	0.80	11.48	1.23	9.57
184.00	6.6776	3.44	2.59	2.80	4.69	0.96	10.77	1.45	8.60
184.20	6.6834	2.83	4.59	2.19	6.79	1.27	9.39	1.55	8.16
184.41	6.6894	2.03	7.35	1.39	9.69	1.65	7.72	1.72	7.41
184.61	6.6952	2.48	5.78	1.84	8.04	1.46	8.56	1.03	10.46
184.90	6.7036	3.01	3.99	2.37	6.16	1.62	7.85	1.52	8.29
185.10	6.7094	2.82	4.62	2.18	6.82	1.59	7.98	1.46	8.56
185.30	6.7152	3.45	2.56	2.81	4.66	1.36	9.00	1.85	6.84
185.50	6.7210	2.95	4.19	2.31	6.37	1.26	9.44	1.61	7.89
185.69	6.7265	2.60	5.37	1.96	7.60	1.00	10.59	0.80	11.48
185.90	6.7326	2.38	6.12	1.74	8.40	1.31	9.22	1.11	10.10
186.10	6.7384	1.91	7.78	1.27	10.14	1.13	10.01	0.99	10.64
186.40	6.7471	2.54	5.57	1.90	7.82	1.74	7.32	1.31	9.22
186.60	6.7529	2.57	5.48	1.93	7.72	0.96	10.77	0.76	11.66
186.80	6.7587	2.74	4.89	2.10	7.11	1.20	9.70	1.45	8.60
187.00	6.7645	2.47	5.81	1.83	8.07	0.80	11.48	0.60	12.37
187.60	6.7818	2.36	6.19	1.72	8.47	1.24	9.53	0.96	10.77
187.79	6.7873	2.23	6.65	1.59	8.95	1.55	8.16	1.27	9.39
188.00	6.7934	2.33	6.30	1.69	8.58	0.73	11.79	1.78	7.15
188.19	6.7989	3.28	3.11	2.64	5.23	1.51	8.33	0.78	11.57
188.49	6.8076	2.28	6.47	1.64	8.76	1.29	9.31	0.68	12.02
188.70	6.8137	3.48	2.47	2.84	4.56	1.64	7.76	1.40	8.82
188.89	6.8192	2.36	6.19	1.72	8.47	1.51	8.33	1.07	10.28
189.10	6.8253	2.48	5.78	1.84	8.04	1.59	7.98	1.13	10.01
189.20	6.8282	2.35	6.23	1.71	8.51	1.57	8.07	1.76	7.23
189.52	6.8374	2.49	5.74	1.85	8.00	1.46	8.56	1.20	9.70
189.70	6.8426	2.29	6.44	1.65	8.73	1.37	8.95	1.14	9.97
190.00	6.8513	2.73	4.93	2.09	7.14	0.99	10.64	0.54	12.64
190.20	6.8571	2.85	4.52	2.21	6.72	1.06	10.33	0.85	11.26
190.40	6.8629	2.59	5.40	1.95	7.64	1.30	9.26	0.70	11.93
190.60	6.8687	2.36	6.19	1.72	8.47	1.21	9.66	1.45	8.60
190.80	6.8745	2.48	5.78	1.84	8.04	1.16	9.88	1.30	9.26
191.00	6.8803	2.54	5.57	1.90	7.82	1.38	8.91	1.73	7.37
191.19	6.8858	2.75	4.86	2.11	7.07	1.69	7.54	1.92	6.53
191.48	6.8942	2.65	5.20	2.01	7.43	1.72	7.41	1.65	7.72
191.70	6.9006	3.10	3.69	2.46	5.85	1.65	7.72	1.20	9.70

Depth (mbsf)	Age (Ma)	Uvi 18O	Temp	U to Cib 18O	Temp	Gb 18O	Temp	Ou 18O	Temp
191.90	6.9064	3.58	2.15	2.94	4.22	1.71	7.45	1.85	6.84
192.10	6.9122	2.58	5.44	1.94	7.68	1.66	7.67	1.45	8.60
192.30	6.9179	2.50	5.71	1.86	7.96	1.40	8.82	1.00	10.59
192.50	6.9237	2.44	5.92	1.80	8.18	1.21	9.66	1.04	10.41
192.70	6.9295	2.40	6.06	1.76	8.33	1.29	9.31	1.09	10.19
193.00	6.9382	2.76	4.82	2.12	7.04	1.36	9.00	1.56	8.11
193.20	6.9440	2.22	6.68	1.58	8.98	1.49	8.42	1.58	8.03
193.50	6.9527	2.35	6.23	1.71	8.51	1.61	7.89	1.75	7.28
193.60	6.9556	2.26	6.54	1.62	8.84	1.38	8.91	1.07	10.28
193.80	6.9614	2.60	5.37	1.96	7.60	1.42	8.73	1.24	9.53
193.98	6.9666	2.36	6.19	1.72	8.47	1.56	8.11	1.46	8.56
194.19	6.9727	2.65	5.20	2.01	7.43	1.71	7.45	1.62	7.85
194.50	6.9817	2.31	6.37	1.67	8.65	1.25	9.48	1.35	9.04
194.70	6.9875	2.12	7.04	1.48	9.35	1.36	9.00	1.09	10.19
194.88	6.9927	3.12	3.63	2.48	5.78	1.40	8.82	1.01	10.55
195.10	6.9990	2.82	4.62	2.18	6.82	1.54	8.20	1.60	7.94
195.50	7.0106	3.05	3.86	2.41	6.02	1.71	7.45	1.31	9.22
195.70	7.0164	2.71	4.99	2.07	7.21	1.50	8.38	1.28	9.35
196.00	7.0251	3.30	3.04	2.66	5.16	1.59	7.98	1.67	7.63
196.20	7.0309	2.94	4.22	2.30	6.40	1.60	7.94	1.45	8.60
196.40	7.0367	2.61	5.33	1.97	7.57	1.37	8.95	1.26	9.44

Appendix C Table 3: DSDP Hole 593 isotopic data c. 120-316 mbsf. Ccp = *Cibicidoides cenop*, GrmS = *Globorotalia miotumida* (sinistral), GrmD = *Globorotalia miotumida* (dextral), Ggb = *Globigerina bulloides*, Ou = *Orbulina universa*, Cs = *Cibicidoides subhaidingeri*, Ggb BIG = *Globigerina bulloides*, big specimens.

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
5.1273	120.30	1.165	1.708	1.577	1.085											
5.1326	120.51	1.079	1.768	1.750	1.151											
5.1372	120.69	1.110	1.686	1.680	1.074											
5.1425	120.90	1.106	1.623	1.690	1.027											
5.1479	121.11	1.254	1.610	1.934	1.000											
5.1517	121.26	1.327	1.802	1.959	1.043											
5.1576	121.49			1.810	1.057											
5.1626	121.69	1.274	1.810	1.758	1.166											
5.1680	121.90	1.284	1.731	1.738	1.185											
5.1728	122.09	1.313	1.759	1.873	1.142											
5.1771	122.26	1.302	1.688	1.688	1.145											
5.1835	122.51	1.296	1.712	1.781	1.159											
5.1886	122.71	1.145	1.732	1.702	1.097											
5.1939	122.92	0.899	1.563	1.513	0.974											
5.1979	123.10	0.894	1.598	1.408	1.116											
5.2009	123.30	1.062	1.541	1.491	1.122											
5.2044	123.53	1.110	1.748	1.473	1.002											
5.2069	123.69	1.135	1.669	1.511	1.204											
5.2098	123.88			1.440	0.965											
5.2132	124.11	0.989	1.626	1.463	1.152											
5.2161	124.30	0.927	1.821	1.474	1.322											
5.2192	124.50	1.133	1.730	1.690	1.209											
5.2219	124.68	0.920	1.563	1.642	1.084											
5.2252	124.90	1.016	1.595	1.403	0.896											
5.2283	125.10	1.174	1.768	1.597	1.115											
5.2313	125.30	1.249	1.784	1.767	1.155											
5.2340	125.48	1.231	1.607	1.669	1.122											
5.2375	125.71	1.220	1.675	1.695	0.983											
5.2435	126.10	1.462	1.760													

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
5.2465	126.30	1.341	1.776	1.898	1.131											
5.2504	126.56	1.203	1.739													
5.2526	126.70	0.860	1.205													
5.2556	126.90	1.040	1.667	1.674	1.140											
5.2617	127.30	1.135	1.843	1.490	1.177											
5.2649	127.51	1.121	1.748	1.396	1.334											
5.2678	127.70	0.934	1.524													
5.2708	127.90	0.820	1.382													
5.2738	128.10	1.015	1.490													
5.2767	128.29	1.160	1.841													
5.2798	128.49	0.885	1.778													
5.2832	128.72	0.795	1.897													
5.2863	128.92	0.878	2.047	1.435	1.580											
5.2890	129.10	0.952	2.162	1.550	1.291											
5.2921	129.30	1.115	1.791													
5.2951	129.50	1.036	1.733	1.475	1.111											
5.2980	129.69	1.146	1.833	1.557	1.318											
5.3012	129.90	1.080	1.908													
5.3045	130.12	1.272	1.779													
5.3071	130.29	1.273	1.661													
5.3103	130.50	1.232	1.801													
5.3132	130.69	1.170	1.807	1.709	1.379											
5.3162	130.89	1.093	1.678	1.670	1.242											
5.3194	131.10	1.169	1.865	1.695	1.254											
5.3224	131.30	1.237	1.864	1.622	1.474											
5.3256	131.51	1.239	1.753	1.674	1.461											
5.3285	131.70			1.825	1.379											
5.3317	131.91	1.159	1.765	1.798	1.314											
5.3347	132.11			1.688	1.304											
5.3381	132.33	1.282	1.892													
5.3411	132.53	1.344	1.829	1.958	1.471											
5.3443	132.74	1.200	1.798	1.915	1.352											
5.3467	132.90	1.120	1.642	1.811	1.234											
5.3493	133.07	1.133	1.714	1.825	1.308											
5.3526	133.29	1.342	1.792	1.990	1.388											
5.3552	133.46	1.343	1.805	1.887	1.404											
5.3586	133.68	1.241	1.721	1.836	1.337											
5.3617	133.89			1.725	1.295											
5.3649	134.10	1.245	1.856	1.729	1.222											
5.3680	134.30	1.377	1.797	1.849	1.512											
5.3710	134.50	1.130	1.544	1.774	1.389											
5.3740	134.70	1.074	1.743	1.517	1.176											
5.3771	134.90	1.111	1.755	1.428	1.134											
5.3801	135.10	1.212	1.934	1.662	1.332											
5.3832	135.30	1.306	1.871	1.760	1.573											
5.3862	135.50	1.284	1.827	1.761	1.283											
5.3892	135.70	1.319	1.762	1.535	1.159											
5.3923	135.90	1.356	1.728	1.514	1.041											
5.3947	136.06	1.436	1.812	1.676	1.269											
5.3986	136.32	1.323	1.879	1.646	1.296											
5.4015	136.51	1.196	1.750	1.531	1.263											
5.4078	136.92	1.074	1.994	1.472	1.472											
5.4109	137.13	1.050	2.191	1.286	1.392											
5.4138	137.32	0.959	2.255	1.406	1.772											
5.4169	137.52	1.066	2.229	1.518	1.632											
5.4197	137.71	1.297	2.070	1.621	1.453											
5.4228	137.91	1.132	1.868	1.403	1.314											
5.4249	138.05	0.963	1.285	1.510	1.123											
5.4282	138.27	1.255	1.734	1.576	1.316											
5.4313	138.47	1.208	1.920	1.723	1.545											
5.4342	138.66	1.042	1.763	1.482	1.327											
5.4378	138.90	0.926	1.760	1.326	1.361											

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
5.4404	139.07	0.813	1.911	1.092	1.226											
5.4427	139.22	0.890	2.065	1.015	1.423											
5.4469	139.50	0.838	1.865	1.146	1.397											
5.4507	139.75	0.915	1.946	1.212	1.313											
5.4571	140.17	0.948	1.808	1.254	1.123											
5.4597	140.34	0.860	1.704	1.113	1.065											
5.4627	140.54	0.830	1.886	0.978	0.901											
5.4656	140.73	0.886	1.999													
5.4685	140.92	0.786	1.818	1.279	1.470											
5.4717	141.13	0.998	1.862	1.469	1.324											
5.4752	141.36	0.961	1.778	1.394	1.195											
5.4779	141.54	1.055	1.786	1.369	1.143											
5.4817	141.79	1.157	1.769	1.418	1.115											
5.4837	141.92	1.071	1.699	1.375	0.989											
5.4867	142.12	0.790	1.332	1.456	1.188											
5.4897	142.32	0.904	1.399	1.518	1.021											
5.4925	142.50	0.998	1.554	1.241	1.161											
5.4963	142.75	0.914	1.607	1.365	1.262											
5.4990	142.93	1.015	1.794	1.237	1.044											
5.5023	143.15	0.720	1.369	1.298	1.168											
5.5049	143.32			1.317	1.173											
5.5081	143.53			1.406	1.327											
5.5116	143.74	1.020	1.825	1.543	1.275											
5.5145	143.84	0.712	1.680	1.230	1.158											
5.5211	144.07	0.497	1.622	1.080	0.992											
5.5266	144.26	0.711	1.883	1.063	1.429											
5.5324	144.46			1.054	1.488											
5.5385	144.67			1.008	1.433											
5.5460	144.93			1.222	1.195											
5.5518	145.13	0.760	1.859	1.219	0.943											
5.5573	145.32	0.845	1.577	1.448	0.995											
5.5626	145.50			1.467	1.214											
5.5666	145.64			1.533	1.236											
5.5750	145.93			1.329	1.082											
5.5808	146.13			1.354	0.922											
5.5875	146.36			1.190	0.873											
5.5921	146.52	0.791	1.734	1.260	1.036											
5.5976	146.71			1.352	0.765											
5.6037	146.92	0.983	1.872	1.259	1.175											
5.6077	147.06			1.276	1.287											
5.6196	147.47	1.067	1.731	1.445	1.206											
5.6245	147.64	1.087	1.795	1.535	1.280											
5.6329	147.93			1.536	1.153											
5.6393	148.15	1.097	1.736	1.521	1.115											
5.6445	148.33	0.898	1.849	1.262	1.232											
5.6494	148.50			1.166	1.369											
5.6544	148.67	0.659	1.846	1.078	1.423											
5.6573	148.77	0.702	1.744	1.067	1.500											
5.6668	149.10			1.572	1.232											
5.6743	149.36	1.128	1.648	1.497	1.070											
5.6790	149.52	1.130	1.728	1.411	0.750											
5.6906	149.92			1.437	1.330											
5.6961	150.11	0.753	1.816	1.270	1.257											
5.7019	150.31	0.792	1.799	1.317	1.325											
5.7076	150.51	0.896	1.807	1.240	1.214											
5.7123	150.67	0.987	1.803	1.362	1.066											
5.7181	150.87	1.015	1.840	1.303	1.199											
5.7239	151.07			1.369	1.241											
5.7314	151.33	0.908	1.793	1.368	1.461											
5.7369	151.52	0.904	1.763	1.471	1.176											
5.7436	151.75	1.078	1.861	1.560	1.514											
5.7496	151.96			1.515	1.280											

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
5.7537	152.10			1.591	1.416											
5.7580	152.25	0.997	1.745	1.581	1.284											
5.7644	152.47	1.072	1.705	1.727	1.162											
5.7725	152.75	1.093	1.619	1.762	1.057											
5.7772	152.91			1.712	1.174											
5.7832	153.12	0.619	1.603	1.151	1.231											
5.7873	153.26	0.645	1.752	0.990	1.385											
5.7928	153.45			0.961	1.360											
5.7989	153.66	0.863	1.910	1.183	1.428											
5.8079	153.97	1.143	1.893	1.462	1.427	1.690	1.440									
5.8125	154.13			1.642	1.255	1.530	1.390									
5.8180	154.32			1.700	0.980											
5.8244	154.54	1.302	1.927	1.476	1.448											
5.8310	154.77	1.234	1.778	1.620	1.220											
5.8362	154.95			1.664	1.159											
5.8406	155.10	1.229	1.812	1.637	1.245											
5.8446	155.24	1.107	1.754	1.669	1.240	1.630	1.390									
5.8516	155.48	1.142	1.698	1.500	1.330	1.440	1.430									
5.8571	155.67			1.644	1.310	1.530	1.400									
5.8649	155.94			1.449	0.915	1.480	1.190									
5.8704	156.13	1.067	1.827	1.481	1.017											
5.8745	156.27	0.990	1.446	1.554	1.144											
5.8803	156.47	1.288	1.784	1.443	0.758											
5.8872	156.71	1.082	1.742	1.505	1.015											
5.8942	156.95	0.730	1.488	1.354	0.938											
5.8991	157.12	1.053	2.283	1.572	1.469											
5.9063	157.37	0.920	2.024	1.394	1.547											
5.9107	157.52	1.035	1.829	1.716	1.550											
5.9176	157.76	0.940	1.664	1.579	1.107											
5.9225	157.93			1.535	1.019	1.650	1.040									
5.9275	158.10			1.615	1.228	1.430	1.030									
5.9324	158.27	1.256	1.799	1.796	1.689											
5.9396	158.52	0.842	1.802													
5.9448	158.70	0.883	1.735	1.535	1.225											
5.9521	158.95	0.988	1.944	1.227	1.327											
5.9573	159.13	1.056	1.825	1.474	1.402											
5.9637	159.35	1.069	1.774	1.850	1.671											
5.9677	159.49	1.255	1.834	1.660	1.192											
5.9744	159.72	1.412	2.204	1.747	1.242											
5.9784	159.86	1.220	1.752	1.577	0.761											
5.9857	160.11	1.267	1.981	1.721	1.204											
5.9921	160.33	0.886	1.560	1.463	1.098											
5.9981	160.54	0.810	1.800	1.520	1.074											
6.0036	160.73	0.827	1.769	1.258	1.147											
6.0112	160.99	0.835	2.214	1.076	1.381											
6.0161	161.16	0.842	1.824	1.120	1.351											
6.0207	161.32	0.955	1.546	1.456	1.158											
6.0268	161.53	0.764	1.880	1.288	1.045											
6.0317	161.70	0.584	1.281	1.322	0.798											
6.0358	161.84	0.920	1.943													
6.0439	162.12	1.109	1.816	1.287	0.838											
6.0479	162.26	0.886	1.700	1.565	1.235											
6.0563	162.55	0.706	1.739													
6.0656	162.87	0.895	1.922	1.501	1.417											
6.0708	163.05			1.620	1.303											
6.0789	163.33	1.100	2.122	1.519	1.159											
6.0856	163.56	1.092	1.862	1.633	1.349											
6.0905	163.73	1.204	2.015	1.649	1.294											
6.0963	163.93	1.096	1.839	1.569	1.304											
6.1021	164.13	1.060	1.657													
6.1073	164.31	1.210	2.025	1.539	1.263											
6.1134	164.52	1.271	2.025													

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
6.1186	164.70	1.218	2.303													
6.1261	164.96	1.016	1.991	1.600	1.525											
6.1311	165.13	0.955	1.969	1.630	1.585											
6.1374	165.35	0.390	1.285	1.568	1.461											
6.1418	165.50	0.586	1.946													
6.1487	165.74	0.813	2.195	1.146	1.329											
6.1548	165.95	0.887	1.963	1.465	1.665											
6.1594	166.11	0.851	1.930	1.393	1.288											
6.1638	166.26	0.816	1.578	1.349	0.778											
6.1696	166.46	1.096	1.967	1.534	1.047											
6.1754	166.66	1.017	2.058													
6.1812	166.86	1.067	1.555	1.422	1.181											
6.1870	167.06	0.934	1.955													
6.1922	167.24	0.893	2.010	1.378	1.331											
6.1980	167.44	1.418	2.739	1.365	0.958											
6.2017	167.57	1.158	2.174	1.460	1.268											
6.2229	168.30	0.965	2.102	1.428	0.875											
6.2292	168.52	1.034	2.472	1.198	0.884											
6.2347	168.71	1.090	2.085	1.478	0.928											
6.2408	168.92	1.022	1.760	1.509	0.850											
6.2469	169.13	0.938	1.972	1.506	1.098											
6.2530	169.34	0.994	2.043	1.602	1.245											
6.2579	169.51	1.287	2.080	1.594	1.272											
6.2640	169.72	0.995	2.002	1.597	1.209											
6.2678	169.85			1.605	1.392											
6.2738	170.06			1.344	0.987											
6.2814	170.32	1.251	2.773	1.249	1.273											
6.2872	170.52			1.261	0.764											
6.2993	170.73			1.528	1.240											
6.3054	171.15	0.910	1.949	1.359	1.311											
6.3176	171.30	1.094	2.468	1.334	1.082											
6.3219	171.72			1.174	1.228											
6.3277	171.92	0.917	2.413	1.114	1.377											
6.3338	172.13	0.852	1.898	1.404	1.307											
6.3393	172.32	0.844	1.947													
6.3436	172.47	0.793	1.842	1.216	1.124											
6.3491	172.66	0.985	1.859	1.479	1.055											
6.3549	172.86	1.080	1.904	1.544	1.352											
6.3610	173.07	1.022	1.985	1.390	1.262											
6.3668	173.27	0.848	1.896	1.287	1.184											
6.3741	173.52	0.990	2.090	1.375	1.264											
6.3798	173.72	0.914	2.021	1.401	1.215											
6.3859	173.93	1.121	2.201	1.403	1.228											
6.3920	174.14	0.975	2.067	1.398	1.429											
6.3966	174.30	1.032	2.034	1.386	1.357											
6.4036	174.54	0.889	1.784	1.369	1.118											
6.4088	174.72	0.926	1.861	1.235	1.094											
6.4129	174.86	0.809	1.653	1.158	1.027											
6.4244	175.26	0.938	1.930	1.184	1.251											
6.4305	175.47	0.927	1.894	1.377	1.489											
6.4375	175.71	0.740	1.838	1.130	1.100											
6.4418	175.86	0.870	1.663	1.232	1.259											
6.4476	176.06	0.987	2.014	1.207	1.280											
6.4551	176.32	0.481	2.240	1.273	1.388											
6.4595	176.47			1.002	1.082											
6.4644	176.64	0.428	1.344	0.985	1.250											
6.4725	176.92			0.825	1.465											
6.4789	177.14	0.767	1.889	1.152	1.227											
6.4835	177.30	0.895	1.889	1.264	1.535											
6.4899	177.52	0.718	1.869	1.253	1.195											
6.4986	177.82	0.700	1.874	1.340	1.373											
6.5009	177.90	0.788	1.958	1.482	1.441											

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
6.5052	178.05	0.936	1.961	1.523	1.313											
6.5116	178.27	1.066	2.224	1.294	1.297											
6.5177	178.48	1.132	2.034	1.495	1.402											
6.5235	178.68	0.919	2.040	1.489	1.169											
7.0813	197.94	1.16	1.75							1.04	0.93	2.80				
7.1273	199.53	1.63	1.77							2.17	1.13	3.93				
7.1714	201.05									1.87	1.12	3.63				
7.2258	202.93									1.64	1.15	3.40				
7.3502	206.71	1.36	1.73							1.80	1.19	3.56				
7.4021	208.26	1.45	2.04							1.47	1.07	3.23				
7.4644	210.12	1.32	1.81							1.57	0.99	3.33				
7.5180	211.72	1.62	1.72							2.06	1.08	3.82				
7.5787	213.53	1.39	1.53							1.86	1.02	3.62				
7.6383	215.31	1.49	1.68							2.08	0.65	3.84				
7.6929	216.94	1.54	1.93							2.36	1.26	4.12				
7.7458	218.52	1.67	1.68							1.09	1.42	2.85				
7.7994	220.12	1.86	1.94							2.39	1.24	4.15				
7.8510	221.66	1.81	1.91							2.23	1.61	3.99				
7.9069	223.33	1.77	1.90							2.34	1.28	4.10				
7.9585	224.87	1.91	1.93							2.34	1.25	4.10				
8.0275	226.93	1.10	1.73							1.81	1.09	3.57				
8.0808	228.52	1.51	1.86							1.80	1.32	3.56				
8.1394	230.27	1.44	1.83							1.91	1.41	3.67				
8.1943	231.91	1.41	1.84							2.07	1.34	3.83				
8.2466	233.47	1.50	1.90							2.08	1.36	3.84				
8.3002	235.07	1.47	1.83							1.85	1.07	3.61				
9.6945	267.53	1.323	1.970	1.900	0.864			2.573	1.186	1.131	1.093	2.89				
9.7053	267.72	1.038	1.879	1.795	0.729			2.366	0.547	1.832	1.561	3.59				
9.7138	267.87	1.044	1.890	1.821	0.935			2.649	0.898	1.403	0.379	3.16				
9.7291	268.14	1.183	1.898	1.867	1.712					1.853	1.428	3.61				
9.7405	268.34	2.736	5.269	1.921	0.914			2.617	0.485	1.634	1.101	3.39	1.243	2.895		
9.7479	268.47	1.174	1.462	2.016	0.865					1.657	1.217	3.42	1.353	1.782		
9.7598	268.68	1.210	1.690	1.854	1.076			2.827	0.850	1.470	0.615	3.23	1.083	2.273		
9.7701	268.86	1.187	1.377	1.731	0.774								1.154	1.978	1.905	0.787
9.7885	269.28	1.045	1.636	1.604	0.865	1.681	0.776	2.755	0.450	1.562	0.890	3.32	0.627	1.664		
9.7959	269.52	1.042	1.693	1.454	1.081	1.637	0.664	2.341	0.400	0.798	0.924	2.56	0.784	1.699	1.696	1.510
9.8030	269.75	0.843	2.118	1.481	1.450	1.550	1.307			0.758	0.274	2.52	0.982	2.569	1.415	1.235
9.8067	269.87	1.145	2.227	1.548	1.097	1.680	1.108	2.214	0.675	1.183	0.977	2.94	1.123	2.726	1.540	1.034
9.8153	270.15	0.902	1.459	1.592	1.425	1.782	0.887	2.576	0.716	1.156	0.423	2.92	0.996	2.004		
9.8203	270.31	1.142	1.838	1.657	1.093	1.788	0.918	2.603	0.399				1.123	2.188	1.576	0.638
9.8246	270.45	1.188	2.396	1.553	1.328	1.770	1.561	2.558	1.336	1.414	0.711	3.17	0.780	1.871	1.608	0.907
9.8329	270.72	1.052	2.394	1.543	1.363	1.784	1.231	2.559	0.700	1.562	1.404	3.32				
9.8384	270.91	1.249	2.536	1.947	1.579			2.542	1.671						1.998	1.096
9.8447	271.15	1.165	2.218	1.793	1.283			2.796	0.930	1.329	0.942	3.09				
9.8498	271.34	1.100	1.994	1.616	1.315			2.661	0.706							
9.8535	271.48	1.111	2.308	1.943	1.134			2.797	0.754	1.261	1.436	3.02	1.088	2.618	1.793	1.296
9.8598	271.72	1.189	2.538	2.079	1.073			2.980	0.650	1.265	0.809	3.03	0.997	2.190	2.002	1.306
9.8657	271.94	1.310	2.189	1.837	1.262			2.680	0.730	1.295	1.199	3.06	1.017	1.782	1.863	1.777
9.8723	272.19	1.237	2.347	1.955	1.007			2.770	0.352	1.390	0.737	3.15	1.237	2.500	1.854	1.133
9.9658	275.72	1.405	1.661	1.189	0.505											
9.9870	276.52			1.949	0.641											
10.0011	277.05	1.252	1.555	1.878	0.716											
10.0194	277.74			1.239	1.653											
10.0337	278.28			1.447	1.737											
10.0496	278.88	1.085	1.583	1.720	0.887											
10.0668	279.53	1.138	1.607	1.622	1.076											
10.0806	280.05	1.336	1.586	2.013	1.098											
10.1036	280.92	1.214	1.893	1.589	0.998											
10.1837	283.94	1.257	1.858	1.609	0.688											
10.1998	284.55	1.159	1.302	1.635	0.720											
10.2141	285.09			1.930	0.800											
10.2311	285.73	1.391	1.694													

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
10.2616	286.88	1.387	1.708	2.098	0.902											
10.2785	287.52	1.422	1.901	2.294	0.979											
10.2934	288.08	1.399	1.876	2.253	1.101											
10.3098	288.70	1.318	1.748	2.037	1.170											
10.3267	289.34	1.612	1.959	2.118	1.107											
10.3424	289.93	1.427	1.820	2.211	1.065											
10.3577	290.51	1.583	1.691	2.222	1.009											
10.4266	293.11	1.600	1.898	2.311	0.830											
10.4425	293.71	1.558	1.727	2.157	1.061											
10.4584	294.31	1.617	1.742	2.378	0.941											
10.4741	294.90			1.993	1.149											
10.4908	295.53	1.859	1.705	2.237	0.843											
10.5061	296.11	1.965	1.848	2.044	1.192											
10.5279	296.93	1.418	1.929	2.039	1.141											
10.5430	297.50	1.592	1.775	2.267	0.874											
10.5583	298.08	1.626	1.687	2.343	1.055											
10.5748	298.70	1.468	1.799	1.888	0.809											
10.5928	299.38	1.517	1.844	2.127	1.013											
10.6810	302.71	1.558	1.801	2.159	0.802											
10.6964	303.29	1.423	1.871	2.045	1.038											
10.7028	303.91	1.541	1.756	1.937	1.107											
10.7277	304.47	1.264	1.752	1.846	0.905											
10.7507	305.34	1.392	1.306	2.083	0.723											
10.7563	305.55	1.182	1.459	1.848	0.872											
10.7605	305.71	1.520	1.860	2.030	0.887											
10.7664	305.93	1.451	1.782	1.950	1.120											
10.7711	306.11	1.402	1.640	2.160	0.880	1.973	0.800									
10.7754	306.27	1.287	1.510	1.998	0.832	2.245	0.982									
10.7825	306.54	1.368	1.901	1.821	1.173	1.849	1.180									
10.7881	306.75	1.312	1.890	1.847	1.143											
10.7910	306.86	1.334	1.828	2.035	0.990											
10.7968	307.08	1.336	1.463	1.560	0.711											
10.8027	307.30	1.542	1.753	1.866	0.683											
10.8077	307.49	1.381	1.543	2.016	1.011											
10.8133	307.70	1.709	1.732	2.319	1.035											
10.8193	307.93	1.638	1.769	1.942	0.870											
10.8249	308.14	1.492	1.708	2.085	1.142											
10.8292	308.30	1.392	1.674	2.006	0.558											
10.8352	308.53	1.505	1.842	2.164	0.909											
10.8400	308.71	1.440	1.860	2.032	0.951											
10.8474	308.99	1.322	1.654	1.921	0.812					2.157	0.919	3.92				
10.8516	309.11	1.672	1.702	2.006	0.815					2.203	0.885	3.96				
10.8543	309.28	1.534	1.613	1.890	0.880	2.087	0.945			2.015	0.601	3.78				
10.8583	309.54	1.679	1.520	2.212	0.936	2.302	0.863			2.263	0.777	4.02				
10.8615	309.74	1.345	1.570	2.097	0.725	2.046	0.822			2.239	0.763	4.00				
10.9018	312.31	1.464	1.675	2.246	1.067	2.230	0.991	3.261	0.393							
10.9054	312.54	1.583	1.771	2.261	1.007	1.963	0.893	2.988	0.491	2.174	1.037	3.93				
10.9075	312.67	1.712	1.921	2.180	1.034	2.226	1.141	2.971	0.758							
10.9106	312.87	1.424	1.591	2.105	0.871	2.400	0.931									
10.9138	313.07	1.505	1.675	2.249	0.833	1.845	0.814	3.202	0.298	2.415	0.770	4.18				
10.9175	313.31	1.591	1.547	2.336	0.820	2.523	1.009			2.525	1.019	4.29				
10.9210	313.53	1.311	1.936	1.967	1.049	1.954	1.129	2.859	0.810	2.193	1.128	3.95				
10.9238	313.71			1.910	1.180											
10.9268	313.90	1.509	1.794	2.062	1.167					2.211	1.021	3.97				
10.9298	314.09	1.618	1.982	2.157	0.735	2.173	1.084	3.005	0.062							
10.9329	314.29	1.406	1.287	2.335	0.923	2.283	0.671			1.990	0.701	3.75				
10.9354	314.45	1.443	1.987	2.043	1.126					2.019	1.469	3.78				
10.9392	314.69	1.527	1.747	2.338	1.598					1.926	0.728	3.69				
10.9425	314.90	1.654	1.786	2.256	1.440	2.348	1.338	2.969	0.654	2.469	1.692	4.23				
10.9461	315.13			2.630	2.124	2.364	1.463	2.884	0.955	2.262	1.386	4.02				
10.9496	315.30	1.552	1.677	2.220	0.880			2.949	0.680	2.524	1.766	4.28				
10.9569	315.52	1.755	1.907	2.405	1.750											

Age (Ma)	Depth (mbsf)	Ccp 13C	Ccp 18O	GrmS 13C	GrmS 18O	GrmD 13C	GrmD 18O	Ou 13C	Ou 18O	Ggb 13C	Ggb 18O	Ggb 13C +1.76	Cs 13C	Cs 18O	Gbg BIG 13C	Ggb BIG 18O
10.9631	315.71	1.825	1.680	2.508	1.035					2.153	0.760	3.91				
10.9746	316.06	2.021	2.883	2.240	1.086			3.489	1.011	2.923	0.431	4.68				
10.9815	316.27	1.698	1.979	2.029	1.849			3.124	0.696	2.100	1.117	3.86				

Appendix C Table 4: DSDP Hole 593 palaeotemperature calculations for c. 120-317 mbsf.

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
5.1273	120.30	1.708	8.77	1.085	11.13						
5.1326	120.51	1.768	8.55	1.151	10.83						
5.1372	120.69	1.686	8.85	1.074	11.17						
5.1425	120.90	1.623	9.08	1.027	11.38						
5.1479	121.11	1.610	9.12	1.000	11.50						
5.1517	121.26	1.802	8.43	1.043	11.31						
5.1576	121.49			1.057	11.25						
5.1626	121.69	1.810	8.39	1.166	10.77						
5.1680	121.90	1.731	8.68	1.185	10.68						
5.1728	122.09	1.759	8.58	1.142	10.87						
5.1771	122.26	1.688	8.84	1.145	10.86						
5.1835	122.51	1.712	8.75	1.159	10.80						
5.1886	122.71	1.732	8.68	1.097	11.07						
5.1939	122.92	1.563	9.30	0.974	11.62						
5.1979	123.10	1.598	9.17	1.116	10.99						
5.2009	123.30	1.541	9.13	1.122	10.96						
5.2044	123.53	1.748	8.37	1.002	11.49						
5.2069	123.69	1.669	8.66	1.204	10.60						
5.2098	123.88			0.965	11.66						
5.2132	124.11	1.626	8.81	1.152	10.83						
5.2161	124.30	1.821	8.10	1.322	10.07						
5.2192	124.50	1.730	8.43	1.209	10.57						
5.2219	124.68	1.563	9.05	1.084	11.13						
5.2252	124.90	1.595	8.93	0.896	11.97						
5.2283	125.10	1.768	8.30	1.115	10.99						
5.2313	125.30	1.784	8.24	1.155	10.81						
5.2340	125.48	1.607	8.88	1.122	10.96						
5.2375	125.71	1.675	8.63	0.983	11.58						
5.2435	126.10	1.760	8.32								
5.2465	126.30	1.776	8.27	1.131	10.92						
5.2504	126.56	1.739	8.40								
5.2526	126.70	1.205	10.38								
5.2556	126.90	1.667	8.67	1.140	10.88						
5.2617	127.30	1.843	8.02	1.177	10.71						
5.2649	127.51	1.748	8.37	1.334	10.02						
5.2678	127.70	1.524	9.19								
5.2708	127.90	1.382	9.72								
5.2738	128.10	1.490	9.31								
5.2767	128.29	1.841	8.03								
5.2798	128.49	1.778	8.26								
5.2832	128.72	1.897	7.83								
5.2863	128.92	2.047	7.29	1.580	8.93						
5.2890	129.10	2.162	6.89	1.291	10.21						
5.2921	129.30	1.791	8.21								
5.2951	129.50	1.733	8.42	1.111	11.01						
5.2980	129.69	1.833	8.06	1.318	10.09						
5.3012	129.90	1.908	7.79								
5.3045	130.12	1.779	8.26								
5.3071	130.29	1.661	8.69								
5.3103	130.50	1.801	8.18								

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
5.3132	130.69	1.807	8.16	1.379	9.82						
5.3162	130.89	1.678	8.62	1.242	10.43						
5.3194	131.10	1.865	7.95	1.254	10.38						
5.3224	131.30	1.864	7.95	1.474	9.40						
5.3256	131.51	1.753	8.35	1.461	9.46						
5.3285	131.70			1.379	9.82						
5.3317	131.91	1.765	8.31	1.314	10.11						
5.3347	132.11			1.304	10.15						
5.3381	132.33	1.892	7.85								
5.3411	132.53	1.829	8.07	1.471	9.41						
5.3443	132.74	1.798	8.19	1.352	9.94						
5.3467	132.90	1.642	8.76	1.234	10.46						
5.3493	133.07	1.714	8.49	1.308	10.13						
5.3526	133.29	1.792	8.21	1.388	9.78						
5.3552	133.46	1.805	8.16	1.404	9.71						
5.3586	133.68	1.721	8.47	1.337	10.01						
5.3617	133.89			1.295	10.19						
5.3649	134.10	1.856	7.98	1.222	10.52						
5.3680	134.30	1.797	8.19	1.512	9.23						
5.3710	134.50	1.544	9.12	1.389	9.78						
5.3740	134.70	1.743	8.39	1.176	10.72						
5.3771	134.90	1.755	8.34	1.134	10.91						
5.3801	135.10	1.934	7.70	1.332	10.03						
5.3832	135.30	1.871	7.92	1.573	8.96						
5.3862	135.50	1.827	8.08	1.283	10.25						
5.3892	135.70	1.762	8.32	1.159	10.80						
5.3923	135.90	1.728	8.44	1.041	11.32						
5.3947	136.06	1.812	8.14	1.269	10.31						
5.3986	136.32	1.879	7.89	1.296	10.19						
5.4015	136.51	1.750	8.36	1.263	10.33						
5.4078	136.92	1.994	7.48	1.472	9.41						
5.4109	137.13	2.191	6.78	1.392	9.76						
5.4138	137.32	2.255	6.56	1.772	8.08						
5.4169	137.52	2.229	6.65	1.632	8.70						
5.4197	137.71	2.070	7.21	1.453	9.49						
5.4228	137.91	1.868	7.93	1.314	10.11						
5.4249	138.05	1.285	10.08	1.123	10.96						
5.4282	138.27	1.734	8.42	1.316	10.10						
5.4313	138.47	1.920	7.75	1.545	9.09						
5.4342	138.66	1.763	8.31	1.327	10.05						
5.4378	138.90	1.760	8.33	1.361	9.90						
5.4404	139.07	1.911	7.78	1.226	10.50						
5.4427	139.22	2.065	7.23	1.423	9.62						
5.4469	139.50	1.865	7.95	1.397	9.74						
5.4507	139.75	1.946	7.66	1.313	10.11						
5.4571	140.17	1.808	8.15	1.123	10.96						
5.4597	140.34	1.704	8.53	1.065	11.22						
5.4627	140.54	1.886	7.87	0.901	11.95						
5.4656	140.73	1.999	7.46								
5.4685	140.92	1.818	8.11	1.470	9.42						
5.4717	141.13	1.862	7.96	1.324	10.06						
5.4752	141.36	1.778	8.26	1.195	10.63						
5.4779	141.54	1.786	8.23	1.143	10.87						
5.4817	141.79	1.769	8.29	1.115	10.99						
5.4837	141.92	1.699	8.55	0.989	11.55						
5.4867	142.12	1.332	9.90	1.188	10.67						
5.4897	142.32	1.399	9.65	1.021	11.41						
5.4925	142.50	1.554	9.08	1.161	10.79						
5.4963	142.75	1.607	8.89	1.262	10.34						
5.4990	142.93	1.794	8.20	1.044	11.31						
5.5023	143.15	1.369	9.76	1.168	10.76						
5.5049	143.32			1.173	10.73						
5.5081	143.53			1.327	10.05						

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
5.5116	143.74	1.825	8.09	1.275	10.28						
5.5145	143.84	1.680	8.62	1.158	10.80						
5.5211	144.07	1.622	8.83	0.992	11.54						
5.5266	144.26	1.883	7.88	1.429	9.60						
5.5324	144.46			1.488	9.34						
5.5385	144.67			1.433	9.58						
5.5460	144.93			1.195	10.64						
5.5518	145.13	1.859	7.97	0.943	11.76						
5.5573	145.32	1.577	8.99	0.995	11.53						
5.5626	145.50			1.214	10.55						
5.5666	145.64			1.236	10.46						
5.5750	145.93			1.082	11.14						
5.5808	146.13			0.922	11.85						
5.5875	146.36			0.873	12.07						
5.5921	146.52	1.734	8.42	1.036	11.34						
5.5976	146.71			0.765	12.55						
5.6037	146.92	1.872	7.92	1.175	10.72						
5.6077	147.06			1.287	10.23						
5.6196	147.47	1.731	8.43	1.206	10.59						
5.6245	147.64	1.795	8.20	1.280	10.26						
5.6329	147.93			1.153	10.82						
5.6393	148.15	1.736	8.41	1.115	10.99						
5.6445	148.33	1.849	8.00	1.232	10.47						
5.6494	148.50			1.369	9.86						
5.6544	148.67	1.846	8.01	1.423	9.63						
5.6573	148.77	1.744	8.38	1.500	9.28						
5.6668	149.10			1.232	10.47						
5.6743	149.36	1.648	8.73	1.070	11.19						
5.6790	149.52	1.728	8.44	0.750	12.62						
5.6906	149.92			1.330	10.04						
5.6961	150.11	1.816	8.12	1.257	10.36						
5.7019	150.31	1.799	8.18	1.325	10.06						
5.7076	150.51	1.807	8.16	1.214	10.55						
5.7123	150.67	1.803	8.17	1.066	11.21						
5.7181	150.87	1.840	8.04	1.199	10.62						
5.7239	151.07			1.241	10.43						
5.7314	151.33	1.793	8.21	1.461	9.46						
5.7369	151.52	1.763	8.32	1.176	10.72						
5.7436	151.75	1.861	7.96	1.514	9.22						
5.7496	151.96			1.280	10.26						
5.7537	152.10			1.416	9.65						
5.7580	152.25	1.745	8.38	1.284	10.24						
5.7644	152.47	1.705	8.53	1.162	10.78						
5.7725	152.75	1.619	8.84	1.057	11.25						
5.7772	152.91			1.174	10.73						
5.7832	153.12	1.603	8.90	1.231	10.48						
5.7873	153.26	1.752	8.35	1.385	9.79						
5.7928	153.45			1.360	9.90						
5.7989	153.66	1.910	7.78	1.428	9.60						
5.8079	153.97	1.893	7.84	1.427	9.61	1.440	9.55				
5.8125	154.13			1.255	10.37	1.390	9.77				
5.8180	154.32			0.980	11.59						
5.8244	154.54	1.927	7.72	1.448	9.51						
5.8310	154.77	1.778	8.26	1.220	10.53						
5.8362	154.95			1.159	10.79						
5.8406	155.10	1.812	8.14	1.245	10.41						
5.8446	155.24	1.754	8.35	1.240	10.43	1.390	9.77				
5.8516	155.48	1.698	8.55	1.330	10.04	1.430	9.59				
5.8571	155.67			1.310	10.13	1.400	9.73				
5.8649	155.94			0.915	11.88	1.190	10.66				
5.8704	156.13	1.827	8.08	1.017	11.43						
5.8745	156.27	1.446	9.48	1.144	10.86						
5.8803	156.47	1.784	8.24	0.758	12.58						

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
5.8872	156.71	1.742	8.39	1.015	11.44						
5.8942	156.95	1.488	9.32	0.938	11.78						
5.8991	157.12	2.283	6.46	1.469	9.42						
5.9063	157.37	2.024	7.38	1.547	9.08						
5.9107	157.52	1.829	8.08	1.550	9.06						
5.9176	157.76	1.664	8.68	1.107	11.03						
5.9225	157.93			1.019	11.42	1.040	11.33				
5.9275	158.10			1.228	10.49	1.030	11.37				
5.9324	158.27	1.799	8.18	1.689	8.45						
5.9396	158.52	1.802	8.17								
5.9448	158.70	1.735	8.41	1.225	10.50						
5.9521	158.95	1.944	7.66	1.327	10.05						
5.9573	159.13	1.825	8.09	1.402	9.72						
5.9637	159.35	1.774	8.27	1.671	8.53						
5.9677	159.49	1.834	8.06	1.192	10.65						
5.9744	159.72	2.204	6.74	1.242	10.43						
5.9784	159.86	1.752	8.36	0.761	12.57						
5.9857	160.11	1.981	7.53	1.204	10.60						
5.9921	160.33	1.560	9.06	1.098	11.07						
5.9981	160.54	1.800	8.18	1.074	11.17						
6.0036	160.73	1.769	8.29	1.147	10.85						
6.0112	160.99	2.214	6.70	1.381	9.81						
6.0161	161.16	1.824	8.09	1.351	9.94						
6.0207	161.32	1.546	9.11	1.158	10.80						
6.0268	161.53	1.880	7.89	1.045	11.30						
6.0317	161.70	1.281	10.10	0.798	12.41						
6.0358	161.84	1.943	7.67		15.98						
6.0439	162.12	1.816	8.12	0.838	12.22						
6.0479	162.26	1.700	8.54	1.235	10.46						
6.0563	162.55	1.739	8.40		15.98						
6.0656	162.87	1.922	7.74	1.417	9.65						
6.0708	163.05			1.303	10.16						
6.0789	163.33	2.122	7.03	1.159	10.79						
6.0856	163.56	1.862	7.96	1.349	9.95						
6.0905	163.73	2.015	7.41	1.294	10.20						
6.0963	163.93	1.839	8.04	1.304	10.15						
6.1021	164.13	1.657	8.70		15.98						
6.1073	164.31	2.025	7.37	1.263	10.34						
6.1134	164.52	2.025	7.37		15.98						
6.1186	164.70	2.303	6.39		15.98						
6.1261	164.96	1.991	7.50	1.525	9.17						
6.1311	165.13	1.969	7.57	1.585	8.91						
6.1374	165.35	1.285	10.08	1.461	9.46						
6.1418	165.50	1.946	7.65		15.98						
6.1487	165.74	2.195	6.77	1.329	10.04						
6.1548	165.95	1.963	7.60	1.665	8.55						
6.1594	166.11	1.930	7.71	1.288	10.22						
6.1638	166.26	1.578	8.99	0.778	12.49						
6.1696	166.46	1.967	7.58	1.047	11.29						
6.1754	166.66	2.058	7.26		15.98						
6.1812	166.86	1.555	9.07	1.181	10.70						
6.1870	167.06	1.955	7.62								
6.1922	167.24	2.010	7.43	1.331	10.03						
6.1980	167.44	2.739	4.90	0.958	11.69						
6.2017	167.57	2.174	6.84	1.268	9.41						
6.2229	168.30	2.102	7.10	0.875	11.15						
6.2292	168.52	2.472	5.80	0.884	11.11						
6.2347	168.71	2.085	7.16	0.928	10.91						
6.2408	168.92	1.760	8.32	0.850	11.26						
6.2469	169.13	1.972	7.56	1.098	10.16						
6.2530	169.34	2.043	7.31	1.245	9.51						
6.2579	169.51	2.080	7.18	1.272	9.39						
6.2640	169.72	2.002	7.46	1.209	9.67						

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
6.2678	169.85			1.392	8.86						
6.2738	170.06			0.987	10.65						
6.2814	170.32	2.773	4.78	1.273	9.38						
6.2872	170.52			0.764	11.64						
6.2993	170.73			1.240	9.53						
6.3054	171.15	1.949	7.64	1.311	9.21						
6.3176	171.30	2.468	5.82	1.082	10.23						
6.3219	171.72			1.228	9.58						
6.3277	171.92	2.413	6.01	1.377	8.92						
6.3338	172.13	1.898	7.83	1.307	9.23						
6.3393	172.32	1.947	7.65								
6.3436	172.47	1.842	8.03	1.124	10.04						
6.3491	172.66	1.859	7.97	1.055	10.35						
6.3549	172.86	1.904	7.81	1.352	9.03						
6.3610	173.07	1.985	7.52	1.262	9.43						
6.3668	173.27	1.896	7.83	1.184	9.77						
6.3741	173.52	2.090	7.14	1.264	9.42						
6.3798	173.72	2.021	7.39	1.215	9.64						
6.3859	173.93	2.201	6.75	1.228	9.58						
6.3920	174.14	2.067	7.22	1.429	8.69						
6.3966	174.30	2.034	7.34	1.357	9.01						
6.4036	174.54	1.784	8.24	1.118	10.07						
6.4088	174.72	1.861	7.96	1.094	10.17						
6.4129	174.86	1.653	8.71	1.027	10.47						
6.4244	175.26	1.930	7.71	1.251	9.48						
6.4305	175.47	1.894	7.84	1.489	8.43						
6.4375	175.71	1.838	8.04	1.100	10.15						
6.4418	175.86	1.663	8.68	1.259	9.44						
6.4476	176.06	2.014	7.41	1.280	9.35						
6.4551	176.32	2.240	6.61	1.388	8.87						
6.4595	176.47			1.082	10.23						
6.4644	176.64	1.344	9.86	1.250	9.48						
6.4725	176.92			1.465	8.53						
6.4789	177.14	1.889	7.86	1.227	9.58						
6.4835	177.30	1.889	7.86	1.535	8.22						
6.4899	177.52	1.869	7.93	1.195	9.73						
6.4986	177.82	1.874	7.91	1.373	8.94						
6.5009	177.90	1.958	7.61	1.441	8.64						
6.5052	178.05	1.961	7.60	1.313	9.21						
6.5116	178.27	2.224	6.67	1.297	9.28						
6.5177	178.48	2.034	7.34	1.402	8.81						
6.5235	178.68	2.040	7.32	1.169	9.84						
7.0813	197.94	1.75	8.35							0.93	10.91
7.1273	199.53	1.77	8.29							1.13	10.02
7.1714	201.05									1.12	10.05
7.2258	202.93									1.15	9.92
7.3502	206.71	1.73	8.44							1.19	9.73
7.4021	208.26	2.04	7.33							1.07	10.30
7.4644	210.12	1.81	8.14							0.99	10.63
7.5180	211.72	1.72	8.46							1.08	10.25
7.5787	213.53	1.53	9.18							1.02	10.51
7.6383	215.31	1.68	8.63							0.65	12.17
7.6929	216.94	1.93	7.72							1.26	9.43
7.7458	218.52	1.68	8.61							1.42	8.71
7.7994	220.12	1.94	7.69							1.24	9.54
7.8510	221.66	1.91	7.78							1.61	7.91
7.9069	223.33	1.90	7.81							1.28	9.33
7.9585	224.87	1.93	7.71							1.25	9.46
8.0275	226.93	1.73	8.43							1.09	10.18
8.0808	228.52	1.86	7.96							1.32	9.18
8.1394	230.27	1.83	8.08							1.41	8.78
8.1943	231.91	1.84	8.05							1.34	9.08
8.2466	233.47	1.90	7.82							1.36	9.01

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
8.3002	235.07	1.83	8.09							1.07	10.28
9.6945	267.53	1.970	7.57	0.864	11.20			1.186	9.77	1.093	10.18
9.7053	267.72	1.879	7.90	0.729	11.80			0.547	12.61	1.561	8.11
9.7138	267.87	1.890	7.86	0.935	10.88			0.898	11.04	0.379	13.36
9.7291	268.14	1.898	7.83	1.712	7.44					1.428	8.70
9.7405	268.34			0.914	10.97			0.485	12.89	1.101	10.14
9.7479	268.47	1.462	9.42	0.865	11.19					1.217	9.63
9.7598	268.68	1.690	8.58	1.076	10.25			0.850	11.26	0.615	12.31
9.7701	268.86	1.377	9.74	0.774	11.60						
9.7885	269.28	1.636	8.78	0.865	11.19	0.776		0.450	13.04	0.890	11.08
9.7959	269.52	1.693	8.57	1.081	10.23	0.664		0.400	13.27	0.924	10.93
9.8030	269.75	2.118	7.04	1.450	8.60	1.307				0.274	13.83
9.8067	269.87	2.227	6.66	1.097	10.16	1.108		0.675	12.04	0.977	10.69
9.8153	270.15	1.459	9.43	1.425	8.71	0.887		0.716	11.85	0.423	13.16
9.8203	270.31	1.838	8.04	1.093	10.18	0.918		0.399	13.27		
9.8246	270.45	2.396	6.07	1.328	9.14	1.561		1.336	9.10	0.711	11.88
9.8329	270.72	2.394	6.08	1.363	8.98	1.231		0.700	11.93	1.404	8.80
9.8384	270.91	2.536	5.59	1.579	8.03			1.671	7.63		
9.8447	271.15	2.218	6.69	1.283	9.34			0.930	10.90	0.942	10.85
9.8498	271.34	1.994	7.48	1.315	9.20			0.706	11.90		
9.8535	271.48	2.308	6.37	1.134	10.00			0.754	11.69	1.436	8.66
9.8598	271.72	2.538	5.58	1.073	10.27			0.650	12.15	0.809	11.44
9.8657	271.94	2.189	6.79	1.262	9.43			0.730	11.79	1.199	9.71
9.8723	272.19	2.347	6.24	1.007	10.56			0.352	13.48	0.737	11.76
9.9658	275.72	1.661	8.69	0.505	12.80						
9.9870	276.52			0.641	12.19						
10.0011	277.05	1.555	9.08	0.716	11.85						
10.0194	277.74										
10.0337	278.28										
10.0496	278.88	1.583	8.97	0.887	11.09						
10.0668	279.53	1.607	8.88	1.076	10.25						
10.0806	280.05	1.586	8.96	1.098	10.16						
10.1036	280.92	1.893	7.84	0.998	10.60						
10.1837	283.94	1.858	7.97	0.688	11.98						
10.1998	284.55	1.302	10.02	0.720	11.84						
10.2141	285.09			0.800	11.48						
10.2311	285.73	1.694	8.57								
10.2616	286.88	1.708	8.51	0.902	11.03						
10.2785	287.52	1.901	7.82	0.979	10.68						
10.2934	288.08	1.876	7.91	1.101	10.14						
10.3098	288.70	1.748	8.37	1.170	9.84						
10.3267	289.34	1.959	7.61	1.107	10.12						
10.3424	289.93	1.820	8.11	1.065	10.30						
10.3577	290.51	1.691	8.57	1.009	10.55						
10.4266	293.11	1.898	7.83	0.830	11.35						
10.4425	293.71	1.727	8.45	1.061	10.32						
10.4584	294.31	1.742	8.39	0.941	10.85						
10.4741	294.90			1.149	9.93						
10.4908	295.53	1.705	8.53	0.843	11.29						
10.5061	296.11	1.848	8.01	1.192	9.74						
10.5279	296.93	1.929	7.72	1.141	9.97						
10.5430	297.50	1.775	8.27	0.874	11.15						
10.5583	298.08	1.687	8.59	1.055	10.35						
10.5748	298.70	1.799	8.18	0.809	11.44						
10.5928	299.38	1.844	8.02	1.013	10.53						
10.6810	302.71	1.801	8.18	0.802	11.47						
10.6964	303.29	1.871	7.93	1.038	10.42						
10.7028	303.91	1.756	8.34	1.107	10.12						
10.7277	304.47	1.752	8.35	0.905	11.01						
10.7507	305.34	1.306	10.00	0.723	11.82						
10.7563	305.55	1.459	9.43	0.872	11.16						
10.7605	305.71	1.860	7.96	0.887	11.09						
10.7664	305.93	1.782	8.25	1.120	10.06						

Age (Ma)	Depth (mbsf)	Ccp 18O	Ccp Temp°C	GrmS 18O	GrmS Temp°C	GrmD 18O	GrmD Temp°C	Ou 18O	Ou Temp°C	Ggb 18O	Ggb Temp°C
10.7711	306.11	1.640	8.76	0.880	11.12	0.800					
10.7754	306.27	1.510	9.24	0.832	11.34	0.982					
10.7825	306.54	1.901	7.82	1.173	9.82	1.180					
10.7881	306.75	1.890	7.86	1.143	9.96						
10.7910	306.86	1.828	8.08	0.990	10.64						
10.7968	307.08	1.463	9.42	0.711	11.88						
10.8027	307.30	1.753	8.35	0.683	12.00						
10.8077	307.49	1.543	9.12	1.011	10.54						
10.8133	307.70	1.732	8.43	1.035	10.44						
10.8193	307.93	1.769	8.29	0.870	11.17						
10.8249	308.14	1.708	8.51	1.142	9.96						
10.8292	308.30	1.674	8.64	0.558	12.56						
10.8352	308.53	1.842	8.03	0.909	11.00						
10.8400	308.71	1.860	7.96	0.951	10.81						
10.8474	308.99	1.654	8.71	0.812	11.43					0.919	10.95
10.8516	309.11	1.702	8.54	0.815	11.41					0.885	11.10
10.8543	309.28	1.613	8.86	0.880	11.12	0.945				0.601	12.37
10.8583	309.54	1.520	9.20	0.936	10.88	0.863				0.777	11.58
10.8615	309.74	1.570	9.02	0.725	11.81	0.822				0.763	11.65
10.9018	312.31	1.675	8.64	1.067	10.29	0.991		0.393	13.30		
10.9054	312.54	1.771	8.29	1.007	10.56	0.893		0.491	12.86	1.037	10.43
10.9075	312.67	1.921	7.74	1.034	10.44	1.141		0.758	11.67		
10.9106	312.87	1.591	8.94	0.871	11.16	0.931					
10.9138	313.07	1.675	8.64	0.833	11.33	0.814		0.298	13.72	0.770	11.61
10.9175	313.31	1.547	9.10	0.820	11.39	1.009				1.019	10.51
10.9210	313.53	1.936	7.69	1.049	10.37	1.129		0.810	11.44	1.128	10.02
10.9238	313.71			1.180	9.79						
10.9268	313.90	1.794	8.20	1.167	9.85					1.021	10.50
10.9298	314.09	1.982	7.53	0.735	11.77	1.084		0.062	14.78		
10.9329	314.29	1.287	10.07	0.923	10.93	0.671				0.701	11.92
10.9354	314.45	1.987	7.51	1.126	10.03					1.469	8.52
10.9392	314.69	1.747	8.37	1.598	7.95					0.728	11.80
10.9425	314.90	1.786	8.23	1.440	8.64	1.338		0.654	12.13	1.692	7.53
10.9461	315.13			2.124	5.64	1.463		0.955	10.79	1.386	8.88
10.9496	315.30	1.677	8.63	0.880	11.12			0.680	12.02	1.766	7.21
10.9569	315.52	1.907	7.79	1.750	7.28						
10.9631	315.71	1.680	8.62	1.035	10.44					0.760	11.66
10.9746	316.06			1.086	10.21			1.011	10.54	0.431	13.13
10.9815	316.27	1.979	7.54	1.849	6.84			0.696	11.94	1.117	10.07

Appendix C Table 5: DSDP Hole 593 isotopic data and palaeotemperature calculations for c. 330-427 mbsf. Gg woodi = *Globigerina woodi*, Cibs = *Cibicidoides wuellerstorfi, rugosa* and/ or *kullenbergi* - see Chapter 3 for details.

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
36/1/40	331.90	11.496	0.059	2.477	14.79	1.485	1.927	9.33
36/1/80	332.30	11.509	0.088	2.227	14.66			
36/1/101	332.51	11.516						
36/1/130	332.80	11.525	-0.332	2.071	16.56			
36/1/137	332.87	11.527						
36/2/18	333.18	11.538	0.271	2.415	13.84			
36/2/61	333.61	11.552	-0.605	2.028	17.79	1.217	1.877	10.34
36/2/80	333.80	11.558						
36/2/118	334.18	11.570	-0.393	2.289	16.83			
36/2/130	334.30	11.574	0.044	2.186	14.86			
36/2/143	334.43	11.579	0.376	1.994	13.37			
36/3/20	334.70	11.588	0.122	2.091	14.51			

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
36/3/61	335.11	11.601	0.329	1.913	13.58	1.640	1.752	8.76
36/3/80	335.30	11.607	-0.090	2.116	15.46			
36/3/118	335.68	11.620	0.022	2.198	14.96			
36/3/130	335.80	11.624	0.589	1.991	12.42			
36/3/148	335.98	11.630	0.009	2.101	15.02			
36/4/37	336.37	11.642	0.237	1.914	14.00			
36/4/80	336.80	11.657	0.291	1.911	13.75	1.559	1.636	9.06
37/1/40	341.50	11.813	0.300	2.108	13.71			
37/1/80	341.90	11.829				1.447	1.743	9.47
37/1/96	342.06	11.835	0.058	2.065	14.80	1.010	1.512	11.12
37/1/130	342.44	11.850	-0.083	1.982	15.43			
37/1/138	342.48	11.851	0.246	1.928	13.96			
37/2/20	342.80	11.863	0.014	1.619	15.00	1.457	1.604	9.44
37/2/58	343.18	11.878						
37/2/80	343.40	11.887						
37/2/118	343.78	11.901						
37/2/130	343.90	11.906	0.067	1.679	14.76			
37/2/148	344.08	11.913	0.091	1.712	14.65			
37/3/40	344.50	11.929	0.131	1.621	14.47	1.144	1.399	10.61
37/3/80	344.90	11.945	0.301	1.622	13.71			
37/3/98	345.08	11.952	-0.726	1.435	18.34			
37/3/130	345.40	11.964	0.224	1.715	14.05	1.231	1.348	10.28
37/3/139	345.49	11.968	-0.127	1.819	15.63			
37/3/143	345.53	11.969	-0.096	1.501	15.49			
37/4/40	346.00	11.987	-0.567	1.831	17.62			
37/4/80	346.48	12.006	-0.397	1.300	15.95	1.410	1.161	8.87
37/4/100	346.60	12.011	-0.236	1.954	15.22			
37/4/130	346.90	12.022	0.304	1.731	12.80	1.472	1.484	8.65
37/4/139	346.99	12.026	0.048	1.845	13.95			
37/5/21	347.31	12.038	0.118	1.801	13.63	1.457	1.319	8.70
38/1/20	350.90	12.177	-0.013	1.456	14.22			
38/1/40	351.10	12.185	-0.213	1.327	15.12			
38/1/58	351.28	12.192	0.060	1.411	13.89			
38/1/80	351.50	12.200	-0.436	1.166	16.12			
38/1/100	351.70	12.208	-0.296	1.405	15.49			
38/1/119	351.89	12.215	-0.242	1.359	15.25			
38/1/130	352.00	12.220						
38/1/138	352.08	12.223						
38/1/148	352.18	12.227	-0.839	1.045	17.94			
38/2/20	352.40	12.235				1.600	1.231	8.18
38/2/40	352.60	12.243	0.176	1.498	13.37			
38/2/60	352.80	12.251				1.560	1.282	8.33
38/2/80	353.00	12.258	-0.192	1.400	15.02			
38/2/100	353.20	12.266						
38/2/120	353.40	12.274	-0.078	1.685	14.51			
38/2/130	353.50	12.278						
38/2/138	353.58	12.281	-0.465	1.736	16.25			
38/2/148	353.68	12.285	0.014	1.910	14.10			
38/3/21	353.91	12.294	-0.208	1.809	15.10	1.144	1.391	9.86
38/3/40	354.11	12.301	-0.875	2.021	18.11			
38/3/61	354.31	12.309	0.091	1.605	13.75			
38/3/80	354.50	12.316	-0.208	1.648	15.10	1.612	1.189	8.14
38/3/101	354.71	12.325	-0.039	1.947	14.34			
38/3/120	354.80	12.328	-0.016	1.492	14.23			
38/3/130	354.90	12.332	-0.317	1.526	15.59	1.047	1.038	10.22
38/3/135	354.95	12.334	-0.516	2.150	16.48			
38/3/143	355.03	12.337						
38/4/21	355.41	12.352	0.277	1.503	12.92	1.617	1.526	8.12
38/4/40	355.60	12.359	-0.474	1.652	16.29			
38/4/60	355.80	12.367	0.163	1.680	13.43			
38/4/80	356.00	12.374	-0.069	1.670	14.47	1.258	1.197	9.43
38/4/100	356.20	12.382	-0.172	1.892	14.93			
38/4/120	356.40	12.390	0.228	1.974	13.14			

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
38/4/130	356.50	12.394	0.086	1.808	13.78	1.438	1.424	8.77
38/4/138	356.58	12.397	0.284	1.336	12.89			
38/4/148	356.68	12.401	0.367	1.556	12.52			
38/5/21	356.91	12.410	0.692	1.792	11.07	1.140	1.372	9.87
38/5/37	357.07	12.416	-0.090	1.735	14.57			
38/5/60	357.30	12.425	0.582	2.018	11.56			
38/5/80	357.50	12.433	-0.314	1.663	15.57	1.159	1.302	9.80
38/5/100	357.70	12.440	-0.378	1.723	15.86			
38/5/120	357.90	12.448	-0.386	1.701	15.90			
38/5/130	358.00	12.452	-0.272	1.914	15.38	1.526	1.375	8.45
38/5/138	358.08	12.455	-0.123	2.037	14.71			
38/5/148	358.18	12.459	-0.016	2.025	14.23			
38/6/16	358.36	12.466	-0.657	1.854	17.12	1.253	1.44	9.45
38/6/37	358.57	12.474	0.043	1.555	13.97			
38/6/60	358.80	12.483	0.257	2.091	13.01			
38/6/80	359.00	12.491	0.037	2.181	14.00	0.869	1.155	10.90
38/6/100	359.20	12.498	-0.710	2.282	17.36			
38/6/118	359.38	12.505	-0.347	1.814	15.72			
38/6/130	359.50	12.510	0.030	1.758	14.03	1.583	1.465	8.24
38/6/138	359.58	12.513	0.018	2.065	14.08			
38/6/148	359.68	12.517	0.151	2.151	13.48			
38/7/20	359.90	12.525	-0.072	1.791	14.48	1.061	1.695	10.17
39/1/20	360.50	12.549	0.307	2.028	12.79	1.134	1.604	9.90
39/1/40	360.70	12.556	-0.015	2.197	14.23	1.542	1.648	8.39
39/1/61	360.91	12.565	0.137	1.942	13.55	1.578	1.563	8.26
39/1/80	361.10	12.572	-0.235	1.923	15.22	1.446	1.629	8.74
39/1/101	361.31	12.580	0.113	2.203	13.66	1.598	1.505	8.19
39/1/118	361.48	12.587	-0.184	2.186	14.99	1.076	1.387	10.11
39/1/130	361.60	12.591	-0.063	2.265	14.44	1.285	1.500	9.33
39/1/138	361.68	12.594	0.058	2.254	13.90	1.331	1.630	9.16
39/1/148	361.78	12.598	-0.085	1.748	14.54	1.368	1.305	9.03
39/2/20	362.00	12.607	-0.747	2.049	17.53	1.578	1.465	8.26
39/2/40	362.20	12.614	-0.152	1.892	14.84	1.373	1.640	9.01
39/2/61	362.41	12.623	-0.033	2.005	14.31	1.189	1.637	9.69
39/2/80	362.60	12.630	-0.160	1.429	14.88	1.231	1.406	9.53
39/2/101	362.81	12.638	-0.180	1.568	14.97	1.313	1.597	9.23
39/2/120	363.00	12.645	0.120	2.162	13.62	1.456	1.337	8.70
39/2/130	363.10	12.649	0.044	2.080	13.96	1.285	1.578	9.33
39/2/138	363.18	12.652	0.025	2.109	14.05	1.392	1.606	8.94
39/2/148	363.28	12.656	-0.06	1.957	14.43	1.148	1.527	9.84
39/3/20	363.50	12.665	0.059	1.966	13.90	1.326	1.544	9.18
39/3/40	363.70	12.673	-0.132	2.080	14.75	1.426	1.336	8.81
39/3/60	363.90	12.680	0.000	1.983	14.16	1.415	1.478	8.85
39/3/80	364.10	12.688	0.075	2.216	13.83	1.580	1.696	8.25
39/3/96	364.26	12.694	-0.913	2.430	18.28	1.703	1.706	7.81
39/3/120	364.50	12.703	0.157	2.198	13.46	1.362	1.673	9.05
39/3/130	364.60	12.707	0.025	2.536	14.05	1.401	1.524	8.91
39/3/138	364.68	12.710	-0.024	2.159	14.27	1.290	1.824	9.32
39/3/143	364.73	12.712	0.165	1.915	13.42	1.588	1.538	8.22
39/3/148	364.78	12.714	0.045	2.225	13.96	1.500	1.683	8.54
39/4/20	365.00	12.723	0.128	1.482	13.59	1.397	1.499	8.92
39/4/40	365.20	12.731	-0.025	1.853	14.27	1.313	1.711	9.23
39/4/59	365.39	12.738	0.302	1.717	12.81	1.616	1.492	8.12
39/4/80	365.60	12.746	0.242	1.871	13.08	1.490	1.702	8.58
39/4/100	365.80	12.754	0.135	1.903	13.56	1.619	1.113	8.11
39/4/118	365.98	12.761	-0.027	1.808	14.28	1.084	1.373	10.08
39/4/130	366.10	12.765	0.040	1.752	13.98	1.235	1.214	9.52
39/4/138	366.18	12.769	-0.043	1.634	14.35	1.075	1.536	10.12
39/4/148	366.28	12.772	0.237	1.843	13.10			
39/5/20	366.50	12.781	0.343	2.025	12.63	0.557	1.483	12.10
39/5/40	366.70	12.789	-0.031	2.074	14.30			
39/5/60	366.90	12.796	-0.089	2.172	14.56	0.992	1.604	10.43
39/5/80	367.10	12.804	0.153	2.062	13.48			

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
39/5/100	367.30	12.812	0.129	2.007	13.58	0.986	0.972	10.45
39/5/120	367.50	12.820	-0.300	2.346	15.51	1.301	1.799	9.27
39/5/130	367.60	12.823	-0.076	2.078	14.50	1.249	1.611	9.47
39/5/138	367.68	12.827	-0.199	2.313	15.06	1.681	1.646	7.89
39/5/148	367.78	12.830	-0.515	2.220	16.48	1.262	1.499	9.42
39/6/20	368.00	12.839	0.152	2.399	13.48	1.396	1.713	8.92
39/6/40	368.20	12.847	0.057	2.314	13.91	1.619	1.569	8.11
39/6/60	368.40	12.854	0.112	1.952	13.66	1.143	1.622	9.86
39/6/80	368.60	12.862	0.110	2.310	13.67	1.220	1.780	9.57
39/6/100	368.80	12.870	-0.646	2.314	17.07	1.630	1.663	8.07
39/6/119	368.99	12.877	0.276	2.509	12.93			
40/1/20	370.10	12.920	0.220	2.363	13.18	1.668	1.476	7.93
40/1/40	370.30	12.928	0.183	2.264	13.34	1.542	2.002	8.39
40/1/60	370.50	12.936	0.133	2.656	13.57	1.513	1.987	8.50
40/1/80	370.70	12.943	-0.011	2.291	14.21	1.565	1.880	8.31
40/1/102	370.92	12.952	0.439	1.877	12.20	1.180	1.911	9.72
40/1/119	371.09	12.959	0.122	2.511	13.61	1.588	2.023	8.22
40/1/130	371.20	12.963	0.371	1.780	12.50	1.366	2.019	9.03
40/1/138	371.28	12.966	-0.269	2.270	15.37	1.468	1.910	8.66
40/1/148	371.38	12.970	0.138	2.599	13.54			
40/2/21	371.61	12.979	0.186	2.232	13.33	1.599	1.928	8.18
40/2/40	371.81	12.986	-0.044	2.314	14.36	1.551	1.692	8.36
40/2/60	372.01	12.994	0.101	2.149	13.71			
40/2/80	372.21	13.005	-0.104	2.123	14.63	1.458	1.901	8.70
40/2/100	372.41	13.024	-0.387	1.955	15.90			
40/2/118	372.59	13.042	-0.178	2.035	14.96			
40/2/130	372.71	13.053	0.120	1.790	13.62	1.327	1.669	9.18
40/2/138	372.79	13.061	-0.346	2.228	15.72	1.410	1.645	8.87
40/2/148	372.89	13.071	-0.365	2.120	15.80	1.656	1.652	7.98
40/3/16	373.06	13.087	-0.402	2.061	15.97	1.681	1.865	7.89
40/3/40	373.30	13.110	-0.283	2.171	15.43			
40/3/60	373.50	13.129	0.205	2.031	13.24	1.529	1.706	8.44
40/3/80	373.70	13.149	0.122	1.967	13.61			
40/3/101	373.91	13.169	0.194	2.047	13.29	1.504	1.763	8.53
40/3/119	374.09	13.186	-0.310	1.841	15.55	1.491	1.344	8.58
40/3/130	374.20	13.197	-0.094	1.932	14.58	1.166	1.666	9.78
40/3/136	374.26	13.203	0.087	1.581	13.77	1.448	1.691	8.73
40/3/143	374.33	13.210	0.162	1.849	13.44	1.623	1.721	8.10
40/4/17	374.52	13.228	-0.113	1.837	14.67	1.491	1.464	8.58
40/4/40	374.75	13.250	-0.104	1.946	14.63	1.466	1.665	8.67
40/4/58	374.93	13.268	0.059	2.140	13.90	1.356	1.797	9.07
40/4/80	375.15	13.289	-0.217	1.876	15.14	1.395	1.675	8.93
40/4/100	375.35	13.308	-0.923	1.815	18.32	1.406	1.613	8.89
40/4/120	375.55	13.327	-0.134	1.910	14.76	1.296	1.546	9.29
40/4/130	375.65	13.337	-0.211	1.892	15.11	1.372	1.683	9.01
40/4/138	375.73	13.345	0.096	1.798	13.73	1.623	1.597	8.10
40/4/148	375.83	13.355	-0.206	1.742	15.09	1.094	1.247	10.05
40/5/16	376.01	13.372	-0.497	1.631	16.40	1.674	1.704	7.91
40/5/40	376.25	13.395	0.251	1.728	13.04	1.296	1.730	9.29
40/5/60	376.45	13.414	0.874	1.736	10.26	1.637	1.775	8.05
40/5/80	376.65	13.434	-0.306	1.760	15.54	1.371	1.809	9.02
40/5/100	376.85	13.453	-0.025	1.472	14.27	1.474	1.516	8.64
40/5/119	377.04	13.471	0.024	1.801	14.05	1.571	1.792	8.29
40/5/130	377.15	13.482	0.026	1.764	14.04	1.306	1.835	9.26
40/5/137	377.22	13.489	-0.140	1.772	14.79	1.185	1.510	9.71
40/5/148	377.33	13.499	-0.526	1.603	16.53	1.340	1.702	9.13
40/6/10	377.45	13.511	-0.571	1.797	16.73	1.368	1.888	9.03
41/1/20	379.70	13.728				0.881	1.946	10.85
41/1/40	379.90	13.748				1.111	1.859	9.98
41/1/60	380.10	13.767						
41/1/80	380.30	13.786				1.046	1.807	10.23
41/1/101	380.51	13.807	-0.072	1.856	14.48	1.171	1.548	9.76
41/1/119	380.69	13.824						

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
41/1/130	380.80	13.835	-0.623	1.845	16.97	0.400	1.865	12.71
41/1/137	380.87	13.841	-0.079	2.027	14.52	1.056	2.008	10.19
41/1/148	380.98	13.852	-0.828	1.855	17.89	1.455	1.756	8.71
41/2/18	381.18	13.871	0.105	1.878	13.69	1.447	1.596	8.74
41/2/40	381.40	13.893	-0.247	1.803	15.27	1.400	1.634	8.91
41/2/58	381.58	13.910	-0.197	1.899	15.05	1.156	1.753	9.81
41/2/80	381.80	13.931	-0.218	2.004	15.14	1.233	1.675	9.53
41/2/100	382.00	13.951	-0.071	1.914	14.48	0.839	1.773	11.01
41/2/121	382.21	13.971	0.205	1.849	13.24			
41/2/130	382.30	13.979	0.048	1.810	13.95	1.346	1.725	9.11
41/2/137	382.37	13.986	-0.198	2.017	15.05	1.168	1.506	9.77
41/2/146	382.46	13.995	0.145	1.952	13.51	1.198	1.855	9.66
41/3/19	382.69	14.017	0.092	2.226	13.75	1.217	1.842	9.59
41/3/40	382.90	14.037	-0.143	2.103	14.80	1.108	1.879	9.99
41/3/61	383.10	14.057	0.251	2.055	13.04	1.015	1.756	10.34
41/3/80	383.30	14.076	0.169	2.045	13.40	1.049	1.720	10.21
41/3/97	383.47	14.093	0.134	1.959	13.56	1.321	1.580	9.20
41/3/120	383.70	14.115				1.381	1.760	8.98
41/3/130	383.80	14.124	-0.515	1.925	16.48	1.096	1.773	10.04
41/3/141	383.91	14.135	0.116	1.926	13.64	1.278	1.692	9.36
41/3/142	383.92	14.136	-0.068	1.973	14.47	1.121	1.745	9.94
41/4/20	384.20	14.163	0.197	1.960	13.28	1.218	1.937	9.58
41/4/40	384.40	14.182	-0.211	1.776	15.11	1.327	1.905	9.18
41/4/60	384.60	14.202	-0.091	1.800	14.57	1.266	1.942	9.40
41/4/80	384.80	14.221	-0.013	1.798	14.22	1.454	1.934	8.71
41/4/100	385.00	14.240	-0.077	1.892	14.51	1.445	1.926	8.74
41/4/119	385.19	14.259	-0.045	1.825	14.36	0.946	1.800	10.60
41/4/130	385.30	14.269	0.224	1.846	13.16	1.120	1.976	9.95
41/4/138	385.38	14.277	0.242	1.835	13.08	1.202	1.888	9.64
41/4/148	385.48	14.287	-0.007	1.840	14.19	1.201	1.908	9.65
41/5/21	385.71	14.309	0.097	1.749	13.73	1.254	1.836	9.45
41/5/38	385.88	14.325	-0.76	1.839	17.59	1.006	1.764	10.38
41/5/60	386.10	14.347	0.147	1.887	13.50	1.130	1.851	9.91
41/5/80	386.30	14.366	-0.004	1.748	14.18	1.088	1.789	10.07
41/5/100	386.50	14.385	0.136	1.938	13.55	1.485	1.941	8.60
41/5/119	386.69	14.404	-0.071	2.154	14.48	1.466	2.080	8.67
41/5/130	386.80	14.414	0.472	2.424	12.05	1.139	1.995	9.88
41/5/138	386.88	14.422	0.061	2.655	13.89	1.158	2.030	9.81
41/5/148	386.98	14.432	-0.159	1.898	14.88	1.358	1.957	9.06
41/6/22	387.22	14.455	0.243	1.893	13.07	1.307	1.706	9.25
41/6/39	387.39	14.471	0.100	1.878	13.71	1.267	1.810	9.40
41/6/60	387.60	14.491	0.134	2.035	13.56	0.805	1.603	11.14
41/6/80	387.80	14.511	-0.640	2.206	17.04			
41/6/100	388.00	14.530	0.251	2.747	13.04	1.249	2.107	9.47
41/6/120	388.20	14.549	0.258	2.664	13.01	1.183	2.092	9.71
41/6/130	388.30	14.559	0.194	2.676	13.29	1.138	1.996	9.88
41/6/137	388.37	14.566	0.425	2.770	12.26	1.018	2.157	10.33
41/6/148	388.48	14.576	0.301	2.672	12.81	0.964	2.215	10.54
41/7/17	388.67	14.595	0.369	2.803	12.51	1.294	2.022	9.30
41/7/40	388.90	14.617	0.195	2.952	13.29	1.052	2.150	10.20
42/1/10A	389.20	14.646	0.506	2.966	11.90	1.333	2.267	9.16
42/1/10B	389.20	14.646	0.202	3.143	13.26	1.317	2.338	9.22
42/1/21	389.31	14.657	0.452	3.009	12.14	1.280	2.470	9.35
42/1/29	389.39	14.664	0.479	2.887	12.02	1.347	2.508	9.10
42/1/40	389.50	14.675				1.364	2.331	9.04
42/1/50	389.60	14.685	-0.089	1.962	14.56	1.083	2.094	10.09
42/1/59	389.69	14.693				1.392	2.228	8.94
42/1/67	389.77	14.701	0.277	2.997	12.92	1.307	2.137	9.25
42/1/80	389.90	14.714	0.271	2.803	12.95	1.027	2.133	10.30
42/1/90	390.00	14.723	0.352	2.749	12.59	0.943	1.822	10.62
42/1/100	390.10	14.733	0.383	3.027	12.45	0.948	2.005	10.60
42/1/110	390.20	14.743	0.264	2.712	12.98	1.001	2.122	10.40
42/1/120	390.30	14.752	0.275	2.998	12.93	0.877	1.953	10.87

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
42/1/127	390.37	14.759	0.242	2.775	13.08	0.462	1.575	12.47
42/1/130	390.40	14.762	0.250	2.956	13.04	1.003	1.868	10.39
42/1/138	390.48	14.770	0.101	2.594	13.71	0.986	2.075	10.45
42/1/148	390.58	14.779	0.278	2.685	12.92	0.764	1.713	11.30
42/2/04	390.64	14.785	0.243	3.031	13.07	0.783	1.930	11.22
42/2/10	390.70	14.791	0.130	2.888	13.58			
42/2/16	390.76	14.797	0.333	3.742	12.67	0.494	1.833	12.34
42/2/28	390.88	14.808	0.065	3.379	13.87	0.855	1.783	10.95
42/2/37	390.97	14.817	-0.032	2.674	14.31	0.488	1.58	12.37
42/2/46	391.08	14.828	-0.111	2.773	14.66	0.918	1.894	10.71
42/2/61	391.21	14.840	0.020	3.187	14.07	0.610	1.88	11.89
42/2/68	391.28	14.847	0.377	2.912	12.47	0.602	1.96	11.92
42/2/80	391.14	14.833	0.058	3.134	13.90	0.955	1.988	10.57
42/2/88	391.48	14.866	-0.078	2.670	14.51	0.969	2.055	10.52
42/2/98	391.58	14.876	0.182	2.643	13.35	0.954	2.084	10.57
42/2/106	391.66	14.884				0.917	2.088	10.71
42/2/116	391.76	14.893	0.093	2.932	13.74	1.038	1.984	10.26
42/2/129	391.89	14.906	0.141	3.022	13.53	0.780	2.079	11.24
42/2/130	391.90	14.907	0.033	2.882	14.01	1.048	2.200	10.22
42/2/137	391.97	14.914	0.133	2.993	13.57	1.090	2.114	10.06
42/2/148	392.08	14.924	0.147	2.721	13.50	0.844	2.113	10.99
42/3/06	392.16	14.932	0.214	2.950	13.20	1.040	2.107	10.25
42/3/10	392.20	14.936	-0.044	2.547	14.36	0.940	2.021	10.63
42/3/16	392.26	14.942	0.185	2.359	13.33	0.944	1.692	10.61
42/3/29	392.39	14.954	0.090	2.718	13.76	0.866	2.059	10.91
42/3/39	392.49	14.964	0.046	2.426	13.96	1.138	1.963	9.88
42/3/49	392.59	14.973	0.050	2.722	13.94	1.035	2.037	10.27
42/3/61	392.71	14.985				1.083	2.062	10.09
42/3/70	392.80	14.994	0.175	2.885	13.38	1.084	2.027	10.08
42/3/80	392.90	15.003	0.284	2.802	12.89	0.728	2.100	11.44
42/3/89	392.99	15.012	0.039	2.781	13.99	0.728	2.020	11.44
42/3/99	393.09	15.022	-0.062	2.593	14.44	0.899	2.041	10.78
42/3/107	393.17	15.029	-0.127	2.737	14.73	1.044	2.025	10.23
42/3/118	393.28	15.040	0.336	2.638	12.66	0.975	2.033	10.49
42/3/128	393.38	15.050	0.116	2.803	13.64	0.925	1.981	10.68
42/3/130	393.40	15.052	0.068	2.685	13.86	0.677	1.845	11.63
42/3/136	393.46	15.057	-0.099	2.758	14.61	1.058	2.248	10.18
42/3/142	393.52	15.063	0.064	2.902	13.87	0.945	2.130	10.61
42/4/03	393.63	15.074						
42/4/10	393.70	15.081	-0.734	2.790	17.47	0.532	1.699	12.20
42/4/12	393.72	15.083	-0.210	2.728	15.10			
42/4/17	393.77	15.087	0.026	2.709	14.04	0.935	2.214	10.65
42/4/26	393.86	15.096	-0.315	2.919	15.58	0.408	2.232	12.68
42/4/36	393.96	15.181	0.036	2.810	14.00	0.920	2.131	10.70
42/4/49	394.09	15.355	0.106	2.727	13.69	0.940	1.997	10.63
42/4/59	394.19	15.490	-0.127	2.650	14.73	0.587	1.869	11.98
42/4/71	394.31	15.651	-0.018	2.848	14.24			
42/4/80	394.40	15.772	-0.140	2.853	14.79	1.136	1.934	9.89
42/4/88	394.48	15.879	0.182	2.856	13.35	0.999	2.060	10.40
42/4/97	394.57	16.000	0.111	2.805	12.77	0.907	2.019	10.75
42/4/107	394.67	16.059	-0.248	2.777	14.38	0.780	2.249	11.24
42/4/121	394.81	16.141	0.004	2.649	13.25	0.921	2.260	10.70
42/4/128	394.88	16.182	0.113	2.656	12.76	0.954	2.285	10.57
42/4/130	394.90	16.194				0.916	2.101	10.72
42/4/139	394.99	16.247	0.087	3.005	12.88	0.598	2.230	11.94
42/4/148	395.08	16.300	0.105	2.953	12.80	0.630	2.383	11.81
42/5/10	395.20	16.313	0.098	2.959	12.83	-0.1990	2.664	15.11
42/5/11	395.21	16.315	-0.130	3.092	13.85	0.901	2.354	10.77
42/5/17	395.27	16.321	-0.128	2.990	13.84	0.829	2.621	11.05
42/5/28	395.38	16.334	0.221	3.073	12.28	0.879	2.560	10.86
42/5/37	395.47	16.344	0.268	3.142	12.07	0.844	2.470	10.99
42/5/47	395.57	16.355	0.076	3.134	12.93	0.821	2.763	11.08
42/5/56	395.66	16.365	0.418	3.235	11.40	0.953	2.772	10.58

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
42/5/72	395.82	16.383	0.184	3.096	12.44	0.505	2.389	12.30
42/5/80	395.90	16.392	0.258	2.894	12.11	0.718	2.430	11.47
42/5/90	396.00	16.403	0.249	3.089	12.15	0.991	2.664	10.43
42/5/98	396.08	16.412	0.136	2.927	12.66	0.931	2.501	10.66
42/5/107	396.17	16.422	0.131	2.819	12.68	0.841	2.206	11.00
42/5/118	396.28	16.435	0.074	2.680	12.93	0.639	2.530	11.78
42/5/128	396.38	16.446	-0.242	2.685	14.35	0.601	2.044	11.93
42/5/130	396.40	16.448	-0.063	2.568	13.55	0.498	1.980	12.33
42/5/138	396.48	16.457	-0.310	2.512	14.66			
42/5/148	396.58	16.469	-0.144	2.935	13.91	0.873	2.147	10.88
42/6/10	396.70	16.482	-0.492	2.966	15.47	-0.1810	2.085	15.04
42/6/17	396.77	16.490	-0.175	2.885	14.05	0.3090	2.330	13.07
42/6/40	397.00	16.516	-0.386	2.867	15.00			
42/6/58	397.18	16.536	-0.269	2.602	14.47	0.6060	2.137	11.91
42/6/60	397.20	16.538	-0.22	2.54	14.25	0.7	2.211	11.54
42/6/78	397.38	16.558	-0.77	2.1	16.73	0.42	1.871	12.63
42/cc/12	397.52	16.574	-0.78	2.12	16.77	0.56	1.521	12.09
43/1/00	398.70	16.707	-0.13	2.37	13.85	0.66	1.761	11.70
43/1/20	398.90	16.729	-0.19	2.03	14.12	0.92	2.211	10.70
43/1/40	399.10	16.752	-0.65	1.77	16.19	0.54	1.771	12.16
43/1/60	399.30	16.774	-0.1	1.75	13.71	0.45	1.421	12.52
43/1/80	399.50	16.797				0.48	1.641	12.40
43/1/100	399.70	16.819	-0.44	1.95	15.24	0.28	1.661	13.19
43/1/120	399.90	16.842				0.34	1.621	12.95
43/1/140	400.10	16.864	-0.08	2.14	13.62	0.62	1.561	11.85
43/2/10	400.30	16.887	-0.21	1.52	14.21	0.42	1.801	12.63
43/2/30	400.50	16.909	-0.75	1.84	16.64	0.57	1.801	12.05
43/2/50	400.70	16.931	-0.89	1.87	17.27	0.56	1.541	12.09
43/2/70	400.90	16.954	-0.78	2	16.77	0.38	1.581	12.79
43/2/90	401.10	16.976	-0.95	2.05	17.54	0.1	1.531	13.90
43/2/110	401.30	16.999	-0.98	1.76	17.68	-0.12	1.471	14.79
43/2/130	401.50	17.021	-1.01	1.82	17.81	0.14	1.471	13.74
43/3/00	401.70	17.044	-0.22	1.87	14.25	0.35	1.471	12.91
43/3/21	401.91	17.067				0.47	1.691	12.44
43/3/38	402.08	17.087				0.54	1.771	12.16
43/3/57	402.27	17.108	-0.52	1.86	15.60			
43/3/77	402.47	17.130	-0.29	2.16	14.57	0.08	1.331	13.98
43/3/102	402.72	17.158	-0.01	2.12	13.31	0.72	1.231	11.47
43/3/117	402.87	17.175	0.34	2.65	11.75	0.42	1.831	12.63
43/3/141	403.11	17.202				0.35	1.611	12.91
43/4/12	403.32	17.226	-1.08	2.51	18.13	0.36	2.071	12.87
43/4/30	403.50	17.246				0.1	1.931	13.90
43/4/48	403.68	17.266	-0.24	2.5	14.34	0.2	1.951	13.50
43/4/68	403.88	17.289	-0.14	2.54	13.89	0.3	1.991	13.11
43/4/90	404.10	17.313	0.09	2.59	12.86	0.16	1.931	13.66
43/4/110	404.30	17.336	0.04	2.81	13.09	0.35	2.131	12.91
43/4/132	404.52	17.361	-0.24	2.48	14.34	0.25	1.781	13.30
43/5/00	404.70	17.381	-0.75	2.34	16.64	0.23	1.571	13.38
43/5/22	404.92	17.406	-0.31	1.47	14.66	1.07	2.131	10.14
43/5/38	405.08	17.424	-0.17	2.03	14.03	0.24	1.671	13.34
43/5/61	405.31	17.449						
43/5/82	405.52	17.473	-0.44	1.88	15.24	0.22	1.411	13.42
43/5/102	405.72	17.496	-0.57	2.1	15.82	0.3	1.641	13.11
43/5/118	405.88	17.513				0.54	1.691	12.16
43/5/140	406.10	17.538	-0.11	2	13.76	0.57	1.601	12.05
43/6/12	406.32	17.563	-0.59	1.95	15.91			
43/6/32	406.52	17.585	0.06	1.33	13.00	0.75	1.821	11.35
43/6/47	406.67	17.601	0.01	2.03	13.22	0.42	1.691	12.63
43/6/70	406.90	17.618	0.06	1.33	13.00	0.27	1.491	13.23
43/6/91	407.11	17.633	-0.63	1.65	16.10	0.4	1.431	12.71
43/6/112	407.32	17.648	-0.76	1.87	16.68	0.76	1.621	11.31
43/6/132	407.52	17.663				0.73	1.641	11.43
43/cc/08	407.70	17.676	-0.07	1.89	13.58	0.69	1.691	11.58

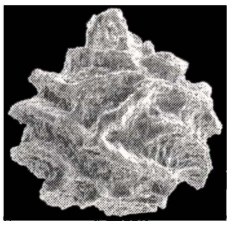
DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	'Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
44/1/00	408.30	17.719	0.09	1.84	12.86	0.63	1.731	11.81
44/1/22	408.52	17.735	-0.28	1.85	14.52	0.84	1.891	11.01
44/1/40	408.70	17.748				0.51	1.921	12.28
44/1/58	408.88	17.761	-0.56	1.85	15.78	0.9	1.851	10.78
44/1/78	409.08	17.775				0.85	1.831	10.97
44/1/100	409.30	17.791	-0.04	2.01	13.44	0.86	1.731	10.93
44/1/121	409.51	17.806	-0.42	2.16	15.15	0.62	1.601	11.85
44/1/137	409.67	17.817	-0.58	1.98	15.87	0.87	1.531	10.89
44/2/12	409.92	17.835	0.21	1.64	12.33	0.71	1.871	11.51
44/2/30	410.10	17.848	-0.06	1.61	13.53	1.03	1.431	10.29
44/2/50	410.30	17.863				1.49	1.991	8.58
44/2/71	410.51	17.878	-0.28	1.98	14.52	1.03	1.891	10.29
44/2/88	410.68	17.890				0.95	1.951	10.59
44/2/110	410.90	17.906	-0.06	2.05	13.53	0.84	1.801	11.01
44/2/131	411.11	17.921	-0.66	1.93	16.23	0.76	1.901	11.31
44/3/00	411.30	17.935	0.05	2.01	13.04	0.67	1.681	11.66
44/3/22	411.52	17.951	0.05	2.05	13.04	0.42	1.691	12.63
44/3/40	411.70	17.963				0.95	1.921	10.59
44/3/61	411.91	17.979				1.01	2.021	10.36
44/3/83	412.13	17.994	-0.3	2.09	14.61	1.08	1.651	10.10
44/3/103	412.33	18.009				0.79	1.981	11.20
44/3/118	412.48	18.020	-0.03	2.07	13.40	0.96	1.951	10.55
44/3/137	412.67	18.033	0.02	1.88	13.18	0.94	1.841	10.63
44/4/10	412.90	18.050	-0.7	1.32	16.41	0.56	1.721	12.09
44/4/30	413.10	18.064	-0.06	1.61	13.53	0.31	1.501	13.07
44/4/50	413.30	18.079	-0.3	1.72	14.61	0.85	1.811	10.97
44/4/68	413.48	18.092				0.64	1.711	11.78
44/4/92	413.72	18.109				0.85	1.711	10.97
44/4/111	413.90	18.122				0.54	1.461	12.16
44/4/130	414.09	18.136	-0.2	2.15	14.16	0.51	1.401	12.28
44/5/00	414.30	18.151	-0.28	1.84	14.52	0.73	1.631	11.43
44/5/20	414.50	18.165	-0.8	1.12	16.86	0.66	1.511	11.70
44/5/38	414.68	18.178	-0.18	1.84	14.07	0.66	1.401	11.70
44/5/60	414.90	18.194	-0.46	1.86	15.33	0.49	1.411	12.36
44/5/80	415.10	18.208				0.83	1.541	11.05
44/5/97	415.27	18.220	0.24	2.08	12.19	0.83	1.541	11.05
44/5/117	415.47	18.235	0.06	2.09	13.00	0.79	1.521	11.20
44/5/141	415.71	18.252				1.25	1.631	9.46
44/6/08	415.88	18.264	0.03	2.01	13.13	1.13	1.491	9.91
44/6/27	416.07	18.278	-0.01	1.88	13.31	0.87	1.451	10.89
44/6/48	416.28	18.293	-0.24	1.62	14.34	0.5	1.371	12.32
44/6/70	416.50	18.309	-0.33	1.77	14.75			
44/6/90	416.70	18.323	0.11	1.55	12.77	0.92	1.531	10.70
44/cc/14	417.18	18.358	0.31	1.93	11.88	1.18	1.451	9.72
45/1/10	418.00	18.417	-0.1	1.8	13.71	1.1	1.581	10.02
45/1/30	418.20	18.431	-0.03	1.18	13.40	1.29	1.611	9.32
45/1/50	418.40	18.446	-0.17	1.5	14.03	1.22	1.681	9.57
45/1/68	418.58	18.459	-0.12	1.7	13.80	0.92	1.571	10.70
45/1/87	418.77	18.472	-0.19	1.45	14.12	1	1.451	10.40
45/1/111	419.01	18.490				0.93	1.451	10.66
45/1/128	419.18	18.502	-0.25	1.7	14.39	1.05	1.591	10.21
45/2/00	419.40	18.518	-0.3	1.6	14.61	0.94	1.561	10.63
45/2/20	419.60	18.532	-0.27	2.04	14.48	0.89	1.651	10.82
45/2/41	419.81	18.547	-0.3	1.97	14.61	1.1	1.511	10.02
45/2/60	420.00	18.561	-0.2	1.48	14.16	1.16	1.541	9.80
45/2/78	420.18	18.574	0.35	2.03	11.70	1.53	1.581	8.43
45/2/100	420.40	18.590				1.08	1.471	10.10
45/2/120	420.60	18.604	-0.05	1.6	13.49	1.02	1.431	10.32
45/2/140	420.80	18.619	-0.17	1.57	14.03	1.06	1.451	10.17
45/3/07	420.97	18.631	0	1.58	13.27	0.85	1.361	10.97
45/3/30	421.20	18.647	-0.28	1.78	14.52	0.83	1.471	11.05
45/3/50	421.40	18.662	-0.01	1.91	13.31	0.8	1.351	11.16
45/3/68	421.58	18.675	0.02	1.62	13.18	1.01	1.441	10.36

DSDP Hole 593 Sample No.	Depth (mbsf)	Age (Ma)	Gg woodi 18O	Gg woodi 13C	Gg woodi Temp°C	Cibs 18O	Cibs 13C	Cib Temp°C
45/3/88	421.78	18.689	-0.08	1.04	13.62	0.96	1.411	10.55
45/3/111	422.01	18.706	0.24	2.23	12.19	0.72	1.531	11.47
45/3/127	422.17	18.717				0.87	1.591	10.89
45/4/00	422.40	18.734	-0.19	1.39	14.12	0.39	1.331	12.75
45/4/19	422.59	18.747	-0.26	1.36	14.43	0.53	1.211	12.20
45/4/37	422.77	18.760	-0.15	1.37	13.94	0.66	1.441	11.70
45/4/60	423.00	18.777	-0.45	1.43	15.28	0.57	1.161	12.05
45/4/78	423.18	18.790	-0.08	1.79	13.62	0.62	1.351	11.85
45/4/98	423.38	18.804	-0.1	1.57	13.71	0.61	1.321	11.89
45/4/120	423.50	18.813	-0.16	1.22	13.98	0.76	1.501	11.31
45/4/138	423.78	18.833				0.68	1.601	11.62
45/5/12	424.02	18.850	-0.16	0.86	13.98	0.96	1.561	10.55
45/5/30	424.20	18.863				0.78	1.581	11.24
45/5/48	424.38	18.876	-0.15	1.62	13.94	0.87	1.581	10.89
45/5/67	424.57	18.890				0.66	1.471	11.70
45/5/88	424.78	18.905	-0.24	1.54	14.34	0.76	1.591	11.31
45/5/111	425.01	18.922	-0.22	1.26	14.25	1	1.521	10.40
45/5/128	425.18	18.934				0.83	1.631	11.05
45/6/00	425.40	18.950	-0.15	1.88	13.94	0.94	1.191	10.63
45/6/18	425.68	18.970	-0.08	1.37	13.62	1.31	1.451	9.24
45/6/36	425.76	18.976	0.17	1.94	12.51	1.33	1.651	9.17
45/6/60	426.00	18.993	-0.09	2.06	13.67	1.02	1.611	10.32
45/6/78	426.18	19.006	0.15	2.01	12.60	0.7	1.291	11.54
45/6/100	426.40	19.022	-0.03	1.95	13.40	1.02	1.591	10.32
45/6/120	426.60	19.036	-0.28	1.55	14.52	0.98	1.341	10.47
45/6/140	426.80	19.050	0.11	1.85	12.77	1.02	1.641	10.32
45/7/10	427.00	19.065	-0.18	1.42	14.07	1.13	1.611	9.91
45/7/27	427.17	19.077	-0.14	1.83	13.89	0.88	1.671	10.85
45/7/46	427.36	19.091				0.7	1.021	11.54
45/cc/18	427.48	19.099	-0.15	2.08	13.94			

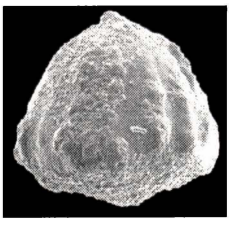
Appendix D

Bolboforma - Selected Images And Associated Data

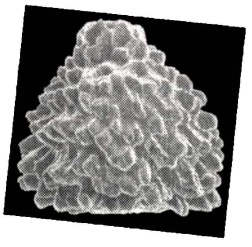
Appendix D - *Bolboforma* - selected images and associated data



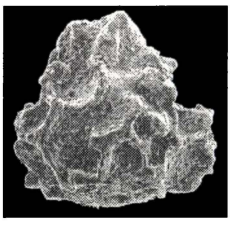
Bolboforma praeintermedia



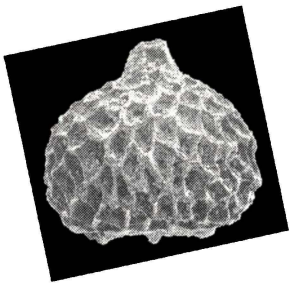
Bolboforma capsula



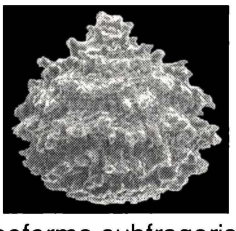
Bolboforma metzmacheri ornata



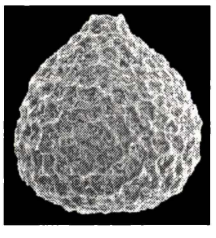
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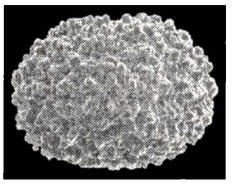
Bolboforma metzmacheri s.s. (ogival form)



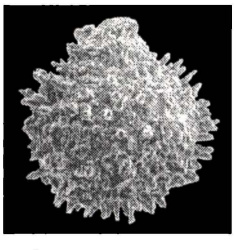
Bolboforma subfragoris s.l. ('spirospinosa')



Bolboforma gracilireticulata



Bolboforma subfragoris s.l. ('spinulosa')



Bolboforma pentaspinosa

Appendix D Figure 1: Selected Late Miocene *Bolboforma* images (images from 160 to 240 μm maximum diameter).

Sites 277 and 593 Palaeogene Age Model

Isotopic data from two studies, Murphy and Kennett (1986) and Keigwin (1980) has been integrated for Site 277 and Site 593 (Holes 593 and 593A). The linear sedimentation rates have been calculated using the following data age/depth model, with the same rates applied to both Site 593 holes (for details of the biostratigraphy see Table 2, Chapter 5):

Appendix D Table 1: Palaeogene age/depth model for Sites 277 and 593.

Site 277		Site 593			
Depth (mbsf)	Age (Ma)	Hole 593 Depth (mbsf)	Age (Ma)	Hole 593A Depth (mbsf)	Age (Ma)
4.50	29	475.00	28.5	461.40	28.5
83.00	30	489.90	30		
184.00	33.7	544.4	33.7		
197.00	35.4				
263.50	37				

Palaeotemperatures have been calculated using the following equations. Equation (1) for benthic foraminiferal calcite (Shackleton and Kennett, 1975):

$$T°C = 16.9-4.38(\delta^{18}O_c-\delta^{18}O_w)+0.1(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (1)$$

where $\delta^{18}O_c$ = foraminiferal calcite$_{(VPDB)}$ and $\delta^{18}O_w$ = seawater$_{(VPDB)}$ = -1.2‰ in an ice-free world, as per the original publication (Shackleton and Kennett, 1975). Substituting the $\delta^{18}O_w$ = seawater$_{(VSMOW)}$ value of -1.0‰, makes the palaeotemperatures c. 0.75°C warmer. Sea surface palaeotemperatures (SSPTs) can be calculated using a slightly modified version of the palaeotemperature equation (2), following Erez and Luz (1983) and Zachos et al. (1994):

$$T°C = 16.998-4.52(\delta^{18}O_c-\delta^{18}O_w)+0.028(\delta^{18}O_c-\delta^{18}O_w)^2 \quad (2).$$

All palaeotemperature calculations for Chapter 5 used seawater $\delta^{18}O_w$ = -1.2‰ ($_{VPDB}$).

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Sites 277 and 593 Isotopic Data Tables

Appendix D Table 2: DSDP Site 277 data from Murphy and Kennett, 1986; Keigwin, 1980. Duplicate data for a given depth has been averaged. G. angip = *Globigerina angiporoides* (planktic), O umbon = *Oridorsalis umbonitus* (benthic).

Site 277 Depth (mbsf)	Age (Ma)	G angip 18O	Temp °C	O umbon 18O	Temp °C
9.90	29.07	1.37	5.57	1.72	3.39
14.40	29.12	1.29	5.92	1.77	3.20
19.40	29.18	1.35	5.65	1.91	2.68
23.90	29.24	1.65	4.34	1.72	3.39
33.40	29.36	1.21	6.27	1.66	3.61
38.40	29.42	1.41	5.39	1.64	3.68
42.90	29.48	1.08	6.84	2.05	2.17
46.90	29.53	1.19	6.36	1.92	2.65
52.40	29.59	1.04	7.01	1.36	4.74
57.40	29.66	1.01	7.17	1.64	3.68
61.90	29.71	0.96	7.37	1.46	4.36
66.90	29.77	0.95	7.41	1.15	5.54
71.40	29.83	1.15	6.54	1.89	2.76
76.40	29.89	1.62	4.47	1.97	2.46
80.90	29.95	1.04	7.01	1.48	4.28
85.90	30.11	1.04	7.01	1.72	3.39
90.40	30.27	1.13	6.64	1.84	2.94
95.40	30.45	1.03	7.04	1.55	4.02
99.90	30.62	0.91	7.61	1.21	5.33
104.90	30.80			1.75	3.28
109.40	30.97	1.07	6.91	1.37	4.70
114.40	31.15	0.78	8.16	1.12	5.65
119.40	31.33	0.68	8.60	1.35	4.77
123.90	31.50	1.07	6.89	1.32	4.89
128.30	31.66	1.18	6.40	1.69	3.50
133.40	31.85	0.80	8.07	1.41	4.57
137.90	32.01	0.68	8.60	1.62	3.76
142.90	32.19	0.79	8.11	1.44	4.43
147.40	32.36	0.63	8.82	1.33	4.85
152.40	32.54	0.85	7.85	1.44	4.43
156.90	32.71	0.64	8.78	1.36	4.74
160.40	32.84	0.60	8.95	1.28	5.04
161.90	32.89	0.66	8.69	1.39	4.64
163.40	32.95	0.76	8.25		
171.00	33.22	0.89	7.67	1.34	4.81
171.40	33.24	1.04	6.88	1.63	3.72
172.00	33.26	0.91	7.59	1.38	4.66
178.50	33.50	0.47	9.53	1.00	6.11
179.00	33.52	0.54	9.22	0.90	6.50
179.70	33.54	0.38	9.93	0.85	6.69
180.50	33.57	0.38	9.93	0.99	6.15
182.50	33.64	0.34	10.10	0.93	6.38
183.90	33.70	0.09	11.21	0.84	6.73
185.40	33.88	0.38	9.95	0.74	7.14
186.90	34.08	0.09	11.21	0.79	6.93
188.90	34.34	0.40	9.86	0.90	6.50
190.40	34.53	0.24	10.55	0.69	7.34

Site 277 Depth (mbsf)	Age (Ma)	G angip 18O	Temp °C	O umbon 18O	Temp °C
191.90	34.73	0.15	10.95	0.73	7.16
198.30	35.43	0.24	10.55	0.88	6.58
198.40	35.43	0.10	11.17	0.64	7.51
199.90	35.47	0.39	9.88	0.95	6.30
201.40	35.51	0.07	11.33	0.77	7.00
207.90	35.66	-0.08	11.97	0.47	8.18
209.40	35.70	-0.19	12.46	0.43	8.34
211.00	35.74	-0.13	12.19	0.51	8.02
220.40	35.96			0.62	7.59

Appendix D Table 3: Combined Site 593 isotopic data (Holes 593 and 593A) (after Murphy and Kennett, 1986), recalculated using palaeotemperature equations detailed above, along with the age/depth model. Duplicate data has been averaged.

Site 593 Depth (mbsf)	Age (Ma)	G angip 18O	Temp (°C)	O umbon 18O	Temp (°C)
2742.00	27.42	0.45	9.62	1.53	4.10
2758.60	27.59	0.43	9.70	1.37	4.70
2772.60	27.73	0.13	11.04	1.62	3.76
2792.60	27.93	0.16	10.90	1.12	5.65
2807.60	28.08	0.04	11.44	1.10	5.73
2822.60	28.23	0.63	8.82	1.35	4.77
2823.60	28.24	0.32	10.19	1.21	5.31
2837.60	28.38	0.57	9.09	1.33	4.85
2838.60	28.39	0.47	9.53	1.25	5.15
2919.60	29.20	0.41	9.79	1.33	4.85
2934.60	29.35	0.31	10.24	0.90	6.50
2949.60	29.50	0.56	9.13	1.67	3.57
2952.60	29.53	0.56	9.13	1.01	6.07
2964.60	29.65	0.46	9.57	1.34	4.81
2969.60	29.70	0.23	10.59	0.69	7.32
2979.60	29.80	0.64	8.78	0.81	6.85
2982.60	29.83	0.63	8.82	1.16	5.50
2994.60	29.95	0.26	10.46	1.15	5.53
3000.41	30.00	0.38	9.93	1.07	5.84
3015.60	30.16	0.19	10.77	0.98	6.19
3028.60	30.29	0.11	11.12	0.93	6.38
3045.29	30.45	0.73	8.38	1.47	4.32
3045.60	30.46	0.52	9.31	1.23	5.23
3055.49	30.55	0.67	8.64	1.32	4.89
3055.49	30.55	0.46	9.57	1.33	4.85
3058.60	30.59	0.52	9.31	1.37	4.70
3065.69	30.66	0.84	7.89	1.49	4.25
3075.60	30.76	0.65	8.73	1.33	4.85
3100.37	31.00	0.85	7.87	1.46	4.36
3110.57	31.11	0.74	8.33	1.46	4.36
3111.60	31.12	0.71	8.47	1.31	4.93
3120.36	31.20	0.94	7.48	1.46	4.36
3126.60	31.27	0.76	8.25	1.31	4.94
3130.97	31.31	0.76	8.25	1.49	4.25

Site 593 Depth (mbsf)	Age (Ma)	G angip 18O	Temp (°C)	O umbon 18O	Temp (°C)
3141.17	31.41	0.39	9.88	1.05	5.92
3141.60	31.42	0.64	8.78	1.65	3.65
3156.60	31.57	0.82	7.98	1.38	4.66
3165.65	31.66	0.62	8.86	1.32	4.89
3171.60	31.72	0.99	7.23	1.46	4.36
3175.85	31.76	0.43	9.73	1.09	5.76
3186.60	31.87	0.85	7.85	1.45	4.40
3196.25	31.96	0.55	9.18	1.27	5.08
3206.45	32.06	0.49	9.44	1.11	5.71
3216.65	32.17	0.38	9.93	0.89	6.54
3230.93	32.31	0.33	10.15	1.03	6.00
3241.13	32.41	0.44	9.66	1.13	5.61
3244.53	32.45	0.39	9.88		
3251.33	32.51	0.59	9.00	1.08	5.80
3261.53	32.62	0.50	9.39	1.12	5.67
3271.73	32.72	0.76	8.25	1.00	6.11
3281.93	32.82	0.45	9.62	1.38	4.66
3296.21	32.96	0.63	8.82	0.93	6.38
3306.41	33.06	0.71	8.47	1.12	5.65
3316.61	33.17	0.64	8.78	1.36	4.74
3326.81	33.27	0.58	9.05	1.37	4.70
3337.01	33.37	0.84	7.92	1.16	5.50
3347.21	33.47	0.51	9.35	1.33	4.85
3361.49	33.61	0.16	10.90	0.86	6.65
3371.09	33.71	0.37	9.97	0.67	7.39
3491.45	34.91	0.04	11.44	0.68	7.36
3501.65	35.02	-0.02	11.70	0.54	7.91
3511.85	35.12	0.19	10.77	0.75	7.08
3522.05	35.22	0.10	11.17	0.85	6.69
3532.25	35.32	0.08	11.26	0.65	7.47
3542.45	35.42	0.17	10.86	0.68	7.36

New Zealand Journal of Geology & Geophysics, 2001, Vol. 44: 535–553
0024–8306/01/4404–0535 $7.00/0 © The Royal Society of New Zealand 2001

History of oceanic front development in the New Zealand sector of the Southern Ocean during the Cenozoic—a synthesis

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Abstract The New Zealand sector of the Southern Ocean (NZSSO) has opened about the Indian-Pacific spreading ridge throughout the Cenozoic. Today the NZSSO is characterised by broad zonal belts of antarctic (cold), subantarctic (cool), and subtropical (warm) surface-water masses separated by prominent oceanic fronts: the Subtropical Front (STF) c. 43°S, Subantarctic Front (SAF) c. 50°S, and Antarctic Polar Front (AAPF) c. 60°S. Despite a meagre database, the broad pattern of Cenozoic evolution of these fronts is reviewed from the results of Deep Sea Drilling Project-based studies of sediment facies, microfossil assemblages and diversity, and stable isotope records, as well as from evidence in onland New Zealand Cenozoic sequences. Results are depicted schematically on seven paleogeographic maps covering the NZSSO at 10 m.y. intervals through the Cenozoic.

During the Paleocene and most of the Eocene (65–35 Ma), the entire NZSSO was under the influence of warm to cool subtropical waters, with no detectable oceanic fronts. In the latest Eocene (c. 35 Ma), a proto-STF is shown separating subantarctic and subtropical waters offshore from Antarctica, near 65°S paleolatitude. During the earliest Oligocene, this front was displaced northwards by development of an AAPF following major global cooling and biotic turnover associated with ice sheet expansion to sea level on East Antarctica. Early Oligocene full opening (c. 31 Ma) of the Tasmanian gateway initiated vigorous proto-circum-Antarctic flow of cold/cool waters, possibly through a West Antarctic seaway linking the southern Pacific and Atlantic Oceans, including detached northwards "jetting" onto the New Zealand plateau where condensation and unconformity development was widespread in cool-water carbonate facies. Since this time, a broad tripartite division of antarctic, subantarctic, and subtropical waters has existed in the NZSSO, including possible development of a proto-SAF within the subantarctic belt. In the Early–early Middle Miocene (25–15 Ma), warm subtropical waters expanded southwards into the northern NZSSO, possibly associated with reduced ice volume on East Antarctica but particularly with restriction of the Indonesian gateway and redirection of intensified warm surface flows southwards into the Tasman Sea, as well as complete opening of the Drake gateway by 23 Ma allowing more complete decoupling of cool circum-Antarctic flow from the subtropical waters. During the late Middle–Late Miocene (15–5 Ma), both the STF and SAF proper were established in their present relative positions across and about the Campbell Plateau, respectively, accompanying renewed ice buildup on East Antarctica and formation of a permanent ice sheet on West Antarctica, as well as generally more expansive and intensified circum-Antarctic flow.

The ultimate control on the history of oceanic front development in the NZSSO has been plate tectonics through its influence on the paleogeographic changes of the Australian-New Zealand-Antarctic continents and their intervening oceanic basins, the timing of opening and closing of critical seaways, the potential for submarine ridges and plateaus to exert some bathymetric control on the location of fronts, and the evolving ice budget on the Antarctic continent. The broad trends of the Cenozoic climate curve for New Zealand deduced from fossil evidence in the uplifted marine sedimentary record correspond well to the principal paleoceanographic events controlling the evolution and migration of the oceanic fronts in the NZSSO.

Keywords New Zealand; Southwest Pacific; Antarctica; Southern Ocean; Cenozoic; paleoclimate; paleoceanography; oceanic fronts; DSDP cores; ice sheets

INTRODUCTION

The New Zealand subcontinent lies in the global oceanic hemisphere at the interface of the Southwest Pacific Ocean and the Southern Ocean. It is proximal to both the frigid Antarctic continent to the south, and the Western Pacific Warm Pool to the north (Tomczak & Godfrey 1994). Consequently, seafloor deposits in the vicinity of New Zealand have the potential for being a sensitive monitor of present and past oceanographic changes driven by any changes in these cold and warm source regions. The most prominent feature evident on satellite imagery of the modern Southern Ocean is the conspicuous bands of circumpolar surface-water masses separated by oceanic fronts (Fig. 1), each marked by sharp changes in vertical water structure, temperature, salinity, and nutrients. This paper overviews some of the geological evidence for the timing and development of these oceanic fronts in the New Zealand sector of the Southern Ocean (NZSSO) during the Cenozoic, an evolution that is closely linked to the changing configuration of the southern continents in relation to their surrounding ocean basins as a consequence of seafloor spreading, and the resultant dramatic changes in the ice budget of Antarctica over this period.

G00052
Received 28 August 2000; accepted 30 July 2001

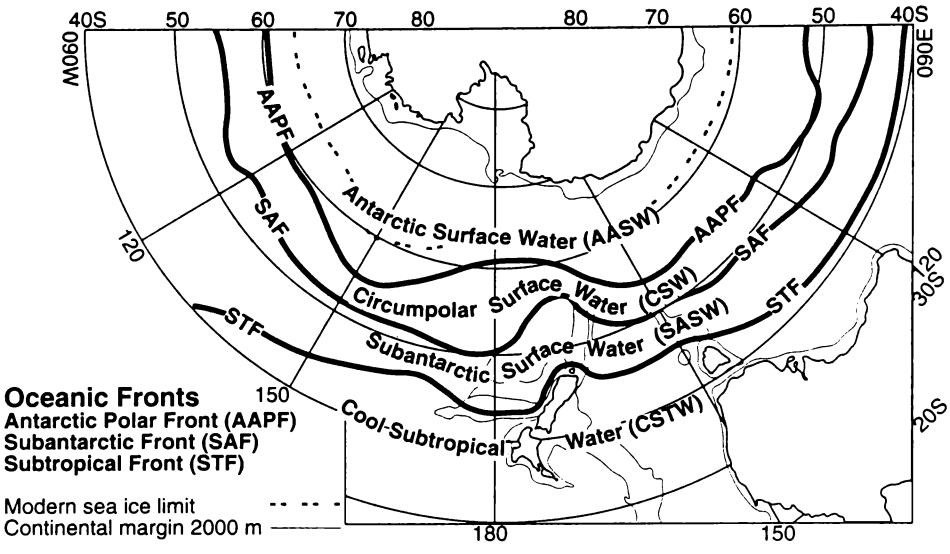


Fig. 1 Modern surface-water masses and their bounding oceanic fronts in the New Zealand sector of the Southern Ocean (adapted from Belkin & Gordon 1996).

SOUTHERN OCEAN FRONTS

Despite various definitions of the Southern Ocean (e.g., Lazarus & Caulet 1993; Belkin & Gordon 1996), it is conveniently treated here as including all antarctic and subantarctic water masses south of the Subtropical Front which, in the New Zealand region, presently lies near 43–45°S latitude (Fig. 1). The Southern Ocean is a key component of the Earth's ocean-climate system through the major role it plays in the meridional transfer of heat. Gordon (1988) estimated that presently at least 60% of the oceanic volume is cooled around Antarctica before being transferred north. In the deep ocean, the transfer of cold water occurs mainly via deep western boundary currents as portrayed in the "thermohaline conveyor belt" model of Broecker & Denton (1990). For surface waters, the heat transfer relates to a combination of wind drift and eddies associated with oceanic fronts.

Oceanic fronts are characterised by marked changes in vertical structures from one side to the other. Typically these are manifested at various levels by enhanced horizontal gradients in temperature and/or salinity, and by concentrated geostrophic flow. A comprehensive review of the position, definition, and structure of the oceanic fronts in the circum-Antarctic Southern Ocean as a whole is provided by Belkin & Gordon (1996). Between New Zealand and Antarctica there are presently three main oceanic fronts separated by four main surface water masses (Fig. 1; Table 1). Although other fronts lie to the north (Tasman Front at c. 30–36°S and Southern Tropical Convergence at c. 20°S) and in the far south (Antarctic Divergence at c. 65°S) of this region, it is the history of development of the three main NZSSO fronts—the Subtropical Front (STF), Subantarctic Front (SAF), and Antarctic Polar Front (AAPF) (Table 1)—that are the principal topic of this review.

ESTABLISHING PALEOPOSITIONS OF WATER MASSES

The evidence for determining past positions of oceanic fronts is essentially limited by our ability to distinguish between cold, cool, and warm surface-water provinces in the geological record of marine sedimentary deposits. Proxy estimations of past sea-water temperatures can be made from various lithological, paleontological, and geochemical properties of sedimentary deposits (e.g., Boggs 1987). Lithological features include the type of deep-sea sediment facies, their textural properties, and compositional data such as the occurrence of ice-rafted debris or particular clay mineral assemblages. Paleontological criteria relate especially to the relative abundances of calcareous and

Table 1 Major oceanic front characteristics and their intervening surface-water masses in the modern NZSSO (see also Fig. 1).

Water mass *or* **oceanic front**	Symbol	Latitude (°S)	Temperature (°C)	Salinity (‰)
Subtropical Water	STW			
Subtropical Front	STF	c. 43–45	15 summer 10 winter	34.8
Subantarctic Surface Water*	SASW			
Subantarctic Front	SAF	c. 52	8 summer	34.5
Circumpolar Surface Water	CSW			
Antarctic Polar Front	AAPF	c. 56	2	34.2
Antarctic Surface Water	AASW			

* In the New Zealand region previously named Australasian Subantarctic Water (ASW).

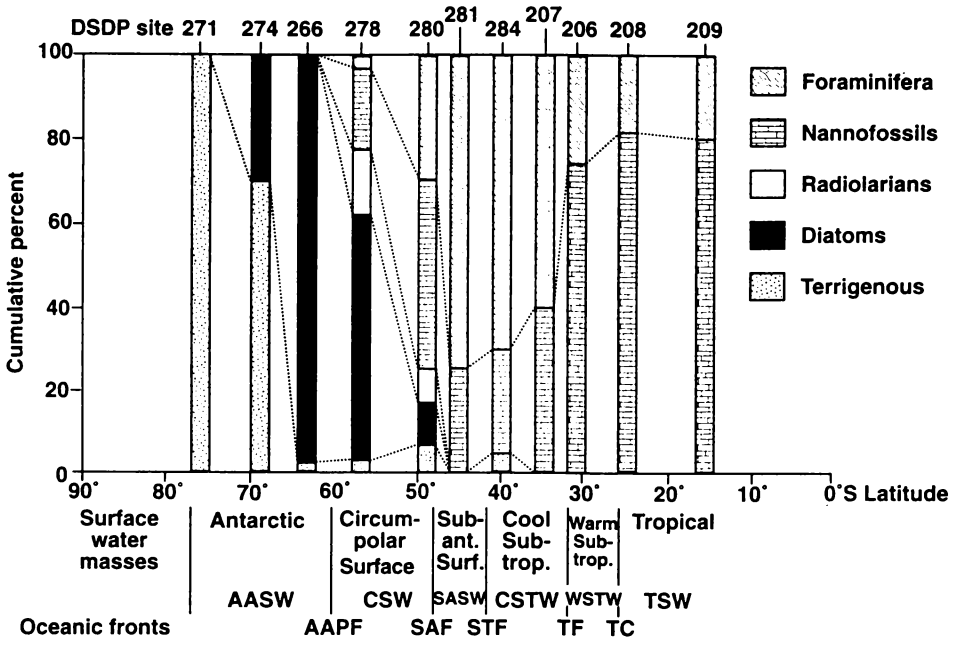


Fig. 2 Composition of core-top sediment samples in relation to modern surface-water masses in a north–south transect of DSDP sites from well north of New Zealand to offshore Antarctic continent (based on data from Burns 1977). Abbreviations defined in Table 1, plus CSTW, Cool Subtropical Water; TF, Tasman Front; WSTW, Warm Subtropical Water; TC, Tropical Convergence; TSW, Tropical Surface Water.

siliceous or other microfossils in the sediments, identifying the key species and species assemblages present, noting species diversity, and recording certain morphometric features of tests, such as coiling directions in some planktic foraminifera (e.g., Arnold & Parker 1999) or degree of silicification and ornamentation in radiolarians (e.g., Lazarus & Caulet 1993). Geochemical information relevant to past oceanic climates comes primarily from measuring the oxygen and carbon isotope composition ($\delta^{18}O$ and $\delta^{13}C$) of calcareous microfossil shells (e.g., Shackleton & Kennett 1975; Rohling & Cooke 1999).

Burns (1977) showed that a general relationship exists between surficial deep-sea bottom sediment types and overlying modern surface-water masses in the wider Southwest Pacific region by determining the main sediment components in a transect of Deep Sea Drilling Project (DSDP) core-top samples stretching from north of New Zealand through the NZSSO to Antarctica (Fig. 2). North of the SAF, biocalcareous sediments dominate, with the proportion of nannofossils to foraminifera increasing northwards. South of the AAPF, the modern seafloor deposits are essentially non-calcareous and are either biosiliceous, consisting predominantly of diatoms, or become increasingly enriched in terrigenous material as the Antarctic continent is approached. Between the AAPF and SAF there is a mix of biosiliceous and biocalcareous components, the former usually dominating and comprising predominantly diatoms, but with a conspicuous contribution from radiolarians (Fig. 2). A broadly comparable kind of zonal relationship between bottom sediment composition and surface-water mass appears to have existed more widely for at least Neogene core sections in the Southern Ocean, which show an overall north–south change in the content of biocalcareous versus biosiliceous versus terrigenous components in both Pliocene and Miocene deposits with paleolatitude (Fig. 3). Consequently, a first-order estimation of possible surface-water masses can be made from trends in the spatial and temporal distribution of different sediment types. Potential problems are well known, and include such matters as poor preservation potential of especially coccoliths and diatoms, dissolution of calcareous microfossils at deep core sites, winnowing of fines in areas of strong bottom currents, and the need to distinguish between local occurrences of biosiliceous sediment that may develop in areas of focused upwelling about continental margins and those indicative of more widespread open-ocean upwelling in cold waters.

For the NZSSO, the primary database of published geological and paleoclimatic information is available in a widely scattered array of 34 long cores obtained during DSDP Legs 21, 28, 29, 30, and 90 (Table 2; Fig. 4), and to a more limited extent from Cenozoic sedimentary sections in onland New Zealand. In this study, the DSDP core

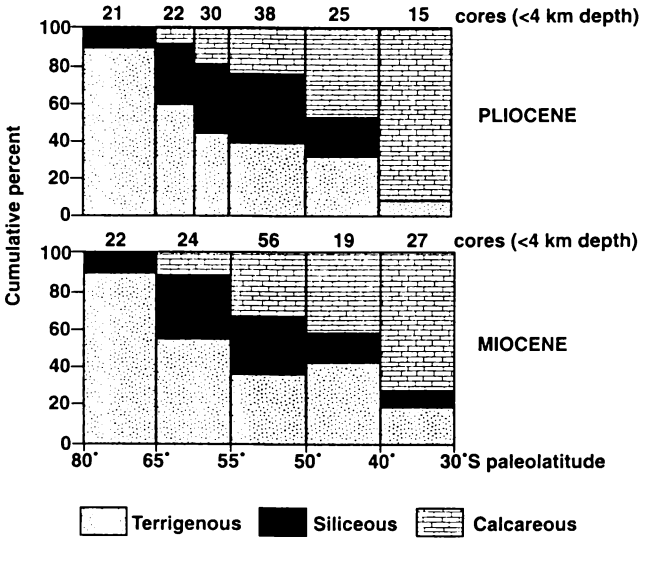


Fig. 3 Broadscale distribution of sediment types with paleolatitude for Pliocene and Miocene intervals of circum-Antarctic Southern Ocean cores from <4 km water depth (adapted from Lazarus & Caulet 1993). Number of cores used to determine percent values for each paleolatitudinal band is shown above tops of bands. Compare with general latitudinal trend shown in Fig. 2 for modern surficial bottom sediments.

lithologies have first been re-assessed in terms of their relative abundances of biocalcareous versus biosiliceous versus terrigenous components, and re-drawn against an age scale including local New Zealand Cenozoic stages (Fig. 5). Second, a variety of paleoclimatic data and interpretations based on the lithological, microfossil, and $\delta^{18}O$ data from these cores is already available (Appendix 1), and this information was compiled and summarised on worksheets. The key references incorporating data most relevant to the Cenozoic as a whole for the NZSSO include those of Shackleton & Kennett (1975) for stable oxygen isotopes, Jenkins (1993) for planktic foraminifera, Lazarus & Caulet (1993) for radiolarians, Hornibrook (1992) for shallow-water macrofauna and microfauna, and Edwards (1975) and Burns (1977) for a variety of microfossil and sedimentologic properties. Third, note was also taken of paleoceanographic and paleoclimatic inferences drawn from studies of other Southern Ocean cores (e.g., Kennett 1980; Kennett & Barker 1990; Stott et al. 1990; Wise et al. 1991; Lazarus & Caulet 1993) and from Cenozoic sections in onland New Zealand (e.g., Carter 1985; Hornibrook et al. 1989; Beu & Maxwell 1990; Hornibrook 1992). By integrating all these kinds of information, it is possible to compile some generalised scenarios for the sequential development of surface-water masses in the NZSSO.

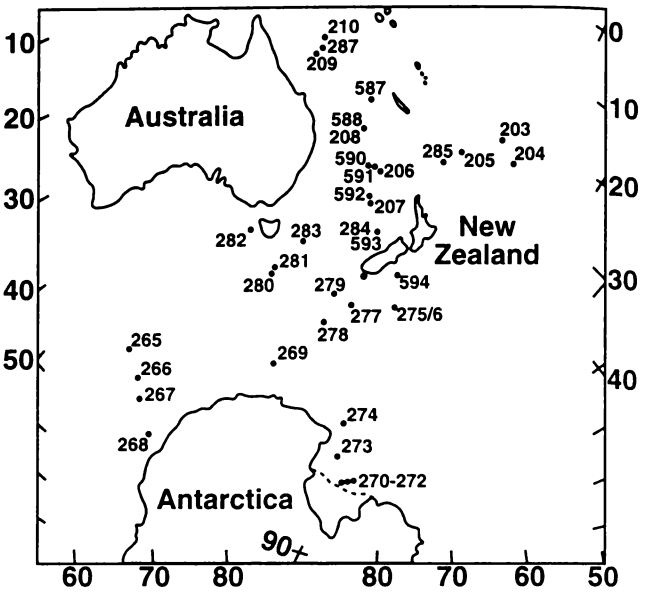


Fig. 4 Location of DSDP core sites in the wider Southwest Pacific region that form the primary basis for the paleoceanographic reconstructions in this study (see also Table 2).

Table 2 Locality information for DSDP cores in the vicinity of the NZSSO (see also Fig. 4).

No.	Leg	Site	Region	Latitude	Longitude	Depth (m)
1	21	210	Coral Sea	13°45.99'S	152°53.78'E	4653
2	21	209	Coral Sea	15°56.19'S	152°11.27'E	1438
3	30	287	Coral Sea	15°54.67'S	153°15.93'E	4653
4	21	203	Fiji Sea	22°09.22'S	177°32.77'W	2730
5	21	204	Fiji Sea	24°57.27'S	174°06.69'W	5364
6	21	205	Fiji Sea	25°30.99'S	177°53.95'E	4330
7	30	285	Fiji Sea	26°49.16'S	175°48.24'E	4658
8	90	587	North Tasman Sea	21°11.87'S	161°19.99'E	1101
9	90	588[1]	North Tasman Sea	26°06.70'S	161°13.60'E	1533
10	90	590	North Tasman Sea	31°10.02'S	163°21.51'E	1299
11	90	591	North Tasman Sea	31°35.06'S	164°26.92'E	2131
12	21	206	North Tasman Sea	32°00.75'S	165°27.15'E	3206
13	90	592	South Tasman Sea	36°28.40'S	165°26.06'E	1098
14	21	207	South Tasman Sea	36°57.75'S	165°26.53'E	1389
15	90	593[2]	South Tasman Sea	40°30.47'S	167°40.47'E	1068
16	29	283	South Tasman Sea	43°54.60'S	154°16.96'E	4729
17	29	282	West Tasmania	42°14.76'S	143°29.18'E	4202
18	29	281	South Tasmania	47°59.84'S	147°45.85'E	1591
19	29	280	South Tasmania	48°57.44'S	147°14.08'E	4176
20	90	594	South New Zealand	45°31.41'S	174°56.88'E	1204
21	29	275/6	South New Zealand	50°26.34'S	176°18.99'E	>2800
22	29	279	South New Zealand	51°20.14'S	162°38.10'E	3341
23	29	277	South New Zealand	52°13.43'S	166°04.29'E	1214
24	29	278	South New Zealand	56°33.42'S	160°11.48'E	3675
25	28	269	Antarctica (New Zealand)	61°40.57'S	140°04.21'E	4285
26	28	274	Antarctica (New Zealand)	68°59.81'S	173°25.64'E	3326
27	28	273	Ross Sea	74°32.29'S	174°37.57'E	495
28	28	271	Ross Sea	76°43.27'S	175°02.86'W	554
29	28	272	Ross Sea	77°07.62'S	176°45.61'W	629
30	28	270	Ross Sea	77°26.48'S	178°30.19'W	634
31	28	265	Antarctica (West Australia)	53°32.45'S	109°56.74'E	3582
32	28	266	Antarctica (West Australia)	56°24.13'S	110°06.70'E	4173
33	28	267	Antarctica (West Australia)	59°15.74'S	104°29.30'E	4564
34	28	268	Antarctica (West Australia)	63°56.99'S	105°09.34'E	3544

[1]Equivalent to Leg 21, Site 208.
[2]Equivalent to Leg 29, Site 284.

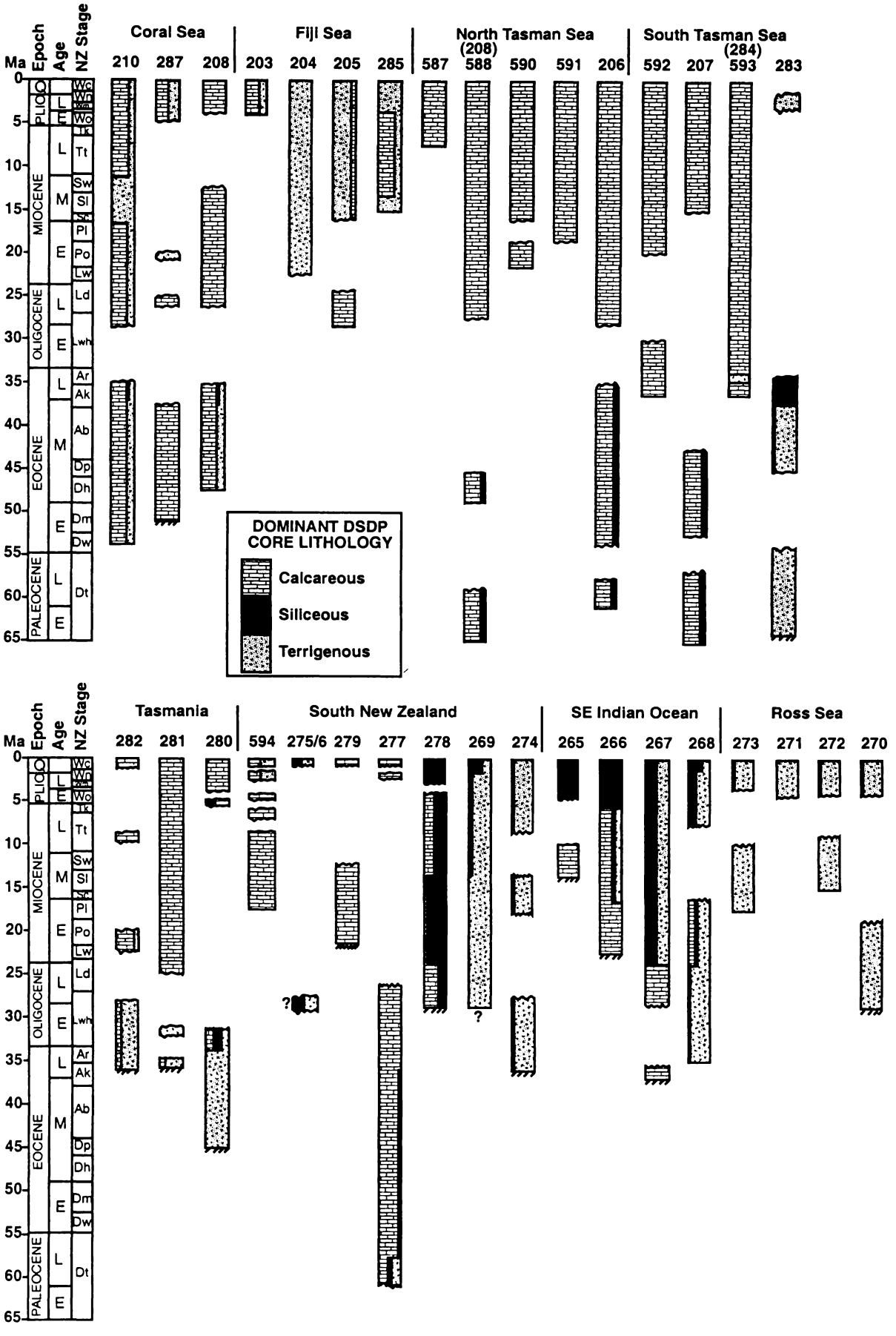


Fig. 5 Generalised stratigraphies for DSDP cores in the wider Southwest Pacific region based mainly on lithological syntheses contained in the relevant DSDP Leg volumes. See Fig. 4 and Table 2 for locality and other information. Ages include New Zealand stage symbols defined in Hornibrook et al. (1989). Diagonal lines at the base of some cores indicate hole drilled to local basement.

CENOZOIC EVOLUTION OF FRONTS

The set of plate tectonic reconstructions generated by Lawver et al. (1992) for the evolution of the Antarctica-Southern Ocean region have been used to compile schematic paleogeographic/paleoceanographic maps for six broad periods in the Cenozoic (Fig. 6A–F), which can be compared with the modern situation (Fig. 6G). The "time slices" adopted are simply conveniently spaced ones through the Cenozoic, and effectively each map represents a "summation" of the major paleoceanographic changes occurring during the 5 m.y. intervals either side of the map age. To attempt to produce a full series of paleoceanographic maps at any higher age resolution that might identify much shorter term fluctuations in the nature and position of water mass and front types is presently premature because of the small number and widespread distribution of available NZSSO cores (Fig. 4).

The map ages, their absolute time ranges, and the approximate New Zealand stages for each interval (see also abbreviated stage symbols in Fig. 5), are as follows:

(A) Paleocene (Teurian, Dt) 60(±5) Ma

(B) Early–early Middle Eocene (Waipawan-Porangan, Dw-Dp) 50(±5) Ma

(C) Late Middle–Late Eocene (Bortonian-Runangan, Ab-Ar) 40(±5) Ma

(D) Oligocene (Whaingaroan-Duntroonian, Lwh-Ld) 30(±5) Ma

(E) Early–early Middle Miocene (Waitakian-Lillburnian, Lw-Sl) 20(±5) Ma

(F) Late Middle–Late Miocene (Lillburnian-Kapitean, Sl-Tk) 10(±5) Ma

(G) Present day 0 Ma

Dominant sediment types forming the core sediments for each time slice, along with some inferred important paleoceanographic conditions and events, are noted in Table 3.

Paleocene (65–55 Ma) (Fig. 6A)

Records are scanty because few DSDP holes penetrate Paleocene strata (Fig. 5). At this time, both the Tasmanian (between South Tasman Rise and Antarctica) and Drake (between South America and Antarctica) gateways were closed, and Antarctica was probably free of ice (Wise et al. 1991; Abreu & Anderson 1998; Zachos et al. 2001). Sediments are almost everywhere biocalcareous, with nannofossils exceeding planktic foraminifera in abundance, and the assemblages of these two groups show moderate diversity and relatively little variation with latitude. The microfossil data suggest that no distinctive Southern Ocean biogeographic province existed, but rather there were separate Pacific and Indo-Atlantic faunal provinces at intermediate to high-southern latitudes throughout most of the Paleogene, before inception of a full circum-Antarctic current (Jenkins 1993). Biosiliceous oozes are restricted to areas of localised upwelling in shallow waters, including in eastern New Zealand (Hollis 1991), but are not indicative of more regional oceanic upwelling. This is consistent with both the generally low sedimentation rates (c. 1 cm/ka) of

Table 3 Dominant core lithologies for mapped Cenozoic time slices in the NZSSO (see Fig. 6), including some inferred paleoenvironmental conditions and times of oceanic front development.

Time slices	Dominant sediments	Antarctic ice sheets	Surface currents[1]	Surface gateways	Oceanic fronts[2]
Paleocene 65–55 Ma (Fig. 6A)	calcareous	no	Warm (I-P)	Tasmanian closed Drake closed	none
Early–Middle Eocene 55–45 Ma (Fig. 6B)	calcareous	no	Warm (I-P)	Tasmanian closed Drake closed	none
Middle–Late Eocene 45–35 Ma (Fig. 6C)	calcareous	mainly no, but growing	Warm (I-P)	Tasmanian closed Drake closed	none
Latest Eocene only	terrigenous-siliceous calcareous	yes - East	Cool (Ant)	Tasmanian leaking West Antarctic open	proto-STF
Oligocene 35–25 Ma (Fig. 6D)	terrigenous calcareous-siliceous calcareous	yes - East no - West	Cold (Ant) Cool (Ant) Warm (I-P)	Tasmanian open West Antarctic open Drake leaking-open	AAPF ?proto-SAF proto-STF
Early–Middle Miocene 25–15 Ma (Fig. 6E)	terrigenous-siliceous siliceous-calcareous calcareous	yes - East no - West	Cold (Ant) Cool (Ant) Warm (I-P)	Tasmanian open West Antarctic closed Drake open Indonesian restricted	AAPF proto-SAF proto-STF
Middle–Late Miocene 15–5 Ma (Fig. 6F)	terrigenous-siliceous siliceous-calcareous calcareous	yes - East yes - West	Cold (Ant) Cool (Ant) Warm (I-P)	Tasmanian open Drake open	AAPF SAF STF
Pliocene–Present day 5–0 Ma (Fig. 6G)	terrigenous-siliceous siliceous-calcareous calcareous	yes - East yes - West	Cold (Ant) Cool (Ant) Warm (I-P)	Tasmanian open Drake open	AAPF SAF STF

[1]I-P, Indonesian-Pacific origin; Ant, Antarctic origin.

[2]AAPF, Antarctic Polar Front; proto-SAF, proto-Subantarctic Front; SAF, Subantarctic Front; proto-STF, proto-Subtropical Front; STF, Subtropical Front.

the calcareous oozes at southern latitudes, values more typical of oligotrophic than upwelling environments today (Lazarus & Caulet 1993), and also the isotope results from Weddell Sea (Kennett & Barker 1990) and Kerguelen Plateau (Barrera & Huber 1991), which suggest the Paleocene Southern Ocean was well stratified.

Thus, the picture that emerges for the Paleocene is an NZSSO influenced predominantly by undifferentiated subtropical surface waters circulating from (north)west to east through the region as part of a large South Pacific warm-water gyre (Fig. 6A) (Barron & Peterson 1991). No faunal evidence exists for the presence of any oceanic frontal system in the region. Based on the lack of warm-water species of the keeled planktic foraminifera *Morozovella* in the Late Paleocene record at Site 277, but by its presence in northern South Island sections of New Zealand, Jenkins (1993) proposed that a transition zone between warm subtropical and cool subtropical (= temperate) waters occurred in the vicinity of 50–55°S paleolatitude at this time. All the fossil evidence from New Zealand supports a predominantly warm subtropical marine climate throughout the Paleocene (Hornibrook 1992), with probably the warmest surface waters occurring in the Late Paleocene, as registered by an increase in the species diversity of both planktic foraminifera (Jenkins 1974) and molluscs (Beu & Maxwell 1990). The low resolution of the core dataset and onland fossil records used here appear insufficiently detailed to positively detect the short-lived extreme event, known as the Late Paleocene Thermal Maximum, at c. 55 Ma near the Paleocene/Eocene boundary (e.g., Kennett & Stott 1991; Zachos et al. 2001).

Early–early Middle Eocene (55–45 Ma) (Fig. 6B)

The surface-water paleoceanographic situation throughout most of the Early–Middle Eocene in the NZSSO remained similar to that in the Paleocene. Deep-sea sediments continue to be dominated by biocalcareous oozes composed of planktic foraminifera and nannofossils with subtropical affinities, while in the vicinity of the Antarctic and Australian coasts the offshore marine deposits were influenced by an increased terrigenous content associated with the inception of continental separation (Burns 1977). Rare occurrences of biosiliceous sediment at Sites 206, 207, and 277 (Fig. 5) again appear to reflect local zones of upwelling and enhanced productivity about some oceanic pedestals.

A notably warm Southern Ocean during the Early–Middle Eocene is supported by near-maximum Cenozoic isotope temperature estimates at this time off southern New Zealand (Fig. 7) (Shackleton & Kennett 1975) and in the Antarctic (Stott et al. 1990). The warming trend during the Late Paleocene in New Zealand continued into this period, which was characterised by consistently warm subtropical or marginally tropical types of marine biota and coastal mangroves and *Cocos* (Hornibrook 1992). Because of this, we infer that the transition zone between warm and cool subtropical surface waters was for a time farther south than it lay in the Paleocene, possibly as far as 60°S paleolatitude (cf. Fig. 6A, B). Certainly, according to the oxygen isotope synthesis of Paleogene marine climates by Zachos et al. (1994), the flattest gradient in sea-surface temperatures between low and high latitudes was during the Early Eocene, amounting possibly to only c. 10°C or less, and the interval includes the so-called Early Eocene Climatic Optimum (Zachos et al. 2001).

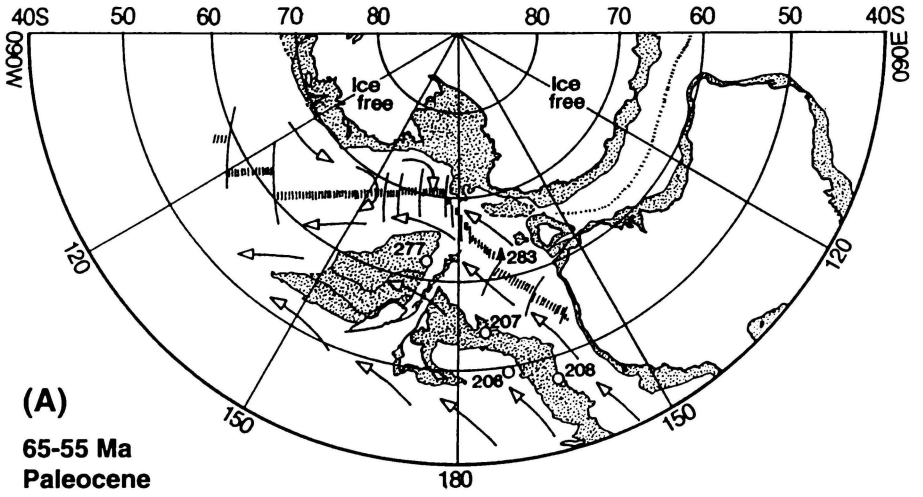
However, passage into the Middle Eocene saw the sudden extinction in New Zealand of keeled planktic foraminifera of the genus *Morozovella*, which Hornibrook (1992) interpreted to be the result of a brief cooling episode. McGowran et al. (1997) presented evidence from the southern Australian margin for a comparable early Middle Eocene cooling event which they labelled Chill 1, and suggested it may have resulted from either a Monterey effect involving CO_2 drawdown due to marine burial of light carbon or to an albedo effect due to widespread ocean basin subsidence associated with the collision of India and Asia. This temperature drop in high-latitude surface waters was at most only a few degrees centigrade (Zachos et al. 1994), and was presumably accompanied by a northwards return towards 50°S paleolatitude of the transition zone between cool and warm subtropical waters.

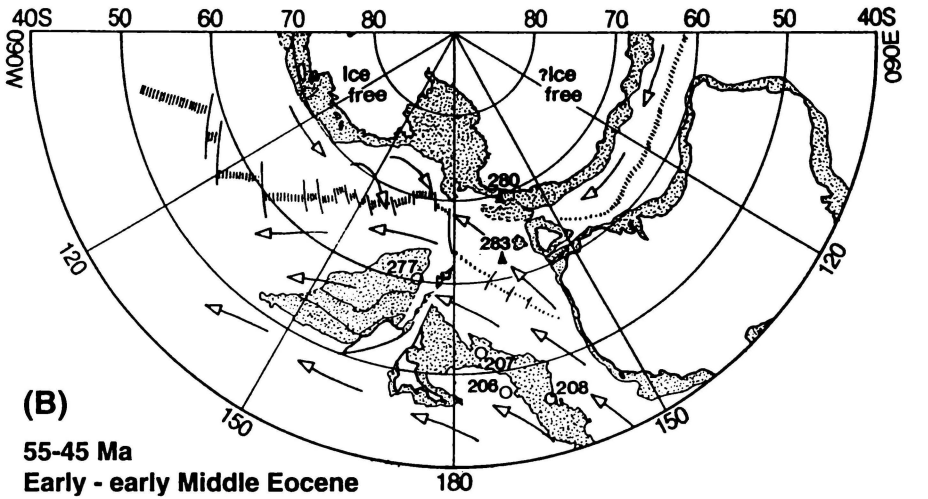
Consequently, apart from cessation of seafloor spreading in the Tasman Sea at c. 55 Ma (Sutherland 1994), and the continued slow drift of the New Zealand subcontinent northwards away from the Pacific-Antarctic Ridge, effectively increasing the oceanic area of the NZSSO, the surface waters and circulation patterns for the first half of the Eocene (Fig. 6B) are similar to those in the Paleocene. East Antarctica probably remained free of ice caps (Wise et al. 1991; Abreu & Anderson 1998; Barker et al. 1999; Zachos et al. 2001), the Tasmanian gateway had not yet opened, the surface waters of the NZSSO were everywhere cool to warm subtropical and fed by the western limb of a south Pacific gyre, and no oceanic fronts were present in the region.

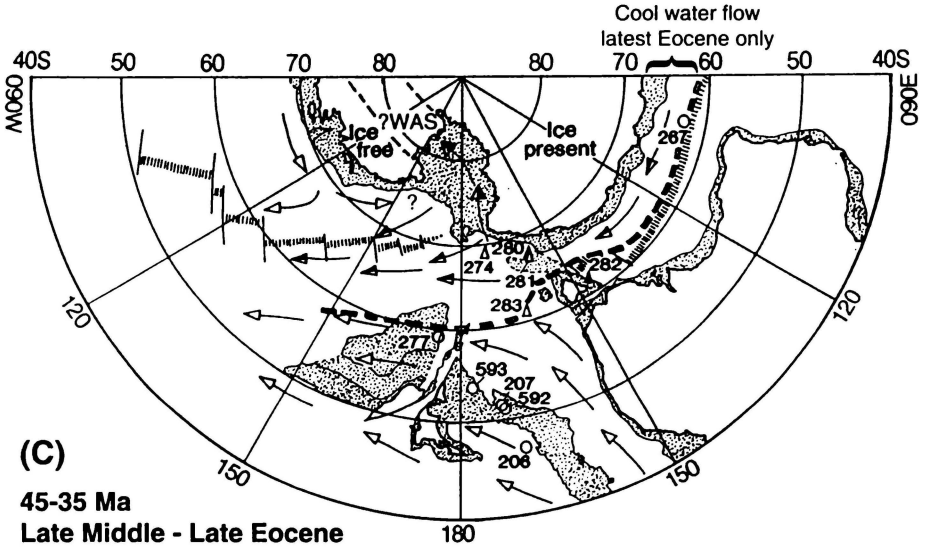
Late Middle–Late Eocene (45–35 Ma) (Fig. 6C)

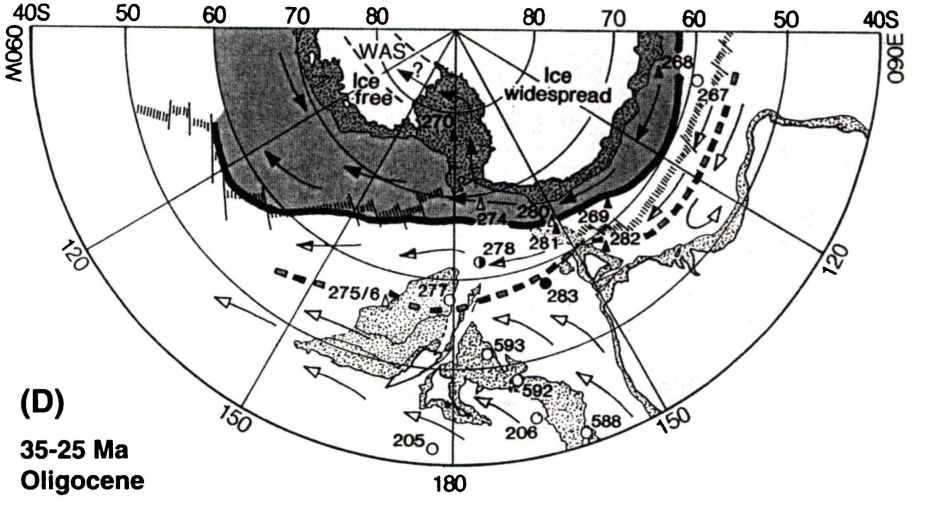
For much of the first part of this interval, the deep-sea core data from the NZSSO suggest that the broad paleoceanographic characteristics of the surface waters in the region remained similar to those occurring in the earlier Eocene and Paleocene. Sediments continue to be carbonate dominated, comprising assemblages of nannofossils and planktic foraminifera having subtropical affinities, with terrigenous and locally biosiliceous deposits in the vicinity of continental margins.

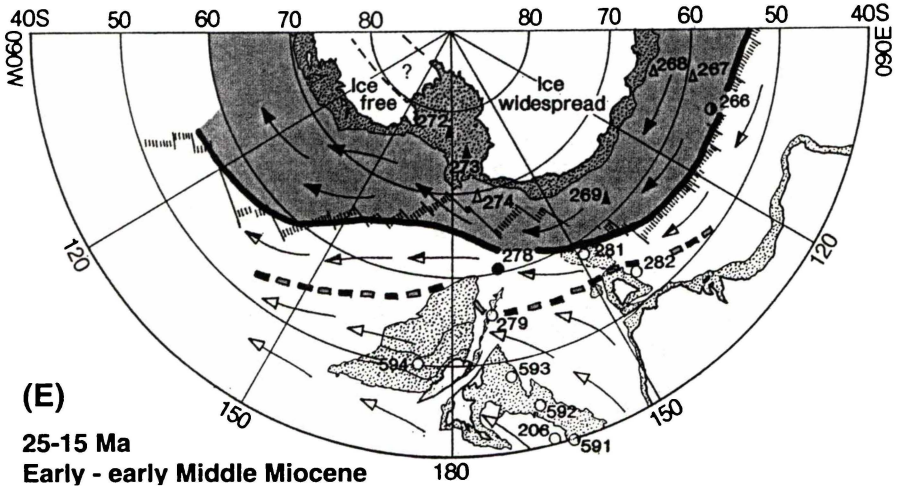
However, by the Late Eocene there is considerable evidence for the onset of changing paleoceanographic conditions in the NZSSO. Deep-water marine sediments appear for the first time at drill sites between Australia and Antarctica, and attest to the ongoing separation since c. 50 Ma of these continents about a maturing oceanic ridge system (Fig. 6C). Wise et al. (1991) and Zachos et al. (1994) compiled evidence from oxygen isotopes, ice-rafted debris, and microfossil and mineralogical data for the appearance by the early Late Eocene of the first major, but still probably ephemeral, ice sheets on East Antarctica, consistent with the ice history synthesis presented by Abreu & Anderson (1998). Lazarus & Caulet (1993) reported that radiolarian faunas close to Antarctica became increasingly endemic at this time, involving distinctive cold-water assemblages. They suggested that a mix of cold and warmer radiolarian species away from the continent may reflect the introduction of the former in a northward-moving cool intermediate water mass developed in, and sinking from, the surface waters near Antarctica. The presence of the cold-water nannofossil *Isthmolithus recurvus* at Site 267 is clear evidence of cool seas first entering the southern portion of the Australian-Antarctic seaway (Burns 1977), and cool-water assemblages of nannofossils appear elsewhere in the Southern Ocean at

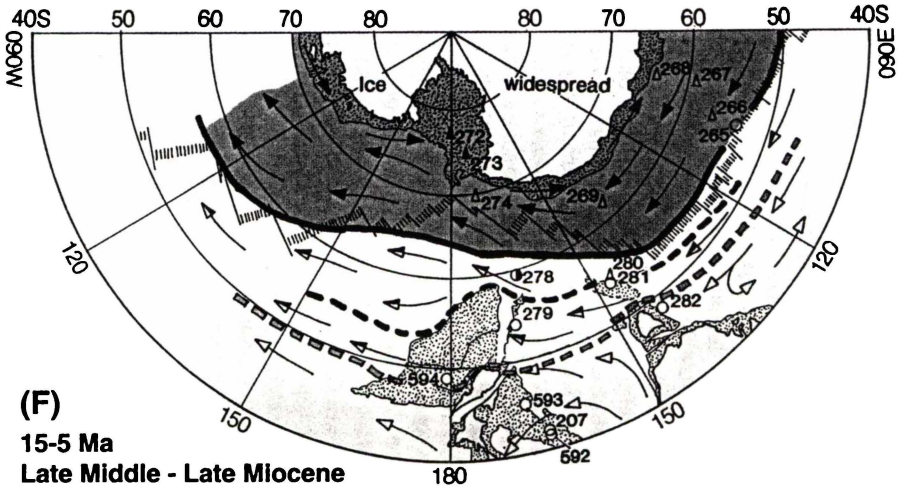

40S 50 60 70 80 80 70 60 50 40S
090W
060E
120
150
180
Ice free
Ice free
277
283
207
206
208
(A)
65-55 Ma
Paleocene

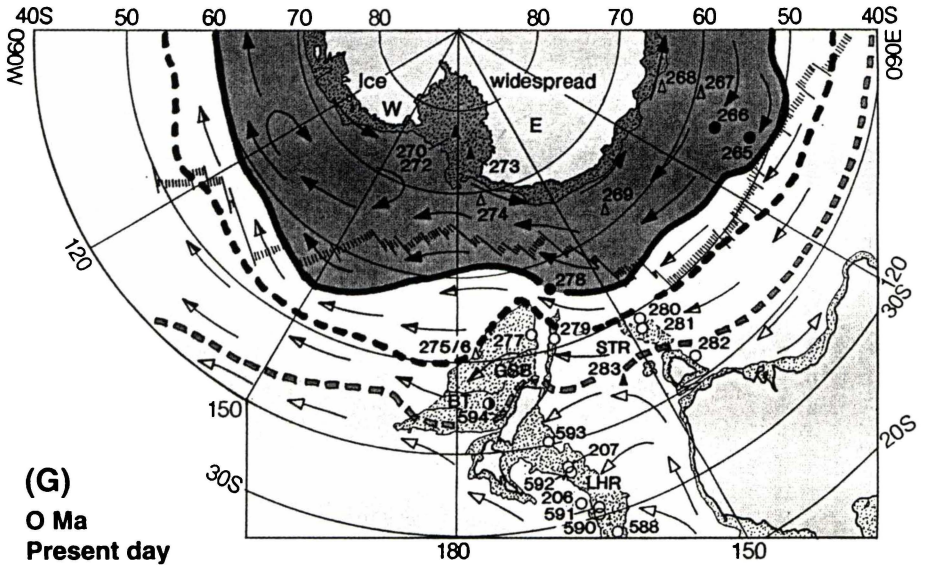

40S 50 60 70 80 80 70 60 50 40S
090W
060E
120
150
180
Ice free
?Ice free
280
283
277
207
206
208
(B)
55-45 Ma
Early - early Middle Eocene


Cool water flow
latest Eocene only
40S 50 60 70 80 80 70 60 50 40S
090W
060E
120
150
180
?WAS
Ice free
Ice present
267
280
274
282
281
283
277
593
207
592
206
(C)
45-35 Ma
Late Middle - Late Eocene


40S 50 60 70 80 80 70 60 50 40S
090W
060E
120
150
180
WAS?
Ice free
Ice widespread
268
267
270
274
280
269
278
281
282
275/6
271
283
593
592
206
588
205
(D)
35-25 Ma
Oligocene







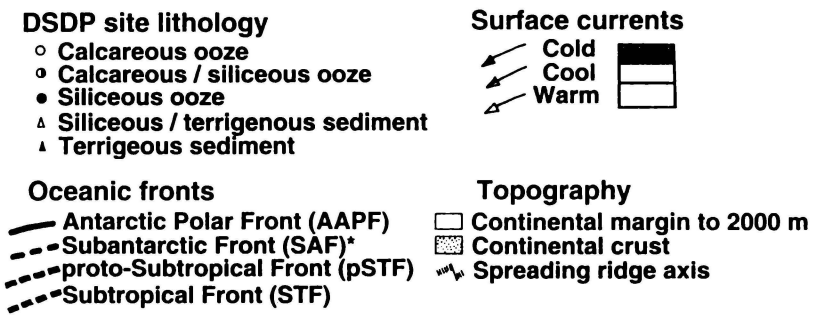


Fig. 6 Series of schematic paleogeographic/paleoceanographic maps for the NZSSO at roughly 10 m.y. intervals through the Cenozoic. The base maps for the paleogeographic reconstructions are adapted from Lawver et al. (1992). Note the changing ice budget through time on East and West Antarctica (e.g., Abreu & Anderson 1998; Zachos et al. 2001). WAS = West Antarctic seaway. Colour versions of this figure can be downloaded from http://sci.waikato.ac.nz/cgi-bin/show_staff.pl?dept=erth&name=erth0033

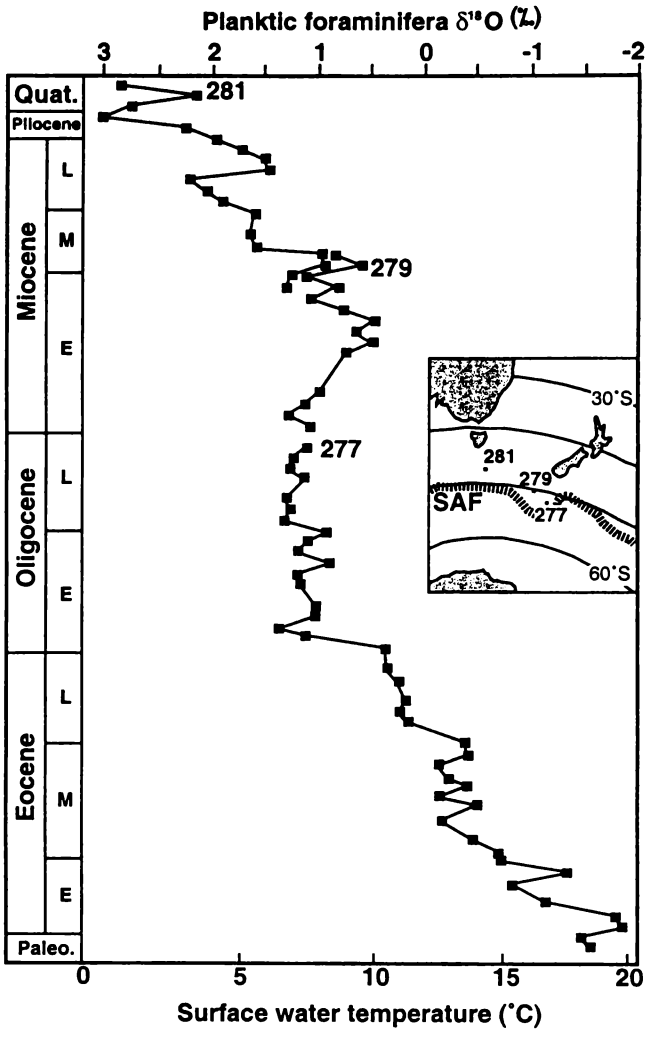


Fig. 7 Planktic foraminiferal $\delta^{18}O$ record and inferred near-surface water temperatures off southern New Zealand (DSDP sites 277, 279, and 281) since the Eocene (after Shackleton & Kennett 1975).

this time (e.g., Crux 1991). A sharp temperature drop into the Late Eocene of several degrees centigrade is suggested by the DSDP Site 277 stable isotope record from south of New Zealand (Fig. 7). This cooling coincides with a significant increase in bolboform numbers at the core site (Grützmacher 1993), a microfossil group known elsewhere at this time to be associated with sediments having a polar character (Kennett & Kennett 1990; Stott et al. 1990). Both cooler temperatures and decreased water column stratification have been inferred from other Southern Ocean isotope records for the Late Eocene (e.g., Stott et al. 1990; Barrera & Huber 1991). Occurrences of widespread mixed terrigenous-biosiliceous deposits in the vicinity of the shallow Tasman Rise suggest intensified upwelling and current circulation (e.g., Hampton 1975), possibly as an embryonic circum-Antarctic current began to sweep through the region once the Tasmanian gateway began to leak (e.g., Barron & Peterson 1991). This increasing differentiation of Southern Ocean surface waters may account for the increase in biogeographic gradients and biotic turnover registered at southern latitudes in the Indo-Pacific region for several microfossil groups during the Middle–Late Eocene (e.g., Sancetta 1979; Aubry 1992; Baldauf 1992; Keller et al. 1992). Significantly, the major extinction event in the entire Cenozoic occurred between the Middle and Late Eocene, affecting a wide range of both planktic marine and terrestrial biota (Berggren & Prothero 1992).

To account for the partitioning of surface waters in the NZSSO during the latest Eocene, a proto-Subtropical Front is portrayed here in the relevant paleoceanographic map (Fig. 6C) as separating distinctive cool and warm water masses. Such a thermal boundary was suggested by Murphy & Kennett (1986) on the basis of isotope-derived surface-water temperature comparisons between DSDP Sites 277 and 593 in the southern Tasman Sea. The scenario shown in Fig. 6C relates strictly to the latest Eocene portion of the time slice; otherwise, the situation envisaged is closer to that depicted in the Early Eocene map (Fig. 6B). As before, the warm surface currents bathing the wider New Zealand region originate out of the tropical west Pacific, whereas by the Late Eocene, when the buildup of ice sheets on East Antarctica had begun (Abreu & Anderson 1998; Zachos et al. 2001), the cool surface waters developed south of the proto-Subtropical Front are inferred to be part of a developing embryonic circum-Antarctic current system (e.g., Barron & Peterson 1991) that was possible because of shallow leakage over the Tasmanian gateway.

Whether or not such a flow was truly circum-Antarctic depends on whether the Drake gateway between South America and Antarctica was also leaking. This matter remains controversial. For example, Barker & Burrell (1982) suggested the Drake gateway did not open until much later in the Oligocene, or even younger (Barker et al. 1999), while Lawver & Gahagan (1998) advocated an early Oligocene opening. A closed Drake gateway possibly allowed development of a small clockwise gyre of warm surface waters to be recirculated off West Antarctica, as shown in Fig. 6C, to eventually mix with the cool currents. If the Drake gateway was indeed closed or only leaking, then we suggest that cool surface flows passing through the Tasmanian gateway may have been directed between East and West Antarctica, along the general strike of the West Antarctic rift system. We label this feature the West Antarctic seaway (WAS) in Fig. 6C, D. The rift experienced an episode of significant extension in the Eocene–Oligocene (Cande et al. 2000), and may have formed a critical marine linkage between the Pacific and Atlantic Oceans at this time. Lawver & Gahagan (1998) also noted the possibility of such a Pacific-Atlantic connection, but rather earlier in the Tertiary than we suggest here. Lazarus & Caulet (1993) inferred an unnamed regional oceanic front in the southern Atlantic and Indian Oceans in a (Late) Eocene reconstruction of surface circulation about Antarctica but, unlike here, showed no front in the NZSSO.

Oligocene (35–25 Ma) (Fig. 6D)

The changing paleoceanographic conditions in the NZSSO during the Late Eocene presaged those that continued, and intensified, into the Early Oligocene. The so-called "Terminal Eocene Event", first enunciated by Wolfe (1978), has become a catch-all expression for the significant changes that occurred in climate, biota, geochemistry, and lithology in the records of both marine and terrestrial deposits in the vicinity of the Eocene/Oligocene boundary, near 34 Ma (e.g., Van Couvering et al. 1981). However, despite some often

sudden and dramatic shifts, the prevailing view is that the biotic changes occurred mainly in sequential or step-wise fashion during the Late Eocene–Early Oligocene, rather than being "instantaneous" and related to some catastophic event (e.g., Prothero & Berggren 1992).

The well-established global climatic cooling and biotic turnover at this time has long been linked to the development of Antarctic glaciation (e.g., Kennett 1977, 1978, 1980; Miller et al. 1991). Zachos et al. (1994) showed that the first major and permanent ice sheets had developed on East Antarctica by the earliest Oligocene, involving an ice volume at least 50% that of the present day, and that by this time sea-surface temperatures off Antarctica in the NZSSO had declined to values in the order of 2–6°C. Oxygen isotope records from both deep-water (e.g., Shackleton & Kennett 1975; Stott et al. 1990; Barrera & Huber 1991; Wei 1991; Miller 1992) (Fig. 7) and shallow-water (e.g., Devereux 1967; Burns & Nelson 1981; Kamp et al. 1990; Buening et al. 1998) sites throughout the Southern Ocean all show a conspicuous $\delta^{18}O$ enrichment of c. 1‰ in the earliest Oligocene, consistent with an abrupt cooling of southern high-latitude surface waters. This feature was labelled Chill II by McGowran et al. (1997) in their chronicle of important Cenozoic paleoceanographic events affecting the southern Australian margin. It was accompanied by the development of the psychrospheric ocean as we know it today (Kennett & Shackleton 1976) and subsequent widespread development of mid-Tertiary hiatuses along the paths of bottom-water movement through the NZSSO (Kennett et al. 1975; Kennett & von der Borch 1986). Pronounced latitudinal differentiation of surface-dwelling plankton associations occurred throughout the Southern Ocean, with northward migration and/or extinction of many former high-latitude taxa, and a reduction in the diversity of species, including, for example, amongst the planktic foraminifera (e.g., Keller et al. 1992; Jenkins 1993), calcareous nannoplankton (e.g., Wei 1991; Aubry 1992), diatoms (Baldauf 1992), and radiolarians (Lazarus & Caulet 1993). Also, bolboforms, inferred to be good subantarctic indicators (Crundwell et al. 1997), reached their maximum Paleogene diversity in the Late Eocene and Early Oligocene Southern Ocean core sites (Spiegler & von Daniels 1991).

Accompanying the Early Oligocene glaciation to sea level on East Antarctica and refrigeration of southern high-latitude surface waters was the final separation of the Antarctic and Australian continents, and full oceanic opening of the Tasmanian gateway south of Tasmania (Kennett et al. 1975; Kennett 1977). Jenkins (1993) suggested this seaway was fully open by c. 31 Ma, allowing unimpeded dispersal of previously Austral gulf planktic taxa, such as the foraminiferan *Jenkinsina samwelli*, into the Southwest Pacific and beyond. The nascent cool-water circum-Antarctic flows postulated for the Late Eocene (Fig. 6C) now evolved into a fuller and much intensified proto-Antarctic Circumpolar Current, traversing the NZSSO and possibly entering the Atlantic by either shallow-water leakage through the Drake gateway or via the West Antarctic seaway resulting from rifting between East and West Antarctica at this time (Fig. 6D) (Barron & Peterson 1991; Lazarus & Caulet 1993; Cande et al. 2000). Lazarus & Caulet (1993) advocated an extensive cold to cool water Southern Ocean in the Early Oligocene, locally extending as far north as 50°S paleo-latitude in the Indian Ocean sector. An AAPF is envisaged separating distinctly antarctic from subantarctic radiolarian assemblages and is positioned in the NZSSO in the vicinity of the Early Oligocene spreading ridge, meandering between c. 60° and 65°S paleolatitude (Fig. 6D). The location of several modern oceanic fronts appears to track, and be partly controlled by, deep bottom topography (Lazarus & Caulet 1993), and, given the weak stratification of the water column in the Early Oligocene (Stott et al. 1990; Barrera & Huber 1991), it is possible the surface circulation system likewise penetrated deeply and was linked to the paleoridge position. The Early Oligocene proto-STF is inferred to have been displaced well northwards in the NZSSO, reaching the vicinity of 55°S paleolatitude (Fig. 6D), a conclusion also reached by Kamp et al. (1990) and Buening et al. (1998) from faunal and isotope evidence in southern Australia and New Zealand, respectively. Based on the occurrence of Oligocene diatomaceous sediments within southern portions of the intervening subantarctic water mass (e.g., DSDP Sites 278 and 280), a situation also apparent from some other Southern Ocean sites at this time (e.g., Shipboard Scientific Party 1988; O'Connell 1990; Zachos et al. 1992), it is possible that a proto-SAF may have begun to differentiate this cool-water zone in the Oligocene (see Fig. 9). However, there is insufficient information to positively locate such a proto-SAF on the relevant NZSSO map (Fig. 6D).

The shallow-marine fossil record for the Oligocene in New Zealand is problematical from a paleoclimatic viewpoint (Hornibrook 1992). Foraminiferal extinctions near the Eocene/Oligocene boundary probably relate to the significant cooling associated with the boundary event mentioned above (Hornibrook et al. 1989), a view supported by oxygen isotope temperature records from New Zealand (Fig. 7) (Devereux 1967; Burns & Nelson 1981). However, any dramatic cooling appears to have been short lived because a variety of warm-water molluscan taxa (Beu & Maxwell 1990) and dispersed occurrences of the benthic foraminiferan *Amphistegina* (Hornibrook et al. 1989) are reported from several New Zealand Oligocene sections. A widespread Oligocene lithology in New Zealand is bryozoan limestone having all the characteristics of temperate-latitude cool-water carbonate facies (Nelson 1978; Nelson et al. 1988), and the abundance of fossil cetaceans and penguins associated with these sediments is supportive of cool water (Fordyce 1992). On balance, we infer that several shallow warm-water taxa survived earliest Oligocene cooling in New Zealand in sheltered coastal niches atop a diversified, island-dotted carbonate platform sitting in mainly temperate (cool subtropical) seas during the Oligocene. The occurrence of several widespread unconformity horizons within these mid-Tertiary carbonate deposits (Nelson 1978), the most celebrated of which is the mid-Oligocene Marshall Paraconformity in South Island (Carter 1985), record condensation, bypassing, and erosion by strong current flows crossing portions of the New Zealand plateau. These flows probably relate to topographically guided, northward-moving filaments of cool (subantarctic) water derived from the rapidly evolving circum-Antarctic current to the south (Fulthorpe et al. 1996).

Early–early Middle Miocene (25–15 Ma) (Fig. 6E)

Throughout this period, a south–north tripartite division of detrital-siliceous, siliceous-calcareous, and calcareous sediments continues to define, respectively, circumpolar belts of cold, cool, and warm surface-water masses (Fig. 6E), first evident in the Early Oligocene. According to Jenkins

(1993), whereas previously the Southern Ocean effectively supported separate South Pacific and Indo-Atlantic faunal provinces, by the Late Oligocene a latitudinally zoned, single major Southern Ocean faunal province prevailed. For example, Jenkins noted that planktic foraminiferal faunas are similar from southern Australia to New Zealand to southeast Atlantic at this time, and no major changes mark the Oligocene/Miocene boundary. Influential factors contributing to a breakdown of faunal provincialism include the continued widening of the Tasmanian gateway and particularly the inception of unimpeded circum-Antarctic flow through the Drake gateway off southern South America, which by this time was certainly fully open (Lawver & Gahagan 1998; Barker et al. 1999).

One consequence of invigorated subsurface flows is the occurrence of widespread hiatuses in several of the Late Oligocene–Early Miocene sections (Fig. 5), limiting paleoceanographic reconstructions. Assignment of radiolarian and diatom assemblages to antarctic or subantarctic waters is at some sites problematical (Burns 1977; Lazarus & Caulet 1993), which could reflect short-term fluctuations in position or eddying at the boundaries of water masses. But, overall, by the Early Miocene, the AAPF had shifted northwards from its Early Oligocene position by c. 5° of latitude, possibly tracking roughly the mid-ocean ridge system now lying between 55 and 65°S paleolatitude as the Southern Ocean continued to expand (Fig. 6E).

The marine fossil record from New Zealand in the Early Miocene includes widespread warm-water molluscan genera (Beu & Maxwell 1990) and a variety of larger foraminifera (Chaproniere 1984), as well as isolated heads of reef coral in northern localities (Hayward 1977). The evidence supports development of increasingly warm subtropical conditions throughout the Early Miocene, culminating in a Neogene climatic optimum in the vicinity of the Early–Middle Miocene boundary zone. Peak warmth is supported by maximum Miocene diversity amongst planktic foraminifera (Jenkins 1993) and the nature of the calcareous nannofossil taxa (Edwards 1968). Tsuchi (1992) noted that a comparable Neogene climatic maximum is characteristic of several circum-Pacific regions at c. 16 Ma. Compared to the Oligocene, the influence of warm subtropical water masses expanded southwards at the expense of cool subtropical and subantarctic flows to bathe the entire New Zealand plateau. Only during the Late Paleocene–Early Eocene was there previously such a sustained period of climatic warmth across the New Zealand region.

The 16 Ma culmination of the Early Miocene warming event is such that a likely major contributing factor was continental-arc collision in the Indonesian region (Jaques & Robinson 1977), significantly restricting the Indonesian gateway (Kennett et al. 1985). This would have prevented westward-flowing Pacific equatorial currents from directly entering the Indian Ocean. Because of a gyral circulation pattern, the effect was probably to gradually redirect and greatly intensify the Early Miocene equivalent of the warm East Australian Current flowing south into the Tasman Sea and across the New Zealand plateau. Additionally, the completed opening of both the Tasmanian and Drake gateways to fuller circum-Antarctic transport of cool water probably fostered an increased decoupling of cool and warm surface waters. The local oxygen isotope record from Site 279 supports climatic amelioration through the Early Miocene (Fig. 7), but the changes are not dramatic as it lies near the southern limit of subtropical surface water incursions at this time (Fig. 6E).

Late Middle–Late Miocene (15–5 Ma) (Fig. 6F)

Following the Neogene climatic optimum near 16 Ma, there was long-term climatic deterioration throughout the remainder of the Cenozoic. This was associated first with increased permanent ice accumulation on East Antarctica in the late Middle Miocene (Chill III phase of McGowran et al. 1997), and second with the development of a permanent ice sheet on West Antarctica in the latest Miocene (e.g., Hodell & Kennett 1986; Kennett & von der Borch 1986). Stable isotope records demonstrate these dual cooling events well (Fig. 7) (Miller et al. 1987). During this Middle–Late Miocene period, the greatly increased buildup of ice on Antarctica, and ongoing widening of the Southern Ocean by seafloor spreading, caused more expansive and intense circum-Antarctic flows. By the Late Miocene, localities such as Sites 279 and 594 that were previously dominated by subtropical microfossil taxa now register a dramatic increase in subantarctic assemblages (Fig. 8) (Lazarus & Caulet 1993). The microfossil characteristics suggest the former proto-STF had now become a full STF resembling the modern, which in the New Zealand region occupied a breached location across the Campbell Plateau before following the trend of the upstanding Chatham Rise out into the South Pacific (Fig. 6F). Moreover, during this period, there is microfossil assemblage evidence (e.g., Burns 1977; Jenkins 1993) to support clear partitioning of the circumpolar belt of subantarctic waters into two zones by a recognisably "modern" SAF. Within the New Zealand region, the position of the SAF is shown to be bathymetrically constrained by the margins of the Campbell Plateau (Fig. 6F), as is the situation in the modern (Fig. 6G). By the latest Miocene, the STF, SAF, and AAPF south of New Zealand lay near 50°S, 58°S (because of southwards deflection by the Campbell Plateau), and possibly near 62°S paleolatitude, respectively (Fig. 6F).

The Middle–Late Miocene interval in New Zealand is mainly characterised by deep-water facies so that fossil assemblages are rather nonspecific as to marine climate (Hornibrook 1992). A decline in foraminiferal diversity is consistent with overall climatic cooling in the Middle Miocene, but with some warm-water incursions suggested by brief appearances in North Island of a few larger foraminiferal taxa (Chaproniere 1984) and of the warm subtropical planktic species *Globorotalia menardii* (Jenkins 1993). However, the close of the Middle Miocene marks the final extinction of most larger foraminifera in New Zealand (Hornibrook 1992). Throughout the Late Miocene, cooling continued as shown by the increasingly lower generic diversity and high percentage of extinctions of molluscs (Beu 1990) and, in the latest Miocene, the appearance for the first time of sinistral populations of the cold-water planktic foraminiferan *Neogloboquadrina pachyderma* in southeastern New Zealand (Vella & Kennett 1975).

In summary, compared to the predominantly warm subtropical surface waters over the New Zealand region during the previous Early–early Middle Miocene period (25–15 Ma), the late Middle–Late Miocene interval (15–5 Ma) became increasingly influenced by cool subtropical waters, with fluctuating incursions of subantarctic water affecting southeastern New Zealand by the close of the period.

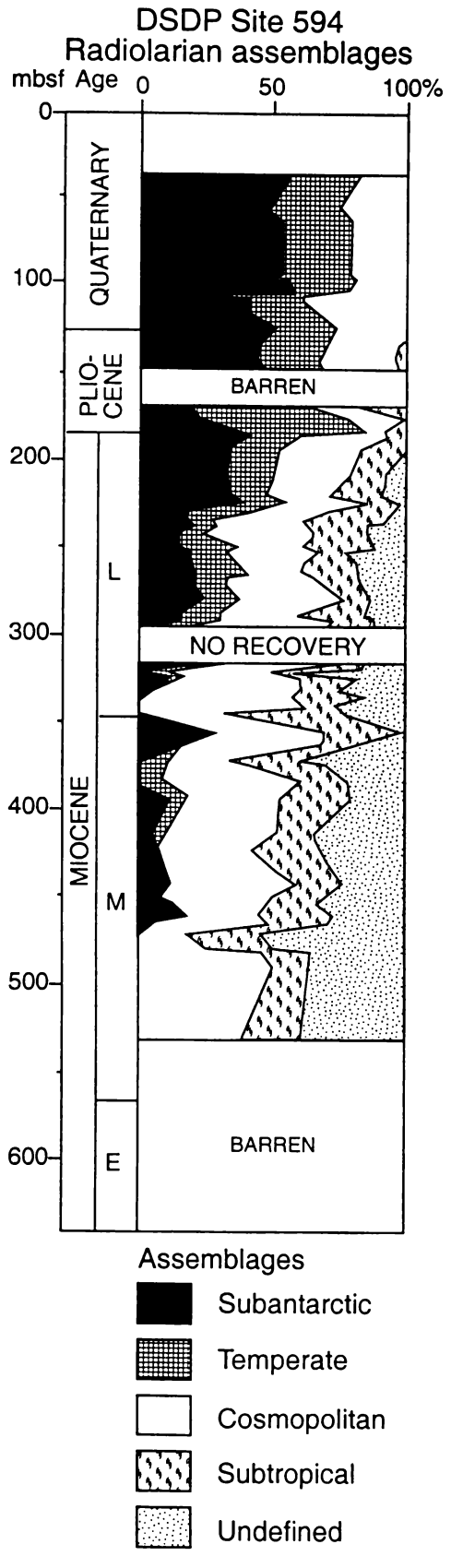


Fig. 8 Neogene development of radiolarian assemblages at DSDP Site 594 off southeastern New Zealand, presently sited in subantarctic water just south of the STF (adapted from Lazarus & Caulet 1993). Note the appearance and increasing significance of radiolarians with subantarctic affinities since the late Middle Miocene, supporting STF establishment north of the site by this time.

Pliocene–Quaternary (5–0 Ma)

Other than the modern situation (Fig. 6G), no paleoceanographic maps are presented for this interval because "average conditions" concerning sediment types, taxa distribution, and oceanic features are broadly similar to those of the present day. During this period of known rapid climatic oscillations between interglacial and glacial episodes (Head & Nelson 1994; Shackleton et al. 1995), incorporating the middle Pliocene Chill IV phase of McGowran et al. (1997) and subsequent expansion of ice sheets in the Northern Hemisphere (Raymo 1994), we infer a "maturing" of all three fronts (AAPF, SAF, and STF) in the NZSSO whose relative positions were maintained during at least the interglacial periods, appearing much like the scenario portrayed by an amalgam of Fig. 6F, G.

However, based mainly on evidence from Last Glacial to Holocene records (marine isotope stages 2 to 1) in offshore cores from the New Zealand region, it appears that during glacial times there has been temporary but considerable northward shifts of the AAPF and the SAF by up to 5–10° of latitude in open oceanic sites south of New Zealand (e.g., Nelson et al. 1993, 1994, 2000; Weaver et al. 1998; Barrows et al. 2000). Whether or not the SAF broke through the bathymetric constraint imposed by the southern margin of Campbell Plateau (Fig. 6G), and whether or not the open ocean movements of the southern fronts were accompanied by compensatory shifts in the STF, are presently debatable. Some existing data suggest no, or not by much, to both propositions (Nelson et al. 1993, 2000; Mackie 1998; Weaver et al. 1998), in which case the much intensified oceanic flows associated with dramatic compression of subantarctic water mass belts, increased westerly windiness, and lowered sea levels during glacials account well for the particularly harsh climatic conditions experienced in southeastern New Zealand at these times (e.g., Nelson et al. 1994). Like the last glaciation, it is probable that, to a greater or lesser degree, depending on global ice volume and extent of sea ice development about the Antarctic continent (Fig. 1), comparable kinds of shifts in Southern Ocean fronts and hydrographic conditions accompanied all the major glacial periods affecting the NZSSO during the latest Miocene–Quaternary (Nelson et al. 2000). Undoubtedly, paleoceanographic results from the recent (late 1998) ODP Leg 181 off eastern New Zealand (Carter et al. 1998) will contribute substantially to this question in the future.

CONCLUSIONS

1. Presently, there exist far too few quality long cores to track in any detail the evolution and migration of oceanic fronts in the NZSSO during the Quaternary, let alone for the Tertiary. However, despite this shortcoming, we have presented a series of schematic generalised paleoceanographic maps (Fig. 6) through the Cenozoic based on a review of published marine paleoclimatic data derived mainly from existing DSDP core and onland New Zealand marine sections. Given the proposition that the Southern Ocean probably holds the key to global climate (Hanna 1996; Pearce 1997), and that paleoceanographic changes therein have played a fundamental role in the development of Cenozoic climatic evolution, sea-level changes, and in terrestrial and biotic evolution (e.g., Kennett 1995), topics being revisited within the NZSSO by recent ODP Leg 181

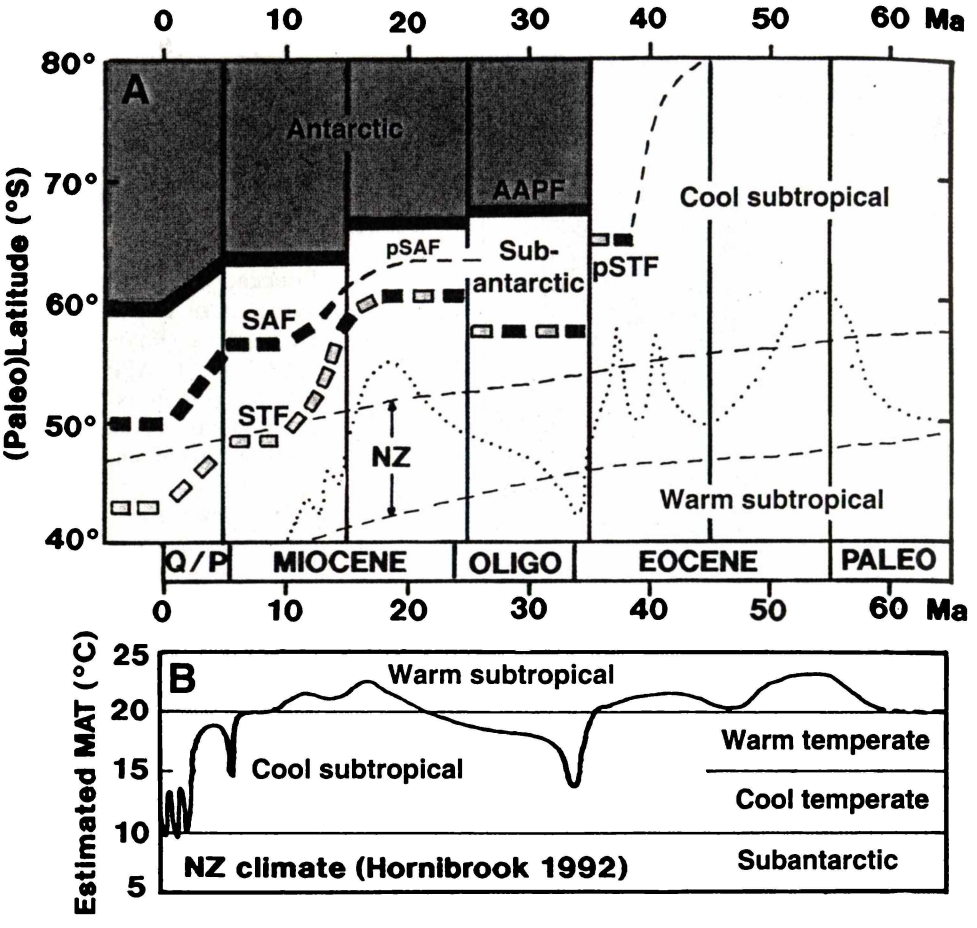


Fig. 9 A, Summary of the Cenozoic evolution of oceanic fronts and their associated surface-water masses (colour coded as in Fig. 6) in relation to paleolatitudes in the NZSSO. **B**, Comparison of the development in (A) with the New Zealand (NZ) marine paleoclimate curve compiled by Hornibrook (1992). The pair of lightly dashed lines in (A) mark the approximate northern and southern latitudinal extent of the "present" New Zealand landmass through the Cenozoic. AAPF, Antarctic Polar Front (thick black line); pSAF, proto-Subantarctic Front (thin dashed black line from the Oligocene); Subantarctic Front (thick dashed black line), pSTF, proto-Subtropical Front (thick dashed red and black line); STF, Subtropical Front (thick dashed red line). Colour versions of this figure can be downloaded from the web site given in Fig. 6 caption.

(late 1998 off eastern New Zealand), Leg 182 (early 1999 off southern Australia), and Leg 189 (early 2000 off southern Tasmania), the principal intention here has been to provide a background framework into which future, more specific paleoceanographic studies can be slotted and compared. Inevitably, major amendments, improvements, and refinements to this skeletal framework are anticipated.

2. Important large-scale controls on the evolution and position of oceanic fronts in the NZSSO during the Cenozoic have been: (1) tectonic control on the distribution of continents and basin topography in the region; and (2) global ice budget on the distribution of surface albedo, in particular the step-wise growth of ice sheets first on East Antarctica and later on West Antarctica (Table 3), which in turn is closely related to the plate tectonic changes that progressively thermally isolated the Antarctic continent. With respect to tectonic control, the NZSSO is itself a consequence of c. 80 m.y. of seafloor expansion about the Pacific-Antarctic(-Indian) spreading ridge separating the Antarctic continent in the south from the New Zealand (-Australian) continents to the north (Lawver et al. 1992). The position of the AAPF through time appears to have been guided by this ridge system in parts of the NZSSO, suggestive of a bathymetric influence on location. Likewise, the SAF off southern New Zealand closely follows the edge of the upstanding Campbell Plateau, and the STF east of New Zealand tracks the crest of Chatham Rise. Critical to the inception of full circum-Antarctic flow that eventually thermally isolated Antarctica was complete opening of first the Tasmanian gateway (by c. 31 Ma) and later the Drake gateway (certainly by c. 25 Ma), while restriction of the Indonesian gateway (c. 16 Ma) probably accounts for the Neogene climatic optimum recorded near the Early/Middle Miocene boundary in the Southwest Pacific.

3. A summary history of oceanic front development in the NZSSO follows.

(1) About 65–45 Ma (Fig. 6A, B) – From Paleocene through Middle Eocene, the entire NZSSO was under the influence of subtropical surface flows sourced out of the western Pacific. No oceanic fronts existed, although a transition zone from warm to cool subtropical conditions is registered near 55°S paleolatitude at this time.

(2) About 45–25 Ma (Fig. 6C, D) – Following ice buildup on East Antarctica during the Late Eocene, we suggest development by the latest Eocene of a proto-STF separating cool-water and warm-water masses offshore from Antarctica. In the vicinity of the Eocene/Oligocene boundary, and certainly by the earliest Oligocene, the position of this proto-STF was displaced by an AAPF at c. 65°S paleolatitude as glaciation reached sea level about East Antarctica. North of the AAPF, an associated belt of subantarctic water continued to be bounded by the proto-STF now positioned north of the Southern Ocean spreading ridge. Mid-Oligocene full opening of the Tasmanian gateway initiated development of a vigorous proto-circum-Antarctic current through the NZSSO, possibly linked to the Atlantic via a West Antarctic seaway. Northeastward-flowing filaments of these cool waters periodically impinged directly upon the New Zealand subcontinent, causing erosion and widespread

unconformity development in Oligocene–earliest Miocene cool-water carbonate deposits on the New Zealand plateau, forcing subtropical circulation northwards.

(3) About 25–15 Ma (Fig. 6E) – During the Early–early Middle Miocene, the influence of warm subtropical waters expanded south onto the New Zealand plateau at the expense of both cool subtropical and subantarctic surface flows. Contributing factors were by now a definitely fully opened Drake gateway, enabling intensified circum-Antarctic current circulation and stronger decoupling of cool from warm water belts; and perhaps more importantly, final closure of the Indonesian gateway by 16 Ma with redirection of intensified warm equatorial water flows southwards into the Tasman Sea.

(4) 15–5 Ma (Fig. 6F) – In the late Middle–Late Miocene interval we recognise the existence of first the STF, and later the SAF, in the vicinity of their present relative positions across and about the Campbell Plateau, respectively. Their development is associated with continued major buildup of ice on East Antarctica and initiation of a significant ice sheet on West Antarctica, coupled with generally more expansive and intensified circum-Antarctic flow.

(5) About 5–0 Ma (Fig. 6G) – During the latest Miocene–Quaternary period of rapidly fluctuating climatic conditions, the relative positions of the AAPF, SAF, and STF in the NZSSO were probably maintained during interglacial episodes, although their average paleolatitude positions continued to decrease by up to c. 5° to the present day because of general northwards drift of the New Zealand subcontinent. However, there is evidence for some significant differential shifts in the location of coeval oceanic fronts during major periods of glaciation within the latest Neogene, ranging from possibly remaining stationary to northward movements (of the AAPF) by as much as 10° of latitude. Details of these short-term oscillations in glacial front migrations within the NZSSO are presently virtually unknown.

4. Finally, an attempt is made in Fig. 9A to summarise the Cenozoic evolution of oceanic fronts and their associated surface-water masses in relation to paleolatitudes in the NZSSO. Superimposed on the diagram is the approximate northern and southern latitudinal extent of the New Zealand "landmass" through the Cenozoic, read simply off the paleogeographic reconstructions (Fig. 6). In turn, this synthesis can be compared in Fig. 9B to the most recent New Zealand Cenozoic marine climate record compiled by Hornibrook (1992), which is based on the southernmost fossil occurrences of warm shallow-water invertebrates and plants, normalised to modern latitude 42°S. Not unexpectedly, the broad trends in the New Zealand paleoclimate curve correspond well to the principal paleoceanographic events controlling the evolution and migration of oceanic fronts in the NZSSO (see also Table 3).

ACKNOWLEDGMENTS

Discussions with many colleagues have been instrumental in preparing this synthesis, including Lionel Carter, Martin Crundwell, Chris Hendy, Chris Hollis, Peter Kamp, Helen Neil, George Scott, and David Waghorn. The paper grew from an invitation by Bob Carter, James Cook University, Queensland, to contribute to a workshop in Townsville in 1996 on paleoceanographic gateways and frontal dynamics in the Australian-New Zealand sector of the Southern Ocean, in support of the proposal to mount ODP Leg 181 off eastern New Zealand. The perceptive comments on the paper by two anonymous referees, including drawing our attention to some other useful references, were much appreciated. Drafting assistance from Frank Bailey and Adam Vonk is gratefully acknowledged, as is funding contribution from within Marsden Fund Contract UOW523 to the University of Waikato.

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Appendix 1 Selection of papers relevant to the surface-water paleoceanography of the NZSSO, especially those marked by an asterisk.

Date	Author(s)	Region	Age	Fronts	Basis[1]	Comment
1963	Kustanowich	Southwest Pacific	Modern	STF	PF	Five latitudinal PF zones east and north of New Zealand
1967	Devereux	New Zealand	Cenozoic	–	OI	First New Zealand-based oxygen isotope climate record
1968	Kennett	New Zealand	Mio–Pliocene	AAPF, SAF	PF	Dramatic latest Miocene cooling in eastern North Island; warming in early Pliocene
1972	Keany & Kennett	Southern Ocean	Plio–Pleistocene	AAPF, SAF	PF, R	Late Neogene climate fluctuations
1973	Vella	New Zealand	Late Neogene	STF	PF	Progressive decline in mean temperature of STW and ASW; STF fluctuations
1975*	Edwards	NZSSO	Cenozoic	AAPF, SAF, STF	PT	Infers surface-water paleocirculation patterns from changing paleogeography
1975*	Shackleton & Kennett	Southern New Zealand	Cenozoic	–	OI	One of first oxygen isotope temperature records for the entire Cenozoic
1977*	Burns	NZSSO	Cenozoic	AAPF, SAF, STF	PF, NF, R	Reconstructions of water mass evolution using microfossil evidence
1978*	Kennett	Southern Ocean	Cenozoic	–	PF, NF, R, D, S	Relates Cenozoic planktic biogeography to evolution of SO water masses
1978	Sancetta	Pacific Ocean	Neogene	–	PF, NF, R	Establishes planktic provinces for four Neogene time slices
1979	Sancetta	Pacific Ocean	Paleogene	–	PF, NF, R, D	Establishes planktic provinces for six Paleogene time slices
1980*	Kennett	Southern Ocean	Cenozoic	–	various	Paleoceanographic and biogeographic overview
1986	Hodell & Kennett	Tasman Sea	Mio–Pliocene	STF	OI, PF, NF	Establishes some late Neogene paleoceanographic events in Tasman Sea
1987	Harwood	Ross Sea (SO)	Cenozoic	AAPF	D	Biosiliceous record off Antarctica
1990	Abelmann et al.	Weddell Sea (SO)	Plio–Pleistocene	AAPF	R, D, S	Biosiliceous record off Antarctica
1990	Baldauf & Barron	Global	Eocene–Quaternary	–	R, D, S	Biosiliceous record global oceans
1990*	Kamp et al.	Southern Australia	Eo–Oligocene	proto-STF	OI, PF, NF	Warm waters decoupled from circumpolar flow and possible proto-STF development
1990	Kennett & Barker	Weddell Sea	Cenozoic	–	OI, various	Relevant to Antarctic ice history
1991	Wei	Southern Ocean	Eo–Oligocene	–	NF	Abrupt temperature decrease in earliest Oligocene from nannofossil evidence
1991	Wise et al.	Southern Ocean	Paleogene	–	OI, Sed, D, NF, PF	Paleogene glacial history of Antarctica
1992*	Hornibrook	New Zealand	Cenozoic	–	FF	Most recent compilation of New Zealand Cenozoic paleoclimate record based on fossils
1992	Kennett & Warnke	Southern Ocean	Cenozoic	various	various	Collection of 18 papers bearing on geology, paleoceanography and paleoclimatology
1992	Shafik	Southern Australia	Eo–Oligocene	–	NF	Seafloor erosion and ocean cooling across boundary
1993*	Jenkins	Southern Ocean	Cenozoic	AAPF, SAF, STF	PF	Traces evolution of five Cenozoic faunal provinces in Southern Hemisphere
1993	Kennett & Warnke	Southern Ocean	Cenozoic	various	various	Collection of 13 papers bearing on geology, paleoceanography and paleoclimatology
1993*	Lazarus & Caulet	Southern Ocean	Cenozoic	AAPF, SAF	R, Sed	Links evolving radiolarian assemblages to changing surface-water circulation patterns
1994*	Zachos et al.	Southern Ocean	Paleogene	–	OI	Establishes absolute sea-surface temperatures for Southern Ocean
1996	Carter et al.	New Zealand	Cenozoic	–	Sed	Traces evolution of shallow through deep water current systems off eastern New Zealand
1998	Buening et al.	New Zealand	Eo–Miocene	proto-STF	OI	Early Oligocene development of proto-STF off eastern New Zealand
1998	Lawver & Gahagan	Southern Ocean	Cenozoic	–	PT	Suggests Early Oligocene opening of Drake Passage

[1]D, diatoms; FF, fossils; OI, oxygen isotopes; NF, nannofossils; PF, planktic foraminifera; PT, plate tectonics; R, radiolarians; S, silicoflagellates; Sed, sediments.