Preliminary ~~reanalysis~~ redating of the Holocene Roonka burials~~, and their chronology,~~ Southeastern Australia

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ABSTRACT

Roonka was one of the most complete excavations of an Aboriginal burial ground in southeastern Australia. The chronology of the site and the nature of its use have proven difficult to interpret. Previous dating and chronological interpretations of the site have emphasised a chronology of changing use and burial practices but the nature of the site and the dates obtained do not clearly support these interpretations. We report on the direct dating of human bone from a further ~~15 burials~~10 burials from the main excavation~~, of which 10 returned successful results~~. In order to further investigate the cultural chronology set out by Pretty (1977),~~ the~~ samples were selected to cover a range of burial types and preservation states. Comparison of these dates with the previous conventional dates and early AMS dates not only show the impact of improving technology but demonstrate that multiple burial styles were in use contemporaneously. Moreover, the results suggest that use of the site may have been discontinuous. Consequently interpretations that assume a chronological sequence for Roonka based on burial practice~~ or analyse the site synchronically~~ are not supported while analyses based on a synchronic interpretation may ignore significant temporal change.

KEYWORDS:

Aboriginal burials, burial practices, chronology, dating, Holocene, Roonka, southeastern Australia.

Graeme Pretty's excavation of Roonka on the Murray River (Figure 1) remains the largest and most complete excavation of an Aboriginal burial ground in Australia (Pretty 1977). Furthermore the chronology of the site with an early date attributed to a hearth of 18000 BP and a series of dates spanning the Holocene means that the finds of the site have the potential to address long standing issues of temporal change throughout the Holocene. Indeed much work has been undertaken to this end (e.g. Pate 2006; Pretty 1977; Prokopec and Pretty 1991). Nevertheless the chronology has remained difficult and many of the analyses have had to rely either upon the initial broad sequence determined by Pretty or have dealt with the remains as simply Holocene. In this paper we revisit the previous dating of the site and present the results of a recent dating effort of a further 13 individuals and redating of two. These results suggest a ~~need for a serious~~ reconsideration of the site and its possible interpretation.

The Site

Roonka lies on the bank of the Murray River in South Australia (Figure 1). The site is located at a point on the river where the East bank is a limestone cliff (Figure 2). The west bank at this point consists of upper terrace deposits lying two to four metres above the modern flood plain. ~~where the site was excavated lies on a rise about five metres above the flood plain.~~ On its eastern margin is a long arcuate~~sand~~ dune, which shelves down to the~~a~~ narrow modern flood plain crossed by channels and a lagoon. It is bordered by typha (reeds) and other edible plants, and the river was a source of fish, birds, shellfish and crustaceans. The flats could have yielded yams, fruits, herbs and game such as possums and the burrowing mammals as well as snakes and lizards (Pretty 1977). The mallee scrub of the high plain beyond was a habitat for larger game including kangaroos, wallabies, wombats and flightless birds (Figure 3).

An extensive surface exposure of human remains on the heavily eroded centre of the Roonka ~~dune~~ dune prompted exploration and then excavation of the site. This was carried out by Graeme Pretty of the South Australian Museum and a group of volunteers in 1968 (Walshe 2009). Excavation continued until 1974. Similar exposures of human remains have been found in s~~ource bordering dunes~~and bodies along the Murray (e.g. Bonhomme 1990; Littleton 1999; Pardoe 1988)~~, however, Roonka remains unusual in the extent of human remains and the artefacts found with them.~~

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Excavations centred upon Trench A (30 x 15 sq m), but three~~wo~~ adjacent Trenches: A1, B and OA (5 by 5 m) were also opened~~.~~ (Figure 2). All of these were located upon the dune. Other areas of the site were excavated ~~including some occupation of a~~as well as a locality of possibly Pleistocene date on the East Bank of the river (Robertson and Prescott 2006). However, analysis of the ~~bio~~archaeology has largely been based upon the excavated remains recovered from Trench A which is also the focus of this paper. The dune is interpreted by Rogers (1990) as a lunette created by wind erosion from the adjacent western alluvial flat. The aeolian deposits lie on a paleosol around 45 cm thick (Layer 4) recorded by Pretty (1977) ~~base of the dune is sand (probably alluvial in origin) overlying basal grey-green clays. Above it lies a 45cm thick layer of terra rosa~~ that has no sign of human occupation with the single exception of an intrusive burial pit. Topping this stable dune core lies a layer of variable thickness (85 -145 cm) of aeolian sand. At the base of this layer (Layer 3) is a scattered series of possible hearths, one of which has been dated based on charcoal to 18050 ± 340 BP (ANU-406, Pretty 1977: 297). Through L~~l~~ayer 3 there is evidence of human activity, particularly two pits apparently from previous occupation and a series of inhumations either in cylindrical shafts or shallow longitudinal pits. At the top of this layer inhumations contain dark ashy soil. A grave from this part of the layer was dated 3930 ±120 BP (ANU-407) while one of the deepest graves was dated through associated charcoal to 6910 ± 450 BP. The layer above this (Layer 2) is humic sand and carbon. This layer seems to have been a disturbed mix of post European debris with older deflation products from a soil surmounting the dune. It is topped by a thin (15-40cm) layer of reddish sand resulting from recent deflation of adjacent surfaces. This was archaeologically sterile (Pretty 1977, 1988).

The extent of disturbance and deflation of the upper levels of the site is comparable to other ~~dune~~ burial sites along the Murray ~~also marked by eroding burials~~ (e.g. Katarapko, Lake Victoria, Rufus River, Lindsay Island, Snaggy Bend (Clarke and Hope 1985, Dowling 1997, Littleton et al. 1994, Pardoe 1993). The most severe deflation appears to have occurred as a result of stocking of European domesticates from the 1840s on (Pretty 1977). However, shorter periods of at least localized deflation and exposure are probable throughout the dune's history. ~~particularly with human occupation upon the dune itself.~~ This leads to a problem of 'unquantifiable absences' (Chapman 1994:42). Pretty and his team did undertake a collection of human bone fragments from the surface of the dune and these have yet to be inventoried. There are also a number of human remains from the area that were handed into the South Australia Museum, or to the police, prior to any excavation of the site (also listed in Table 1).

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In all 108 distinct graves were excavated from Trench A. ~~However, s~~Some of these graves contain more than one individual and others represent more than one pit (e.g. Grave 13 which is a mixed assemblage of at least two adults and three children). Burials were excavated carefully and in three cm. spits with great attention paid to identifying the pit structure at its greatest elevation. Pretty's concern was with stratigraphy since he saw this as the main way of establishing a site chronology (Pretty1977). Our recent inventory of the ~~site skeletons~~graves and human remains (Table 1) ~~demonstrates how the number of discrete individuals is a minimum count of the total number of burials from the area~~is calculated from the minimum number of individuals within each grave. ~~This inventory was comprehensive in that the minimum number of individuals within a grave~~Our results, therefore, differ slightly from previous counts~~ was determined hence the numbers differ from previous counts~~ (Prokopec 1979, Prokopec and Pretty 1991, Candy 2009).

Burials and their sequence

Pretty using radiocarbon, stratigraphy and burial style ultimately determined four broad periods of site use:

I: Pleistocene, older occupation

II: The 'necropolis', 7000 – 4000 BC

III: Occupation and burial, 4000 BC – AD 1850

IV Post European colonization (Pretty 1977).

Roonka I is represented at the base of Layer 3 by what were described as scattered hearths including mussel shell. These are associated with the single charcoal date of 18150 ± 340 BP (Pretty 1988). There are further possibly Pleistocene finds from East Bank including what was described as three badly preserved skeletons "little more than shadows in the sand" (Pretty pers com. in Robertson & Prescott 2006:2592).

Roonka II (Layer 3) is primarily represented within the Trench A excavation and is represented by 23 deeper inhumations (12 graves) distinguished by the bone preservation (manganese staining, high levels of mineralisation, poor condition), the deposit (coarse red sand with ironstone nodules), and the lack of any intrusive occupation residues. Graves within this deposit consisted of what Pretty (1977, 1988) identified as vertical shafts (or shaft tombs) as well as graves containing extended burials. No occupation debris was associated with the Roonka II burials.

The largest number of burials is associated with Roonka III which Pretty initially divided into two phases: IIIa or IIIb (Pretty 1977). Three burial styles were identified: supine extended; contracted (i.e. variable degrees of flexion and lying on the side); and recumbent contracted (the trunk on its back but the legs in a kneeling or squatting position i.e. lower legs folded under the thighs). Unlike the Roonka II burials, these graves were both superimposed on each other and associated with occupation debris. The initial distinction between IIIa and IIIb was that extended burials were stratigraphically above the recumbent contracted positions (associated with one charcoal date of 3930±120BP). Extended and contracted burials were assumed to be contemporary (Pretty 1988). The association between these burials and the nature of occupation appears distinct from what is described for Roonka II. While some graves seem to have evidence of a gap in occupation following burial (or at least avoidance of that particular place) others show extensive reworking of pits and disturbance of bone.

The occupation debris on the site consists of surface platforms of cobbles as well as ovens dug below the surface and rubbish pits. There is some confusion about the extent of this activity – Pretty always referred to it as occupation (Pretty 1977, 1988) but the density of it in the area of burials in particular requires some reanalysis since the site archives suggest a scattered and intermittent set of activities rather than a coherent occupation layer (Walshe 2009: 288). The confounder is the erosion of this level.

In Trench B there is a clear shallow midden layer covering a thinner discontinuous layer of hearths and burnt mammal bone. On the midden's surface are several ashy hearths. There is an associated assemblage of both stone and bone artefacts.

The last burials at Roonka III date to European contact: three graves found with trade goods have been dated by Pretty to AD 1840-1855. This marks the beginning of the last phase of site use as the site is heavily impacted by initially the movement of stock and then agricultural activities including the keeping of pigs. Clearing of trees as well as the damage sustained by stock led to extensive deflation of the dune contributing to the difficulty of interpreting the upper levels of the site (Pretty 1977).

Dating of the site

The original dating of Roonka was based upon a series of conventional radiocarbon dates (collagen, apatite and charcoal) as well as detailed analysis of stratigraphy (Table 2) (Pretty 1988). Thermoluminescence dating of sediments provided a sequence for dune formation (Robertson and Prescott 2006) which ties in with the radiocarbon dating of charcoal in~~at~~ the major dune layers.

Pretty faced two challenges at the Roonka site. The first was the state of radiocarbon technology at the time. Only conventional dates were possible, they were expensive, and direct dating of bone required large samples. Dating of a sample of graves was undertaken on charcoal from the grave fill and on both the crude collagen (HCl extracted protein) and apatite fraction of the bone. Based on analysis of the laboratory records, Pretty tended to only accept the collagen dates where these results came back in agreement with the apatite. ~~This pre-treatment for collagen and apatite is currently considered unreliable for dating archaeological remains (Petchey 1999).~~ The second challenge was the stratigraphy. As a dune the site had been subject to erosion. This was particularly severe with the introduction of European stock (Pretty 1977), but probably also occurred throughout the period of the site's use. ~~In addition the burials were intrusive into that stratigraphy.~~ While emphasis was placed upon identifying the uppermost level of the intrusive burial cuts the reworking of dune sands and cross cutting of graves made meant that those determinations were really a minimum i.e. a *terminus post quem*. Tolcher's description of the attention paid to gauging and recording those relationships is a testament to the archaeological effort to construct a stratigraphic sequence in the most challenging of conditions (Tolcher 2009).

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From this record of dates and stratigraphic position, Pretty (1988) suggested the following sequence:

Phase II: erect and recumbent extended burials in layers 3 and 2/3 (c7000-4000BP);

Phase IIIa: Recumbent contracted burials (<4000 BP);

Phase IIIb: Fully extended and contracted burials (<1500 BP).

Pretty noted that despite this phasing there was no distinct break within the burial sequence indicative of temporal discontinuity (Pretty 1988). It was thought, however, that there was a distinct shift between Phase II and Phase IIIa from drilled shell and bone artefacts to undrilled objects (Pretty 1977).

In some publications burials were seriated using Uranium/Thorium uptake and tied to the radiocarbon ages (Pretty et al. 1998). While these ages show a strong correlation ($r^2 = 0.778$, d.f. 13), individual differences are up to 2,500 years suggesting it is an unreliable indicator of individual burial ages.

Additional dating was undertaken by Pate and colleagues (1998) recognising the problems of stratigraphy and that the only solution would be to date individual burials. Pate's eight extra dates along with Pretty's original determinations are shown in Table 2 and Figure 4 recallibrated using SHCal13 (Hogg et al. 2013). This redating suggested that the original sequence might be problematic. For example, Grave 51 assumed by Pretty to be an older grave because of its stratigraphic depth and the vertical burial position yielded a late Holocene date (Pate et al. 1998). Immediately apparent, however, are the large error margins on these dates making it impossible to determine whether burials occurred continuously or were episodic.

Samples and Methods

As a consequence, in consultation with the River Peoples of Murray and Mallee Association Inc., we submitted 15 samples of human bone for analysis (Table 3). All samples were from either a long bone fragment or a phalanx. The 15 were selected to sample a range of preservation and to include each style of burial.

All bone dates were prepared and analysed at the Waikato Radiocarbon Dating Laboratory in New Zealand. Gelatin was extracted from each specimen and ultra-filtered following protocols outlined in Petchey et al. (2014). Bone selected for ^{14}C conform with standard quality control parameters; a %N value that ranges between 11 and 16, a %C value between 30 and 45, a C:N ratio range of 3.1-3.5 and a % ultra-filtered gelatin yield of >0.5% of the starting weight of bone powder (Petchey et al. 2014).

Ten of 15 samples yielded sufficient well-preserved carbongelatin for a radiocarbon date (Table 3). Of these, nine yielded sufficient protein to also collect carbon and nitrogen stable isotopes for dietary evaluation. The majority of the values confirm the primarily non-marine nature of the individuals (Pate & Owen 2014, Richards & Hedges 1999), justifying the use of a terrestrial calibration (SHCal13, Hogg et al. 2013) rather than a mixed marine/terrestrial calibration. The isotope results fall within the ranges noted by Pate (Pate 2000, Pate & Owen 2014) for the Roonka sample but indicate a +2-2.5‰ increase in nitrogen from the two 4,000-year-old dates to the 1,500-year-old individual indicative of a probable shift in trophic levele BP. This is a small sample but potential temporal change needs further testing.

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Results

The new dates ~~end up being~~are somewhat clustered, which is distinctly different from previous dates despite efforts to make sure that we had sampled preservation and burial style straddling across the entire time period (Figure 4). Three dates are around 45~~0~~00 cal BP, one 1500 cal BP and the remaining six less than 500 years. Three of these are securely before European contact, the remainder could be post-contact.

The technical advances in radiocarbon ~~dating~~ precision are obvious when the error margins of the recent dating sample are compared to the older dates (Figure 4). Contrary to the previous work which has suggested continuity, calibration and presentation of the entire error ranges demonstrates how insecure that interpretation is. ~~We made efforts to straddle the time period that Trench A was in use but the results group around 4000 cal BP, 1500 cal BP and to less than 500 cal. BP.~~ There have also been significant improvements in the pretreatment and interpretation of the reliability of bone dates. Our attempt to date the two 'oldest' burials (107 and 89) at Roonka originally dated by charcoal was unsuccessful – both bone samples dissolved in acid demonstrating poor preservation. We also redated Burial 51 (dated by Pate et al. 1998) and the adult from Grave 108 (dated by charcoal by Pretty1977). Our dates for both are younger. The inventory of remains in Burial 51 identified a series of isolated elements from a comingled individual (probably a lag deposit). ~~In addition the field notes for Burial 51 indicate that the body was covered with organic remains which supports the younger date.~~ Given the good preservation state of the Burial 51 bone (as indicated by the high % gelatin yield (Table 3)) i~~I~~t is quite possible that the contradiction in dates therefore is the result of dating some of the lag deposit incorporated when the pit for Burial 51 was made. ~~but the range for Burial 51 falls within three standard deviations.~~ The carbon sample for Burial 108 was a general carbon sample from the grave pit and therefore the disparity may be due to the incorporation of older material from the sediments as the grave was filled. Both of these instances will need further checking.

Three of the dates (burials 77, 16, 70 and 78) are unable to be resolved. ~~since their margins come into modern but i~~It should be noted one of these individuals (Burial A78) had caries which does open the possibility of them being post-contact burials.

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The contradiction between this recent dating and earlier ~~models~~ analyses is not unexpected (Pate et al. 1998). ~~The difficulty is with the dune landform~~One difficulty is with the interpretation of the stratigraphy. While the core of the dune has stabilised, the upper sediments have been reworked and localised conditions within the dune affect diagenesis (Pate 1997, 1998). Most of the obvious erosion ~~obviously~~ occurred after European settlement and use of the area ~~dune~~ by stock (Pretty 1977). Dune erosion and loss of sediments is also like to have occurred during the late Holocene when the Murray River gorge would have been susceptible to the variable and more intense periods of aridity and flooding. ~~However, there is no guarantee particularly during the late Holocene with variable and more intense periods of aridity and of flooding, that dune erosion and loss of sediments did not occur in parts of the dune.~~ Burials in ~~dunes~~ sand bodies can be subject to periods of exposure and of re-covering as evidenced by the finding below surface of bleached and ~~fragmented~~ weathered remains at Roonka (Hodges pers. com.) and elsewhere (Littleton 2000). Furthermore, as the dating of Gillman mound in ~~,~~ Adelaide (Littleton et al. 2013), indicates, stratigraphic depth is not necessarily indicative of relative age. Burial pits were dug to a range of depths and the ~~dune's~~ site~~surface~~ probably had an undulating surface as sediments accumulated around vegetation or were removed from discrete blowouts. Human activity on the dune would have assisted in this disturbance of the dune's surface. Detailed re-examination of burials needs to be undertaken to check for signs of both previous exposure and of animal disturbance.

The discovery of multiple styles of burial in use within a short time frame and possibly contemporaneously confirms other finds along the Murray River (Littleton 2007, Littleton & Allen 2007). There are two possible scenarios given the formality of these practices. One is that they represent change over much shorter spaces of time than envisaged by Pretty (1988). The other is that they are micro-traditions in the sense of Chapman (2006) distinctive to a segment of society or restricted to particular segments of society. Distinguishing between these two alternative requires more dating and finer interpretation of burial practices looking particularly for any evidence of coherent clusters of similar burial patterns reflecting precise knowledge and memory (Littleton and Allen 2007) and of social distinction.

Discussion

~~Stripping back the inferences then what we have for Roonka in relation to dates is~~The simplest chronology and interpretation of site use is: a possible start date of 18,000 BP based on a radiocarbon date from charcoal (the uncertainty around this single date rests on the identification of the source sample as a hearth and not the base of a tree); the dates for burials on ~~North~~ Roonka Flat from possibly 7000 BP and a stratigraphic pattern of burials which

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may suggest that erect graves are the earliest with a possible addition of new burial styles over time. However, in reality there is very little indication of the way in which the site was used even in broad terms as either episodic or continuous.

This redating effort opens up the possibility of being able to finally address issues of temporal change and continuity based on the burial record and begin to answer some of those initial queries that Graeme Pretty, the Aboriginal community and the excavation volunteers had about this burial place. While Roonka has been interpreted as part of a culture historical sequence, Pretty's interpretation is that the site as a whole represented a central place with variable use over time. He interpreted (particularly in his earlier work) that the site had a distinct cultural chronological sequence reflected by change in purpose and by changes in the particular burial practices used at the site (Pretty 1977, 1988; Pretty and Kricun 1989). His sequence implies for the Holocene initial use as a cemetery for selected individuals and then on-going persistent use for burial but with occupation co-occurring. However, it is this 'later group' that is seen as indicative of the development and marking of social status (Pate 2006). The practices at Roonka Pretty saw as part of a broader set of practices along the Murray River, potentially representing only a limited set of burial modes in use at any one time (Pretty 1977). Alternate readings have resulted in a largely synchronic view of the site as indicative of intensification based upon evidence of local exploitation of resources, inferred limited gene flow and moderate levels of disease reflecting high population density (Pate 2000, 2006; Pardoe 1995; Webb 1984, 1995). The inference has been that increased population density led to people settling into riverine resources and depending on mass harvesting of particular resources.

An alternative model of more stochastic variation as people adapt flexibly to changing circumstances might be more consistent with both Holocene environmental patterns and archaeological sequences elsewhere (Ulm 2013**)**. The new dates, which suggest episodic use and possibly more heterogeneity in burial practices over short spaces of time, demonstrate that this could be the case. Such a model, however, is~~It is however~~ not testable on the existing analyses since, as this small sample shows, it requires both more dates and a focus on variability rather than an average. If, however, we do not assume either an aggregate site use or a clear culture sequence then aspects of continuity and change become apparent.

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REFERENCES

Bonhomme T 1990. Report on Burials and Sandmining in the Riverine Plain. Unpubd. report to NSW National Parks and Wildlife Service, Sydney.

Candy R 2009. Palaeodemography of the Roonka Flat. In Walshe K (ed) *Roonka: Fugitive Traces and Climatic Mischief*, pp. 299-311. South Australian Museum, Adelaide.

Chapman J 1994. The Living, the Dead and the Ancestors; Time, Life Cycles and the Mortuary Domain in Later European Prehistory. In Davies J (ed) *Ritual and Remembrance: Responses to Death in Humnan Societies*, pp. 40–85. Sheffield Academic Press, Sheffield.

Chapman RW 2006. Mortuary Analysis: A Matter of Time? In Rakita G, Buikstra J, Beck LA, Williams S. (eds.) *Interacting with the Dead. Perspectives on Mortuary Archaeology for the Next Millennium*, pp. 25–40. University Press of Florida, Gainesville.

Clark P, Hope J 1985. Aboriginal burials and shell middens at Snaggy Bend and other sites on the Central Murray River. *Australian Archaeology* 20:68–89.

Dowling P 1997. A Great Deal of Sickness. Unpublished MA Thesis, Australian National University, Canberra.

Hogg AG, Hua Q, Blackwell PG et al. 2013. SHCal13 Southern hemisphere calibration, 0-50,000 years cal BP. *Radiocarbon* 55(2): 1-15.

Littleton J. 2000. Taphonomic effects of erosion on deliberately buried bodies*. Journal of Archaeological Science* 27(1): 5-18.

Littleton, J 1999. East and West: Burial practices along the Murray River. *Archaeology in Oceania* 34: 1–14.

Littleton J 2007. From the perspective of time: Hunter-gatherer burials in south-eastern Australia. *Antiquity* 81(314): 1013–1028.

Littleton J, Allen H 2007. Hunter-gatherer burials and the creation of persistent places in Southeastern Australia. *Journal of Anthropological Archaeology* 26(2): 283–298.

Littleton J, Johnston H, Pardoe C 1994 The Lake Victoria Lakebed Survey. Unpubd report for the NSW National Parks and Wildlife Service, Sydney.

Littleton J, Walshe K, Hodges J 2013. Burials and time at Gillman Mound, northern Adelaide, South Australia. *Australian Archaeology* 77: 38–51.

Pardoe C 1988. The cemetery as symbol. The distribution of prehistoric Aboriginal burial grounds in southeastern Australia. *Archaeology in Oceania* 16: 173–178.

Pardoe C 1993. Wamba Yadu, a later Holocene cemetery of the Central Murray River. *Archaeology in Oceania* 28: 77–84.

Pardoe C 1995. Riverine, Biological and cultural evolution in southeastern Australia. *Antiquity* 69(265): 696–714.

Pate, FD 1997. Bone collagen diagenesis at Roonka Flat, South Australia: Implications for isotopic analysis. *Archaeology in Oceania* 32: 170-175.

Pate, FD 1998. Bone collagen preservation at the Roonka Flat Aboriginal burial ground: A natural laboratory. *Journal of Field Archaeology* 25: 203-217.

Pate FD 2000. Bone chemistry and palaeodiet: Bioarchaeological research at Roonka Flat, lower Murray River, South Australia 1983-1999. *Australian Archaeology*50: 67–74.

Pate FD 2006. Hunter-gatherer Social Complexity at Roonka Flat, South Australia. In David B, Barker B, McNiven I.J. (eds) *The Social Archaeology of Indigenous Australia*, pp.226-241. Aboriginal Studies Press, Canberra.

Pate FD, Owen TD 2014. Stable carbon and nitrogen isotopes as indicators of sedentism and territoriality in Late Holocene South Australia. *Archaeology in Oceania* 49: 86-94.

Pate FD, Pretty GL, Hunter R, Tuniz C, Lawson EM 1998. New Radiocarbon Dates for the Roonka Flat Aboriginal Burial Ground, South Australia. *Australian Archaeology* 46, 36–37.

Petchey F 1999. New Zealand bone dating revisited: A radiocarbon discard protocol for bone. *New Zealand Journal of Archaeology* 19: 81-124.

Petchey F, Spriggs M, Bedford S, Valentin F, Buckley H 2014 Direct radiocarbon dating of burials from the Teouma Lapita cemetery, Efate, Vanuatu. *Journal of Archaeological Science* 50: 227-242.

Pretty GL 1977. The Cultural Chronology of Roonka Flat - A Preliminary Consideration. In Wright RVS (ed) *Stone Tools as Cultural Markers* pp. 288–331. AIAS, Canberra.

Pretty GL 1988. Radiometric Chronology and Significance of the Fossil Hominid Sequence from Roonka, South Australia. In J. Prescott, (Ed) *Early Man in the Southern Hemisphere Supplement to Archaeometry: Australasian Studies 1988*, pp. S32-S52. University of Adelaide Press, Adelaide.

Pretty GL, Kricun M 1989. Prehistoric health-status of the Roonka population. *World Archaeology* 21(2): 198–224.

Pretty GL, Henneberg M, Lambert KM, Prokopec M 1998. Trends in stature in the South Australian Aboriginal Murraylands. *American Journal of Physical Anthropology* 106(4): 505–514.

Prokopec M 1979. Demographical and morphological aspects of the Roonka population. *Archaeology & Physical Anthropology in Oceania* 14(1): 11–26.

Prokopec M, Pretty GL 1991. Observations on Health, Genetics and Culture from Analysis of Skeletal Remains from Roonka, South Australia. In Ortner DJ, Aufderheide D (eds) *Human*

Paleopathology: Current Syntheses and Future Options, pp. 151–9. Smithsonian Institution, Washington.

Richards, M.P., Hedges, R.E.M., 1999. A Neolithic revolution? New evidence of diet in the British Neolithic. *Antiquity* 73: 891-897.

Robertson GB, Prescott JR 2006. Luminescence dating at the archaeological and human burial site at Roonka, South Australia. *Quaternary Science Reviews* 25(19–20): 2586–2593.

Rogers PA 1990. Late quaternary stratigraphy of the Roonka archaeological sites *Quarterly Geological notes (The Geological Survey of South Australia)* 113: 9-14.

Tolcher H 2009. In search of the Ngaiawang. In Walshe K (ed) *Roonka: Fugitive Traces and Climatic Mischief*, pp. 33-158. South Australian Museum, Adelaide.

Ulm S 2013. "Complexity" and the Australian Continental Narrative: Themes in the Archaeology of Holocene Australia. *Quaternary International* 285, 182–192.

Walshe K (ed) 2009. *Roonka: Fugitive Traces and Climatic Mischief*. Hyde Park Press, Adelaide.

Webb S 1984. Intensification, population and social change in southeastern Australia: The skeletal evidence. *Aboriginal History* 8(1-2): 154-172.

Webb S 1995. *The Palaeopathology of Aboriginal Australians*. Cambridge University Press, Cambridge.

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FIGURES

Captions

Figure 1: Location of Roonka in south-eastern Australia.

Figure 2: Map of Roonka showing the surrounding environment and excavation areas referred to in text (modified from Pretty 1988).

Figure 3: Recent photograph of Roonka site area from east bank of the Murray River.

Figure 3: Calibrated radiocarbon dates from Roonka (most recent analysis at the bottom), calibrated in OxCal v.4.2.3 (Bronk Ramsey 2013) using the SHCal13 atmospheric curve (Hogg et al. 2013). C = Charcoal.

Table 1: Inventory of the human remains from Roonka based on identification of the minimum number of individuals.

Location	**Adult**	**Juvenile**	**Infant**	**Subtotal**
1A	3	1	1	5
A	101	38	13	152
B	13	6	2	21
B/1	0	0	0	0
B1	1	0	0	1
Dune*	9	1	1	11
Baulk	6	0	0	6
East Bank	0	0	0	0
North Flat	10	0	0	10
Station*	1	0	0	1
0A1	2	0	0	2
0A2	1	0	0	1
Blanchetown*	2	0	0	2
Roonka*	1	0	0	1
Total	**150**	**46**	**17**	**213**

* Unexcavated remains handed in prior to excavation of the Roonka site but known as coming from the Roonka area.

Table 2: Radiocarbon dates reported by Pretty (1977 and site archives) and Pate (1998) recalibrated in OxCal v.4.2.3 (Bronk Ramsey 2013) using the SHCal13 atmospheric curve (Hogg et al. 2013). Paired collagen apatite dates are indicated with the apatite conventional age in brackets under the collagen result.

	Conventional Radiocarbon Age	Calendric yrs 95.4% prob. (median)	Material	Sample Number
A-77^	220 ± 80 BP	AD 1510-1950 (AD 1960)	Charred sand	ANU 3262
A-80^	410 ± 60 BP	AD 1440-1650 (AD 1540)	Crude collagen	ANU 4038b
A-51*	1330 ± 140 BP	AD 460-1030 (AD 760)	Crude collagen	OZA 672
A-92*	1770 ± 150 BP	50 BC-AD 630 (AD 300)	Crude collagen	OZA 673u1
A-32A*	1870 ± 170 BP	BC 340-AD 590 (AD 180)	Crude collagen	OZA 674U2
A-10^	2120 ± 100 BP (1890 ± 100) BP	380 BC –AD 120 (120 BC)	Crude collagen	ANU 1783 (ANU 1782)
A-64^	2870 ± 260 BP (4030 ± 200) BP	1650-390 BC (1040 BC)	Crude collagen	ANU 3877B (ANU 3877A)
A-9^	3080 ± 70 BP (2780 ± 160) BP	1450-1050 BC (1280 BC)	Crude collagen	ANU 1751C ANU 1751B
A-12A*	3480 ± 180 BP	2290-1300 BC (1770 BC)	Crude collagen	OZA 671U2
A-4*	3610 ± 150 BP	2350-1520 BC (1930 BC)	Crude collagen	OZA 667
A-23*	3620 ± 360 BP	2920-1030 BC (1990 BC)	Crude collagen	OZA 669
A-48^	3930 ± 120 BP	2860-1980 BC (2360 BC)	Charcoal	ANU 407
A-87*	4240 ± 360 BP	3710-1820 BC (2800 BC)	Crude collagen	OZA 670
A-1*	4730 ± 310 BP	4230-2620 BC (3420 BC)	Crude collagen	OZA 666
A-108^	5610 ± 120 BP	4710-4070 BC (4420 BC)	Charcoal	Z 2001
A-89^	6910 ± 450 BP	6760-4800 BC (5800 BC)	Charcoal	ANU 1408
A-107^	7480 ± 440 BP	7460-5560 BC (6380 BC)	Charcoal	ANU 1428

^ = Dated by Pretty (1977 plus field archive); * - Dated by Pate et al 1998.

Lab code prefixes – i.e. ANU (Australian National University); OZA (ANSTO); Z (Ruder Boskovic Institute, Zurich.

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Commented [FP24]: 6660-6020BP, 6370BP
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Table 3: Quality control data and stable isotope results for radiocarbon samples submitted to the Waikato Radiocarbon Dating Unit. All results on ultrafilered gelatin (Petchey et al. 2014).

Sample No.	Burial	Conventional Radiocarbon Age	Calendric yrs 95.4% prob. (median)	C:N	% gelatin Yield	%C	δ15N vs Air ‰	δ13C vs PDB ‰	Burial Type Original sequence
39308	A-13A	na		na	0	na			Fully extended
39309	A-16	178 ±25 BP	290-1950BP (150BP)	3.32	2.4	43.26	11.94	17.99	Fully extended
39310	A-18	380±25 BP	490-320 BP (390 BP)	3.28	2.2	43.58	12.96	19.15	Contracted IIIb
39311	A-20	4093 ±25 BP	4790-4420 BP (4520 BP)	3.35	0.6	42.19	10.44	18.93	Fully extended IIIb
39312	A-48	na		na	0	na			Recumbent contracted IIIa
39313	A-50	1511 ±25 BP	1410-1300 BP (1350 BP)	3.4	2.6	43.09	13.03	18.53	Fully extended IIIb
339314	A-51	450 ± 25 BP	520-330 BP (480 BP)	3.23	7.4	43.90	11.65	19.45	Erect II
39315	A-70	179 ±25 BP	290-1950 BP (150 BP)	3.23	5.5	43.59			Unassigned
39316	A-78	209 ±25 BP	300-1950 BP (190BP)	3.38	2.0	44.40	12.60	21.26	Recumbent contracted IIIa
39317	A-80	322 ±25 BP	450-290 BP (380	3.31	7.6	43.84	11.69	21.74	Contracted IIIb

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			BP)						
39318	A-89	na		na	0	na	12.58	20.27	Erect II
39319	A-90	4455 ±25 BP	5270-4860 BP (4990 BP)	3.31	1.7	41.37	10.94	19.00	Fully extended IIIb
39320	A-107	na		na	<0.034	na			Erect II
39321	A-108A	4032 ±25 BP	4570-4350 BP (4470 BP)	na	1.0	na			Recumbent contracted IIIa
39322	A-110				<0.064				Contracted IIIb

$\delta^{13}C$ measured relative to VPDB with precision of ±0.1‰. $\delta^{15}N$ measured relative to AIR and with precision of ±0.2‰.