because (1) this is the only fossiliferous deposit in Wright Valley, (2) the argument that this is a terrestrial outwash deposit is unsatisfactory, and (3) because a more accurate date on this deposit would provide a valuable clue to the minimum age for glacial dissection of the subjacent crystalline basement floor of Wright Valley.

The Pecten Glaciation is said to be the oldest of four glaciations that entered Wright Valley from the Ross Sea. The stratotype is in the middle of Wright Valley, some 40 kilometers west of McMurdo Sound, and comprises a basal unweathered till overlain by the Pecten gravels. Scanning electron microscope studies show that the unweathered till contains a high proportion of fine quartz that displays outlines and microtopography characteristic of a glacial origin. The Pecten gravels contain a smaller proportion of glacial quartz. Dropped pebbles and boulders are present in both units. Quartz grains with fluvial and volcanic origins occur most commonly in the Pecten gravels. The basal unweathered till contains a few, probably reworked, foraminifera, fragments of molluscan shell, and numerous complex and fragile carbonate structures which take the form of elongate spines, hooks, barbs, and cellular networks. The exact origin of these structures is uncertain but they are thought to be holothurian spicules.

Intact and fragmented shells of *Chlamys tuftsensis* Turner are the most obvious fossil present in the Pecten gravels. Much of the shell material is densely bored, probably by a clinoid sponge. Sponge spicules and few ostracod fragments are also present. The Pecten gravels contain a rich and well preserved assemblage of calcareous foraminifera. *Buccella* n.sp. is the dominant taxon, the minor taxa including species of *Triloculina, Marginulina, Dentalina, Lagena, Globulina, Ramulina, Fissurina, Neoconorbina, Rosalina, Turrispirillina, Patellina, Elphidium,* and *Globocassidulina.* Some tests show evidence of predation, perhaps caused by a boring polychaete.

A comparison of this fauna with Recent assemblages from the McMurdo Sound-Ross Sea area suggests that the Pecten-gravels foraminifera inhabited marine water no deeper than 90 meters. The presence of large numbers of *Buccella* n. sp., as well as considerable numbers of *Elphidium* support the existence of a relatively shallow inshore marine environment. This new species of *Buccella* also has been found in large numbers in the Scallop Hill Formation on White Island. The following conclusions are drawn from preliminary studies:

1. The deposits of the Pecten Glaciation stratotype are *in situ* marine sediments, and the microfauna in them is an unmodified and natural assemblage of relatively shallow water taxa.

2. The argument that the Pecten gravels were deposited in a glaciofluvial environment is rejected, as is the existence of a Pecten Glaciation. Sediments at the stratotype were deposited in interglacial or near interglacial conditions.

3. Following the major phase of glacial dissection of Wright Valley a marine incursion converted it into a fjord. This fjord was ice-covered, probably by a floating glacier tongue from the western end of the valley, during all or most of the year. The unweathered till and Pecten gravels are composed largely of glacial rock flour, boulders, and pebbles dropped from this floating ice tongue.

4. Glacio-isostatic rebound brought about a regression of marine waters from the valley, probably leaving large brackish and saline lakes. A series of relatively minor glacial advances later occurred in parts of Wright Valley.

5. Micropaleontological work suggests that the Pecten gravels and the Scallop Hill Formation (of Black and White Islands) are correlatives.

6. Isotope dating of subjacent volcanic rocks from Wright Valley and Black Island indicates that the Pecten gravels and Scallop Hill Formation are no older than late Pliocene (3.4 to 3.9 million years) while an isotope date on shell material of *Chlamys tuftsensis* indicates an age no younger than 800,000 years. The writer favors marine transgression into Wright Valley during the late Pliocene.

Bathymetry and bottom sediments of Lake Vanda, Antarctica

Campbell S. Nelson *and* A. T. Wilson
School of Science, University of Waikato
Hamilton, New Zealand

Lake Vanda (77°32'S. 161°30'E.) occupies an undrained bedrock depression in the lowest part of the Wright Valley, Victoria Land, Antarctica, 29 kilometers west of Wright Lower Glacier and 18 kilometers east of Wright Upper Glacier. The lake has a maximum length of 5.64 kilometers, a maximum width perpendicular to the length of 1.51 kilometers, an area of about 5.21 square kilometers, and a permanent covering of about 3.6 meters of ice. During the Dry Valley Drilling Project, it is proposed to core the entire thickness of bottom sediments in Lake Vanda to elucidate, among other things, aspects of lake stratigraphy, petrology and hydrology, geothermal gradients in the area, and paleoclimates. To assist in locating the best site for the Lake Vanda drill hole, the writers spent 10 days in January 1972 establishing a general bathymetric map of the lake and the nature of the bottom surface sediments. Preliminary results of this

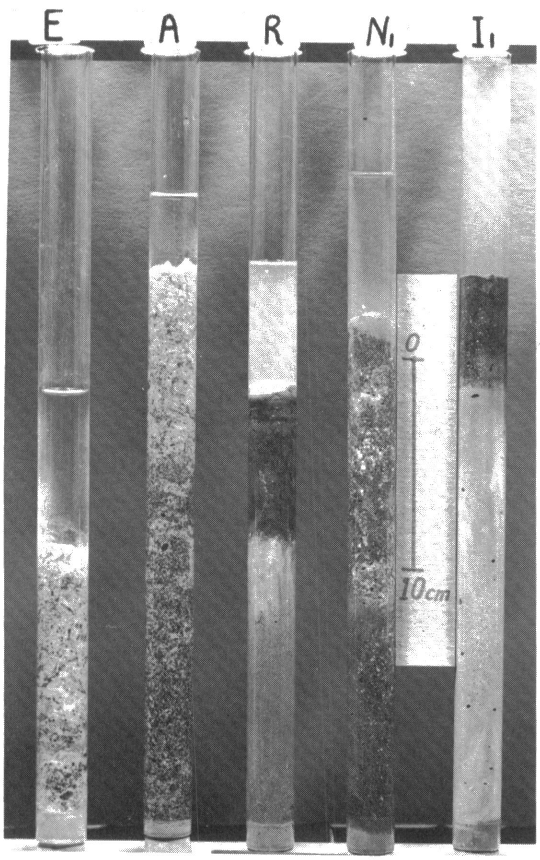

Figure 2. Bottom sediment cores from Lake Vanda. Location of cores and water depth are given in fig. 1. See text for lithological descriptions.

reconnaissance are reported here; more detailed textural, mineralogical, geochemical, and biological investigation of the sediments is in progress.

The depth of the lake was measured to the nearest 0.1 meter through holes drilled in the ice cover at 25 points (A to Y in fig. 1). All depth measurements were made from the lake water level. Additional spot depths recorded in selected earlier works (Wilson and Wellman, 1962; Ragotzkie and Likens, 1964; Angino *et al.,* 1965) were corrected for the mid-January 1972 lake level of 84.3 meters above sea level (personal communication, Vanda Station personnel) and the data combined in constructing the generalized bathymetric map shown in fig. 1. A maximum depth of 68.8 meters is recorded near the center of the western lobe of the lake within a 68-meter "depression" alined roughly north-south across the general east-west trend shown by the shallower isobaths. The maximum depth zone appears to correspond to that position in the lake farthest from the influence of easterly and westerly sediment sources.

The lake bottom sediments were sampled at each of the 25 drill holes using a 40-centimeter-long gravity corer. Broadly, two contrasting bottom sediment facies are recognised, each sharply separated by the 60-meter depth contour. Shallower than 60 meters, the environment is aerobic; the sediments are mainly pale fawn, massive, medium and coarse quartzofeldspathic sands (mean grain size 0.25 to 1.00 millimeter) overlain by a lighter colored layer of biological detritus up to 13 centimeters thick (fig. 2, cores E and A). This organic layer consists mainly of dead algae with living and dead diatoms, living green algae, fungal mycelia,

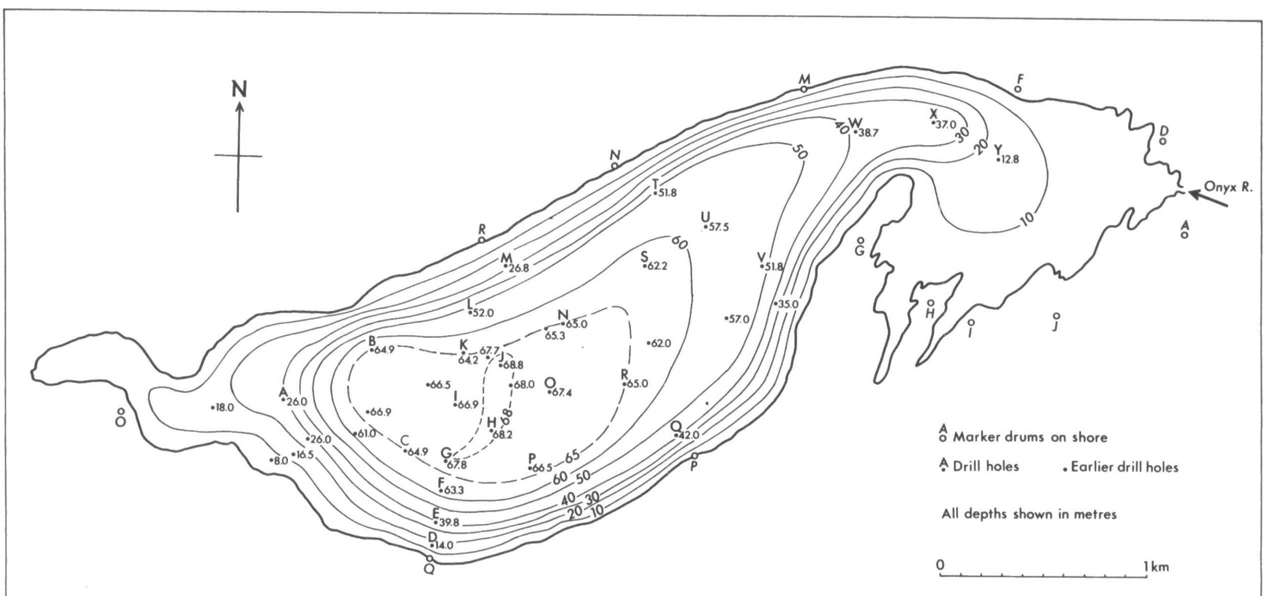

Figure 1. Bathymetry of Lake Vanda, Wright Valley, Antarctica. All depths are in meters below the mid-January 1972 lake level of 84.3 meters above sea level.

bacteria, and scattered terrigenous sand. In very shallow locations the sediments are difficult to core as they become increasingly gravelly and resemble those above the present shore of Lake Vanda.

In contrast, below 60 meters the environment is anaerobic. The sediments emit a strong hydrogen sulfide odor, and they consist of grey, grey-green, and green sandy muds (mean grain size less than 0.06 millimeters) and muddy fine and medium sands (mean grain size 0.125 to 0.50 millimeters). They are rich in finely disseminated organic matter (average 6 percent by weight) and contain variable but significant quantities (to 10 percent by weight) of authigenic calcite (fig. 2, cores R, N, and I). The detrital minerals in the muds and sands include mainly quartz, plagioclase feldspar, and mica. The cores are grossly stratified and, in particular, commonly show a prominent white crust, consisting of finely banded layers of calcite and gypsum a few millimeters thick and some 4 to 10 centimeters below the sediment surface. The crust characteristically separates underlying thick sandy muds and muddy sands, rich in finely divided organic material and authigenic calcite, from overlying medium sands whose topmost levels display poorly defined laminae of fine mucilaginous organic material and fine to medium sand (fig. 2, core R).

Enlarged copies of the bathymetric map of Lake Vanda (fig. 1) are available from the writers on request.

We thank the Antarctic Division, Department of Scientific and Industrial Research, New Zealand, and personnel of the U.S. Navy and the U.S. Antarctic Research Program for their help and hospitality, and also members of the 1971-1972 Japanese Antarctic Research Expedition for permission to use their ice holes on Lake Vanda for additional depth measurements and sediment sampling.

References

Angino, E. E., K. B. Armitage, and J. C. Tash. 1965. A chemical and limnological study of Lake Vanda, Victoria Land, Antarctica. *University of Kansas Science Bulletin*, 45(10): 1097–1118.

Ragotzkie, R. A., and G. E. Likens. 1964. The heat balance of two antarctic lakes. *Limnology and Oceanography*, 9(3): 412–425.

Wilson, A. T., and H. W. Wellman. 1962. Lake Vanda: an antarctic lake. *Nature*, 196(4860): 1171–1173.

Glaciological studies of past climatic variations in the South Shetland Islands

OLAV ORHEIM[1] *and* COLIN BULL
Institute of Polar Studies and Department of Geology
The Ohio State University

VALTER SCHYTT
University of Stockholm
Sweden

The fourth consecutive season of glaciological studies at Deception Island, and the second season of studies at Livingston Island, were carried out from January 10 to February 2, 1972, by a five-man group consisting of Dr. Colin Bull, Mr. James Curl, Dr. Olav Orheim, and Mr. Michael Quinn, all from The Ohio State University, and Dr. Valter Schytt, University of Stockholm, Sweden.

The primary objectives of the work were: (1) completion of the studies, started in the 1970-1971 season, of the ice stratigraphy exposed on the walls of a 100-meter-deep crater formed through a glacier by the August 1970 volcanic eruption, (2) collection of ice samples from the crater walls for radiometric dating and geochemical analyses, and (3) mass balance studies on glacier G-1 on Deception Island and on Rotch Dome on Livingston Island. Bad weather, particularly an abnormally high frequency of strong winds, hampered the field work. Despite this, most of the primary objectives were accomplished, but it was not possible to complete the full program of sample collection for geochemical analyses. Some secondary programs were also curtailed.

This season, as before, there was a strong international aspect to the Deception Island research. The U.S. group stayed at the Argentine station, together with the geologists Dr. Nestor Fourcade and Dr. Jose Viramonte from Argentina and Mr. Michael Harvey from Great Britain. A Chilean geologist also stayed there for a few days. Two assistants from the Instituto Antártico Argentino operated the station. The Argentine group and the British geologist worked at the island from early December to late January. Once again, we thank the Instituto Antártico Argentino for allowing us the use of their facilities and for supporting us.

The work at Livingston Island included studies of the shear-plane moraine ridges that border the western edge of Rotch Dome. The actual moraine cover was thin, the ridges low, and the lichen population was well established, with individual species measuring up to 10 centimeters in diameter. There is certainly no rapid glacier retreat, but more likely a near-balance.

[1] Now at Norwegian Polar Institute, Oslo.