AGES AND ASHES IN LAKE FLOOR SEDIMENT CORES FROM VALLEY LAKE, MT GAMBIER, SOUTH AUSTRALIA

by C. E. BARTON*† & M. W. MCELHINNY*

Summary

BARTON, C. E. & MCELHINNY, M. W. (1980) Ages and ashes in lake floor sediment cores from Valley Lake, Mt Gambier, South Australia. *Trans. R. Soc. S. Aust.* **104**(6), 161-165, 28 November, 1980.

A set of four cores from Valley Lake shows a sequence of fresh water organic muds above a band of aragonite 8–10 cm thick, overlying a graded calcareous tuff. Magnetic remanence and susceptibility measurements indicate the absence of volcanic episodes since the onset of deposition of the organic muds 5000 to 6000 years ago. Radiocarbon ages of ~14 000 years and ~38 000 years for the aragonite band and the tuff respectively are not considered to reflect their ages of formation.

Introduction

Valley Lake (37° 51′S, 140° 46′E) is the second largest of the four lakes in the Recent volcanic craters at Mount Gambier, South Australia. Chemical and biological aspects of the lake have been described by Bayly & Williams (1964), and the morphology and benthos by Timms (1974). The lake is now fresh and at a level considered to be controlled by the ground water table.

The geology of the Mt Gambier complex has received considerable attention, the most recent being a detailed study by Sheard (1978) which includes a review of the previous work. In Sheard's reconstruction the two larger lakes, Blue Lake and Valley Lake occupy open craters called maars, formed by volcanic explosions, as do the smaller lakes, Brownes Lake and Leg of Mutton Lake.

Two charcoal samples picked from soils beneath tuff layers have been radiocarbon dated. The first was collected by C. G. Stephens in the township of Mt Gambier and dated at 4830 ± 70 BP (Gill 1955; Fergusson & Rafter 1958), and the second was collected 4 miles away to the SSE and dated at 1410 ± 90 BP (Blackburn 1966). Blackburn was of the opinion that these dates may represent separate volcanic episodes, and this view has also been adopted by Sheard (1978).

Four cores were recovered in 54 mm (class 12) PVC tubes using a 6 m Mackereth corer (Mackereth 1958): VB in 16 m of water from the deepest part of the lake, and VA, VC and VD in 14.5 m of water from the flattish area about 50 m NE of the deepest part (see Timms (1974) bathymetric chart). Echo soundings showed small scale variations in bottom topography not resolved in Timms' chart; cores were collected as close as possible from the hollows.

* Research School of Earth Sciences, Australian National University, P.O. Box 4, Canberra, A.C.T. 2601.

† now at: Geophysics Department, Edinburgh University, U.K.

Core descriptions

All four cores displayed the same features: approximately 1 m of black fresh-water organic muds, above a very clearly defined 8–10 cm band of extremely fine grained creamy white aragonite, overlying a graded column of calcareous tuff. VD achieved the maximum penetration through the tuff and is pictured in Figure 1.

Shells are abundant in the organic muds and were identified by B. J. Smith as ". . . assemblages of ostracod shells and the small freshwater bivalve *Pisidium* sp. These are found in fresh waters low in dissolved salts and usually permanent."

X-ray analysis of the creamy white band performed by J. Caldwell of A.N.U., gave a composition of 95% aragonite + 5% low magnesium calcite. Under the microscope much of the material consisted of rods ~1 μm in length. Diatoms were common and, in contrast to the underlying tuff, there was a marked absence of quartz and ferromagnesian (opaque) minerals.

The graded tuff was rich in carbonates with some euhedral rhombs (calcite/dolomite) but mainly irregular fragments. Volcanic glass, angular with inclusions of crystallites and gas bubbles, was common. Quartz grains, usually fairly well rounded, were present together with a scattering of microfossils.

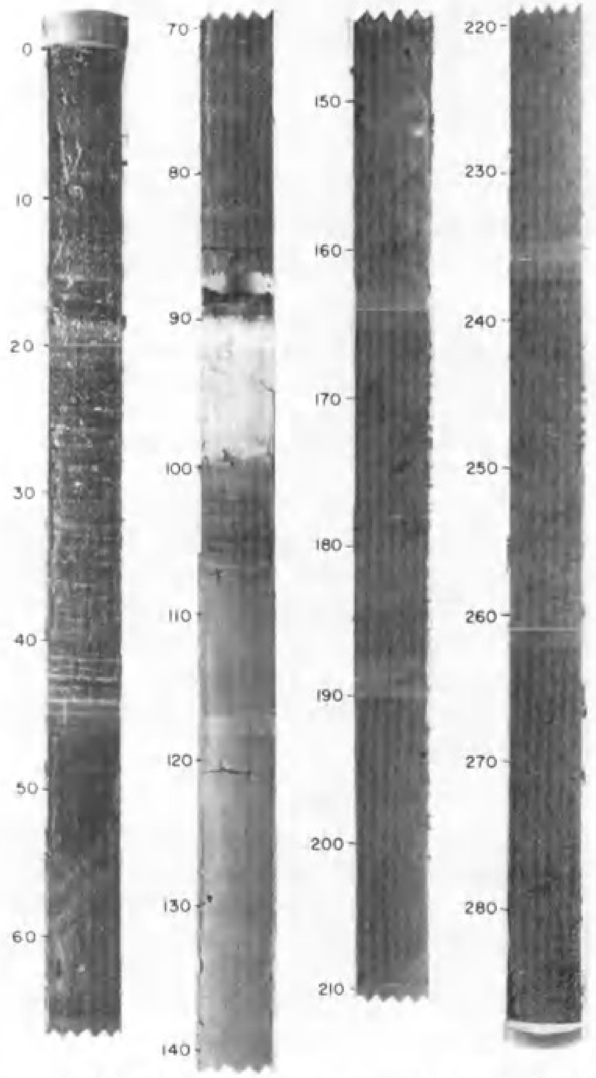

Fig. 1. Photocomposite section through Valley Lake core VD. Distances from top of core given in cm.

Evidence of horizontal bedding occurred in the top 10 cm of the tuff column, but otherwise the material appeared to have been rapidly deposited under water. The boundary with the aragonite band was less abrupt than that between the organic muds and the aragonite, but nevertheless quite sharp, as can be gauged from the photograph.

J. R. Dodson examined samples from the aragonite band and the upper calcareous tuff for pollen grains. In the aragonite there were plenty of grains, particularly *Casuarina* and *Eucalyptus* with some aquatic taxa, whereas the tuff contained very few grains: a scattering of *Casuarina* and *Eucalyptus* but no *Compositae*. Although insufficient material was examined to provide a definitive conclusion, these assemblages are consistent with a Holocene age for the aragonite and preclude an age greater than 15 000 BP for the deposition of the tuff, which must have occurred rapidly (Dodson pers. comm.).

Magnetic results

Measurements of the horizontal natural remanent magnetisation (NRM) were made at 1 cm intervals along the length of each complete core using an automated version (Barton 1978)[1] of the "Digico" whole core spinner magnetometer (Molyneux *et al.* 1972). VD was sliced open, subsamples were extracted in adjacent pairs of perspex cube shaped pots (volume 5.3 cm^3) every 2.5 cm, and measured on a cryogenic "SQUID" magnetometer (Goree & Fuller 1976).

All cores yielded mutually consistent results, showing a large contrast in NRM intensity between the organic muds (typically 0.5–1.5 $mA.m^{-1}$) and the calcareous tuffs (typically 100–180 $mA.m^{-1}$) as illustrated in Figure 2. A well dated magnetic secular variation pattern exists for SW Victoria covering the last 1000 years based on the magnetic remanence of sets of cores from L. Keilambete, L. Bullenmerri and L. Gnotuk (Barton[1]). Unfortunately, the directional results from Valley Lake (Fig. 2) are too scattered to permit magnetic dating. Magnetic cleaning in an alternating magnetic field (AF) of peak value 15 mT failed to reduce the scatter. Median demagnetising fields (i.e. the peak AF required to halve the initial remanence) for 8 specimens distributed throughout core VD ranged from 2 to 6.5 mT, which is too low to sustain a stable primary remanence. The high water content in the organic muds (85–90% by weight) certainly contributes to this instability.

Initial susceptibility measurements on core VD (Fig. 3) reflect a contrast of about 3 orders of magnitude between the organic muds and the calcareous tuffs. Much of the organic mud is weakly diamagnetic, i.e. the susceptibility is negative.

Radiocarbon dating

An initial radiocarbon age of 38 400 BP on the total organic fraction from VD 107–117 cm prompted a more detailed investigation into the chronology of these cores. The results are given in Table 1. Both the calcareous tuff

[1] Barton, C. E. (1978) Magnetic studies of some Australian Lake Sediments. Ph.D. thesis (unpubl.), Australian National University, Canberra.

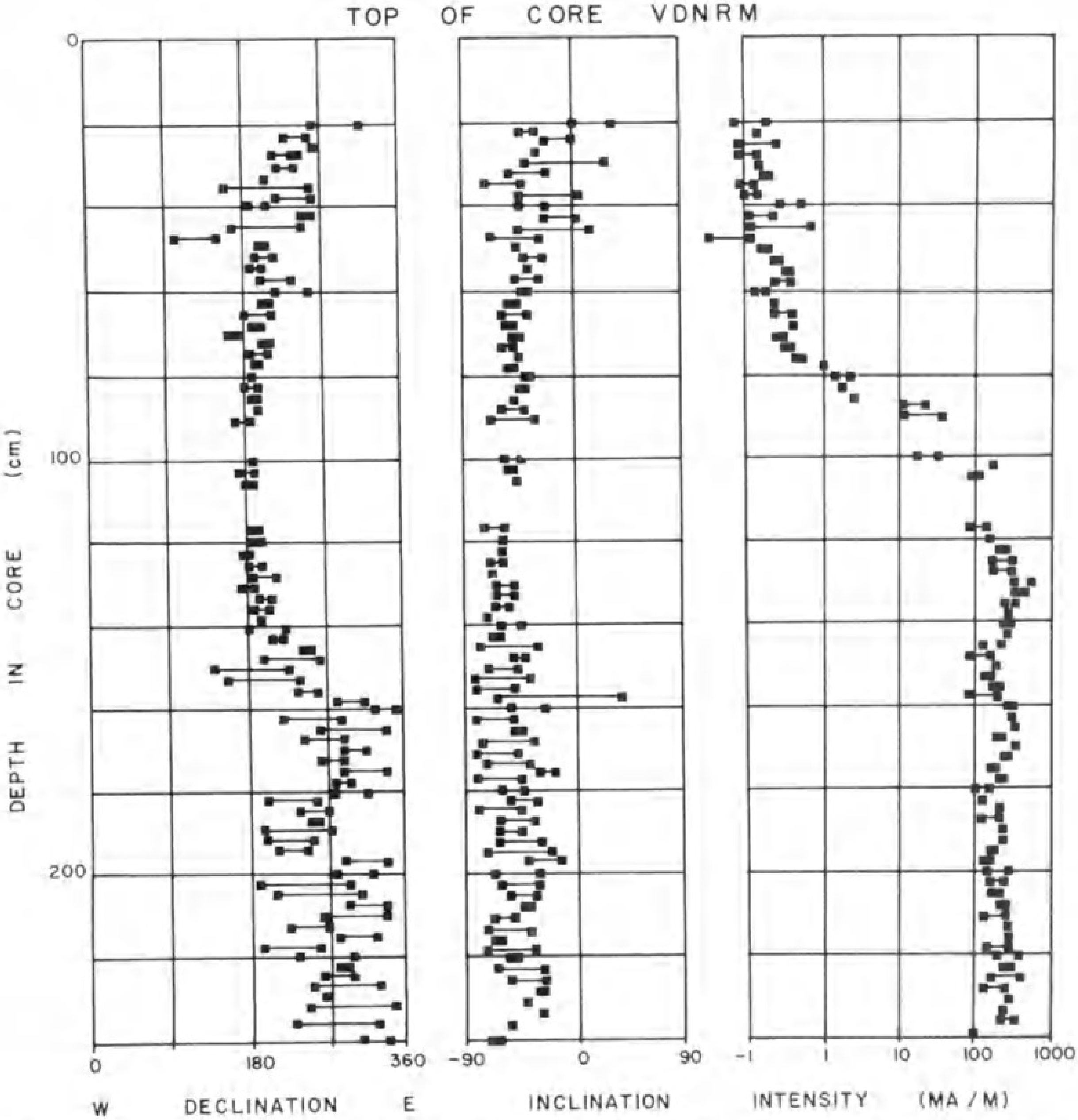

Fig. 2. NRM results for core VD. Vertical grid interval (bar spacing) is 20 cm; pairs of measurements at same stratigraphic level linked by lines. Above 20 cm core was too wet to be subsampled; whole core measurements showed that intensity remained low in this zone.

and the aragonite band yielded barely sufficent organic carbon to obtain a date, hence the large counting uncertainties. A carbonate date was obtained for the aragonite band in VA.

Radiocarbon ages are plotted against the equivalent distance from the top of VB in Figure 4. Correlation between VD and VB for sample ANU 1809 is based on equal sedimentation rates within the tuffs and may therefore be in error by up to say ± 5 cm; there can be no uncertainty about the equivalent position in VB of the aragonite band, sample ANU 2051.

Within the organic muds, the monotonic ^{14}C age sequence is consistent with uniform deposition since 6000 BP. The fact that the ^{14}C ages within the organic muds plotted in Figure 4 extrapolate to near the origin is taken to indicate the absence of any major systematic increase in ages due to the incorporation of ancient carbon (from say, the Miocene limestone basement which outcrops around parts of the lake). Although further age determinations are really requred to confirm this, it is worth noting that no systematic age increases in excess of a few hundred years have been

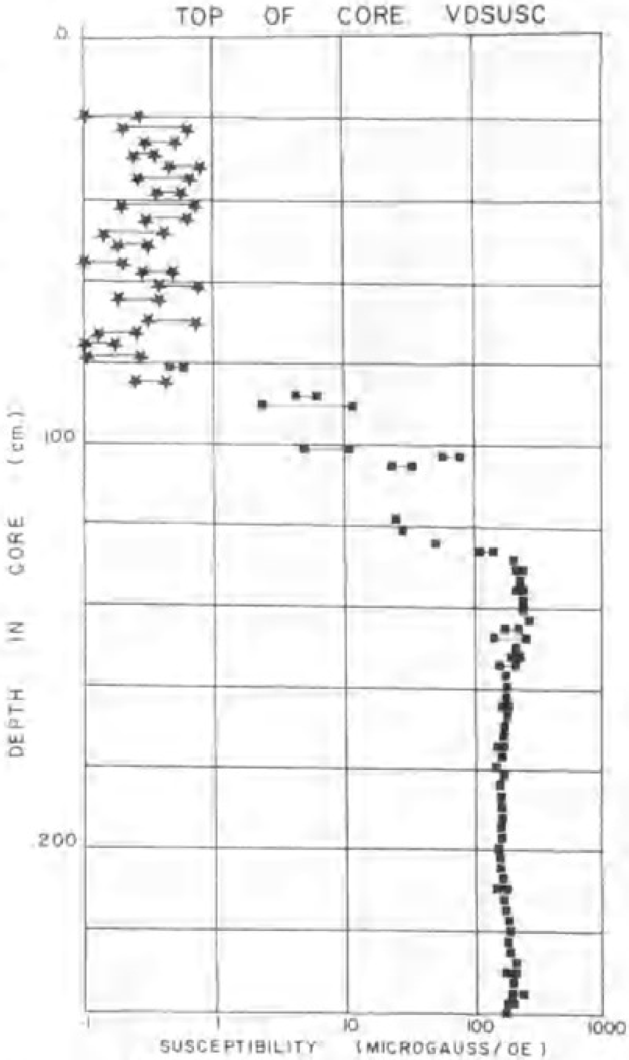

Fig. 3. Initial susceptibility results for core VD. Format of plot is as for Fig. 2 except that negative (diamagnetic) susceptibilities plotted as positive with X instead of square. Much of upper 80 cm of organic muds diamagnetic. Volume susceptibility of 1 Gauss Oersted^{-1} in cgs equivalent to 4π in SI system and dimensionless.

found in sequences from L. Keilambete, L. Bullenmerri and L. Gnotuk in SW Victoria (Bowler & Hamada 1971; Barton & Polach 1980). These lake sediments have been intensively dated by radiocarbon and are from similar geological environments to Valley Lake.

Ages of eruption

The graded calcareous tuff has every appearance of having been rapidly deposited in a single episode into a lake containing at least 1–2 m water. Excluding the possibility that this occurred 38 000 years ago, which is inconsistent with previous age determinations, the pollen data, and the morphology of the Mt Gambier complex, there must be considerable amounts of ancient organic carbon (charcoal) incorporated in the tuff to account for such an age.

Intensive radiocarbon analysis of magnetically correlated cores of organic mud from Bullenmerri, 38°15′S, 143°06′E (Barton[1]; Barton & Polach 1980) indicates a 25% probability of >20% anomalies in radiocarbon ages. These muds are not dissimilar from those in Valley Lake. Although these figures overestimate the dating uncertainties in many lacustrine sequences, e.g. Keilambete, 38°13′S, 142°52′E, (Bowler & Hamada 1971; Barton & Polach 1980), they should nevertheless be regarded as a guide in assessing the significance of isolated ^{14}C determinations. Hence the 6180 ± 80 BP age at the bottom of the organic muds is not necessarily inconsistent with an eruption age of 4800 BP.

Magnetic intensity and susceptibility contrasts between the organic muds and the tuffs provide a sensitive measure of the presence of volcanic ejecta within the sequence. At no point within the organic muds do either of these

TABLE 1. *Conventional radiocarbon ages for samples from three Valley Lake cores. All determinations, with the exception of that marked *, are made on total organic fractions.*

ANU Sample number	Depth in Core (cm)	Equivalent Depth in VB (cm)	^{14}C age ± 1 SD	Comment
ANU 2125	VB 40–50	40–50	2960 ± 90	Organic mud
2126	VB 80–90	73–83	3960 ± 80	Organic mud
2052	VB 110–120	103–113	6180 ± 80	Organic mud
2051	VA 117–122	114–122	13900 ± 370	Aragonite (organic)
			15450 ± 160*	Aragonite (inorganic)
1809	VD 107–151	141–151	38400 + 2070) 1640)	Calcareous tuff

* total inorganic fraction

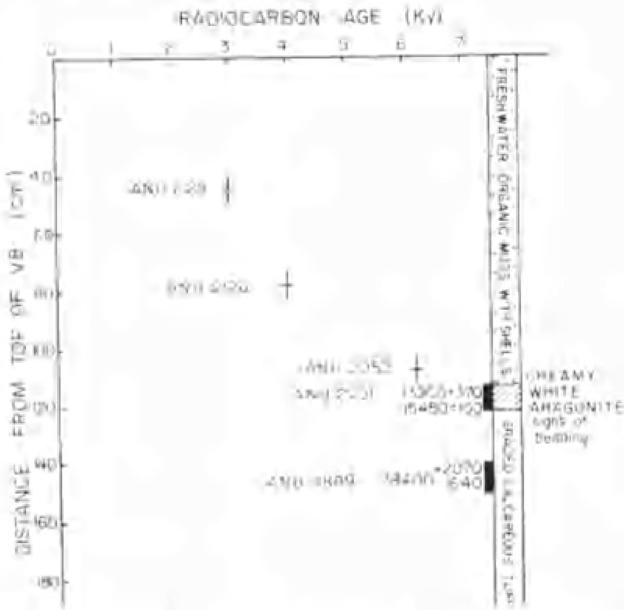

Fig. 4. Conventional radiocarbon age-depth plot for core VB together with simplified log of core. Ages expressed in units of 1000 years (Ky). Vertical error bars denote sample lengths and horizontal ones, 1 standard deviation counting uncertainties in ages. Samples ANU 2051 and ANU 1809, taken from cores VA and VD respectively, marked at their equivalent distances from top of core VB.

parameters even remotely approach the high values within the tuffs, nor is there any evidence to the naked eye of a volcanic interlude. It is therefore concluded with some confidence that no eruption has occurred near the lake since the deposition of the calcareous tuffs.

The problem remains as to the significance of the organic and inorganic ages of 14 000 years for the aragonite band. Sufficiently slow deposition of aragonite could explain the 6000 year time break at the upper boundary indicated by the average age of the whole band. However, since the organic muds indicate fresh water conditions throughout the last 5000 to 6000 years, it is considered improbable that conditions under which only 95% pure aragonite was deposited could have existed within the lake for many thousands of years previously. The preferred conclusion, and one which is more consistent with the geological evidence, is that the aragonite was produced fairly rapidly at the end of the eruptive phase at 5000 BP or possibly 6000 BP, and that both ages reflect the presence of dead carbon derived from the volcanic ejecta or from stirring of the original lake floor.

Acknowledgments

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AMINO ACID RACEMIZATION DATING OF LATE QUATERNARY STRANDLINE EVENTS OF THE COASTAL PLAIN SEQUENCE NEAR ROBE, SOUTHEASTERN SOUTH AUSTRALIA

BY C. C. VON DER BORCH, J. L. BADA & D. L. SCHWEBEL

Summary

The amino acid racemization dating technique has been applied to three selected mollusc samples collected from the Quaternary strandline sequence of southeastern South Australia. Results of the study are consistent with previous uranium-series age determinations in the area and imply that at least the uppermost component of the Woakwine Range barrier-estuarine sequence was emplaced during the last interglacial sealevel maximum around 125 000 years ago.