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

VON DER BORCH, C. C., BADA, J. L. & SCHWEBEL, D. L. (1980) Amino acid racemization dating of Late Quaternary strandline events of the coastal plain sequence near Robe, southeastern South Australia. *Trans. R. Soc. S. Aust.* **104**(6), 167-170, 28 November, 1980.

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.

Introduction

Oxygen isotope studies of deep-sea pelagic sediments, combined with magnetostratigraphy and other dating techniques (Shackleton & Opdyke 1976; Hays *et al*, 1976), have established a relatively detailed chronology of Quaternary glacial and interglacial stages. Related eustatic sealevel oscillations recorded as stranded shoreline deposits on continental margins are currently under scrutiny. Although more difficult to date, they serve as an independent check on some of the deep sea data. In addition, the establishment of an acceptable chronology for Quaternary and older shoreline sequences is of foremost interest from a geodynamics point of view. A correctly dated succession of terraces can reveal the temporal variation in uplift rate of convergent plate boundaries such as island arcs, and mid-plate tectonic movements such as regional warping on passive margins. It is of interest to establish acceptable chronologies from coastal strandline sequences from a variety of tectonic settings and areas.

The coastal plain of southeastern South Australia (Fig. 1) is characterized by what may be one of the most complete and best preserved sequences of Quaternary strandlines in existence. At least 20 emergent shorelines, consisting of stranded calcareous sand barriers and associated lagoonal and lacustrine deposits, occur in a region 90 km wide by about 400 km long (Fig. 1). A sequence of less obvious siliceous sand beach ridges of Plio-Pleistocene age (not shown in Fig. 1) extends for a further 100 km east of the Naracoorte Range into the State of Victoria (Hills 1960; Blackburn *et al.* 1967).

The calcareous strandlines shown in Figure 1 owe their preservation to a combination of

Fig. 1. Coastal Plain, southeastern South Australia, showing Quaternary strandlines; section X-Y refers to Figure 2.

* School of Earth Sciences, Flinders University of South Australia, Bedford Park, S. Aust. 5042.
† Scripps Institution of Oceanography and Institution of Marine Resources, California.
‡ Esso Australia Ltd, Sydney.

factors, the dominant of which has been gentle regional upwarping of the coastal plain throughout the Quaternary, centred on the volcanic region in the extreme southeast of the state (Hossfeld 1950; Sprigg 1952). This upwarping has been responsible for the stranding of the sequence, in which oldest shorelines in general lie furthest inland. Preservation of these strandline features has been due largely to rapid "case-hardening" of the calcareous barrier facies sands by extensive calcrete development which generally begins immediately the sands become stabilized by vegetation. Only high sealevels are represented in the record, due to a combination of relatively slow uplift rate and the dynamics of sediment transport as sea level rises from a low stillstand.

In common with other Quaternary shoreline successions of this type, the establishment of chronological sequence and absolute age of individual strandlines is fraught with difficulties. Palaeomagnetic studies of cores from recent stratigraphic drilling suggests that the oldest component of the complex Naracoorte Range barrier, shown in Figure 1, is older than the Bruhnes-Matuyama magnetic reversal at 720 000 years; all ridges to the southwest are younger (Cook *et al.* 1977). Limited radiocarbon dating of the youngest deposits in the sequence reported by Blackburn (1966), von der Borch (1976), Cook *et al.* (1977) and Schwebel (1979)[1] has established a preliminary chronology of Holocene and late Pleistocene sediments from lagoonal and lacustrine areas near the present coast. Uranium-series dating techniques have been applied to aragonitic lagoonal sediments and molluscs dating back to the last interglacial high sealevel (Schwebel 1979)[1].

This paper reports an initial application of the amino-acid racemization (AAR) dating technique (Masters & Bada 1978) to the problem of deciphering the chronology of some aspects of the Woakwine strandline region shown in Figure 1. It serves as an independent check on uranium series dates obtained from

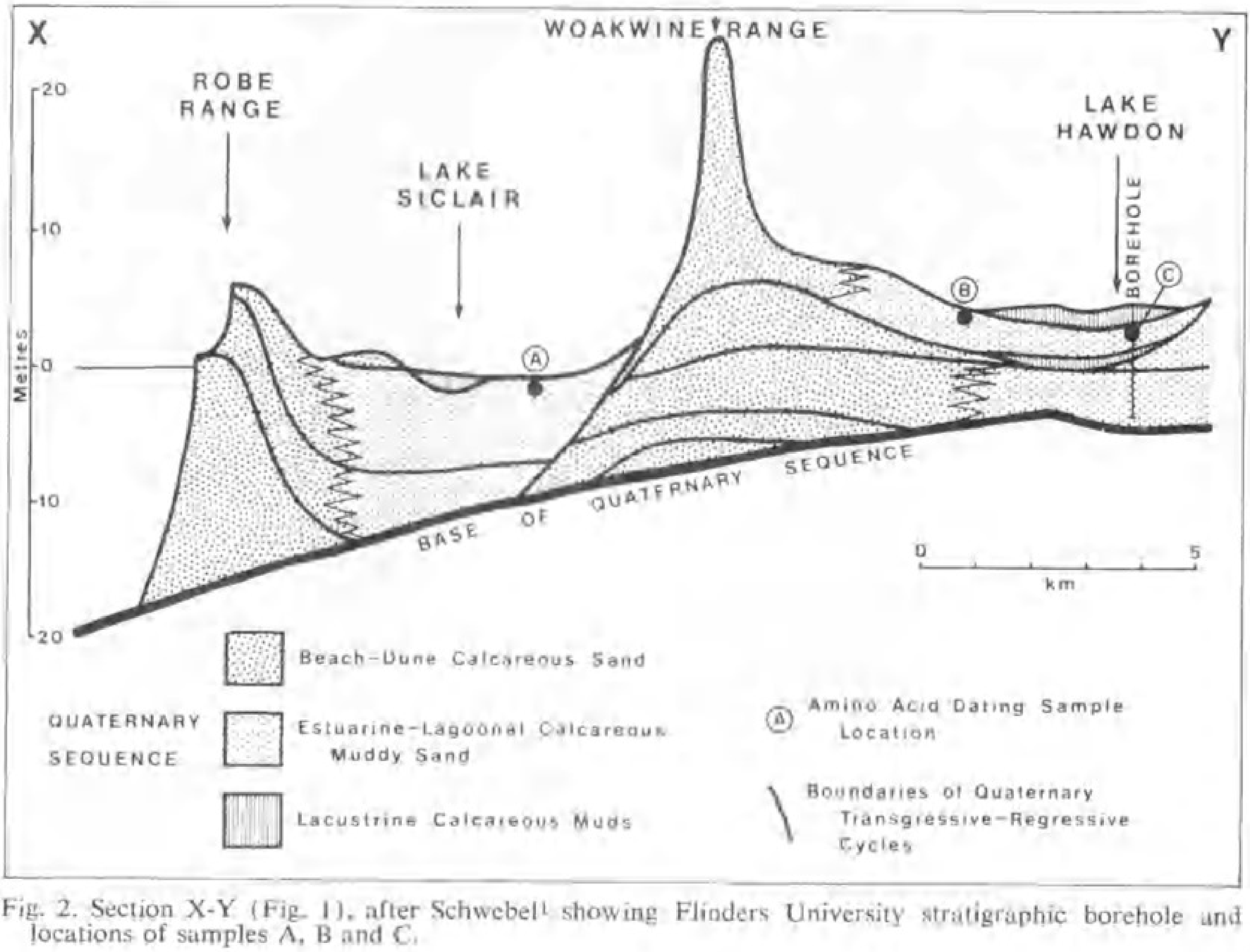

Fig. 2. Section X-Y (Fig. 1), after Schwebel[1] showing Flinders University stratigraphic borehole and locations of samples A, B and C.

samples beyond the range of ^{14}C techniques (Schwebel 1979)[1].

Sample localities

Material used for AAR dating was obtained from localities A, B and C (Fig. 2) on the transect X-Y (Fig. 1). The mollusc *Katelysia scalarina* (Lamarck) was selected as the species most suitable for the racemization analysis since it has relatively thick, non-porous valves.

Sample A is a surface sample from a shallow pit at Lake St Clair where articulated specimens were selected. This locality lies on the first interdune flat inland from the present coast, where dates on molluscs have been reported by Blackburn (1966) at 4330 ± 100 years using ^{14}C. Stratigraphic observations by Schwebel (1979) are in accord with the above date, and show the sediments to have been deposited during the peak of the Holocene sealevel transgression prior to final separation of the flat from the ocean by modern barrier accretion and possible sea level decline. Because of the established radiocarbon dates, this sample was used as a reference point for the calculations involved in determining the ages of samples B and C.

Sample B is from the side of a drain locally known as Drain L which intersects the Woakwine Range barrier and its related estuarine-lagoonal strata to the east. Shells comprising sample B, many of which are in-situ, occur within a 20–30 cm thick indurated layer, on an erosion surface which is onlapped by Holocene lacustrine calcareous muds of the most recent Lake Hawdon phase.

Sample C, interpreted by Schwebel (1979)[1] to come from the same horizon as that of sample B, was collected from a stratigraphic borehole (Fig. 2) from a mollusc-rich layer 280 cm below the sediment surface. Articulated samples of *Katelysia scalarina* (Lamarck) were sampled and used for dating.

Dating methods and procedures

Approximately 5–10 grams of a single cleaned *Katelysia* valve were processed according to the procedures described for the "total" fraction by Masters & Bada (1977). The alloisoleucine/isoleucine (alleu/iso) ratio was determined on a *Beckman-Spinco* Model 118

[1] Schwebel, D.A. (1979) Quaternary stratigraphy of the southeast of South Australia. Ph.D. thesis (unpubl.). Flinders Univ. of S. Aust.

TABLE 1. *Extent of amino acid racemization in* Katelysia *shells from marine terrace deposits in southern Australia*

Sample	D/L alanine	D/L glutamic acid	D/L leucine	alleu/iso
A	0.29	0.17	0.28	0.11
B	0.63	0.30	0.35	0.28
C	0.73	0.37	0.46	0.36
Modern *Katelysia*	0.13	0.08	0.09	0.01

automatic amino acid analyzer. The enantiomeric ratios of the other amino acids were determined by gas chromatography of the N-trifluoroacetyl-L-prolyl peptide methyl esters (Hoopes *et al.* 1978).

Results and discussion

The racemization results for the various samples are given in Table 1. The extent of AAR in sample A is consistent with a Holocene age for this sample. Substituting the measured alleu/iso ratio and an age of 4330 years (Blackburn 1966) in eq. (2) of Masters & Bada (1977) yields $k_{iso} = 2.3 \times 10^{-6}$ yr^{-1}. The value of K_{eq} in this equation was assumed to be ~1.3. This k_{iso} value is in close agreement with that calculated using Holocene *Chione* molluscs from Southern California coastal archaeological sites. This is the expected result due to the similarity of the mean annual air temperatures of the Californian and South Australian localities (Felton 1965; Floegel 1972), and since the *Katelysia* and *Chione* species have similar shell morphologies.

The extent of AAR in sample C is nearly identical to that measured in *Chione* (Masters & Bada 1977) and *Protothaca* molluscs (Wehmiller 1977) from a terrace deposit in San Diego, California. This terrace has been dated at 120 000 ± 10 000 years by uranium-series dating of corals (Ku & Kern 1974). Since the Holocene sample suggests that the rate of racemization is similar at the Californian and Australian sites, the similarity of the extent of racemization in sample C and the 120 000-year-old Californian terrace supports the conclusion that sample C corresponds in age to the maximum high-sea level stand during the last interglacial period (i.e. Stage 5e in the O^{18}/O^{16} palaeotemperature curve, ~125 000 B.P.).

In comparison to sample C, the extent of AAR is consistently slightly less in sample B. On this basis, it would appear that sample B may come from one of the other episodes of high sea level, tentatively dated at ~85 000 and 105 000 years B.P., which occurred in the vicinity of the last interglacial period (Bloom *et al.* 1974). Substituting the measured alleu/iso ratio for sample C and an age of 120 000 years for this sample into eq. (2) in Masters & Bada (1977), yields $K_{iso} = 2.9 \times 10^{-6} yr^{-1}$. Using this k_{iso} value to date sample B yields an age of ~92 000 years.

The AAR dates for samples B and C given above imply that the uppermost portion of the Woakwine Range strandline complex was formed during the last interglacial high sea level. This is in accord with the uranium series data of Schwebel (1979).

Sample B with an age of 92 000 years appears slightly younger than C, which is about 120 000 years old. In fact, the age of B lies approximately midway between the 85 000 and 105 000-year-old sealevel highs described by Bloom *et al.* (1974). If the assumption is made that C actually correlates with the 125 000 year sealevel high (i.e. that the date used to calculate the k_{iso} value given above is a few thousand years too young), then B could possibly be correlated with the established 105 000-year-old sealevel high. On the other hand the small number of samples, and the resolution of the amino acid dating technique as applied to the study area, may imply only that the two samples B and C were laid down in response to some stage or stages of the last interglacial sealevel maxima, of the order of 120 000 years ago.

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