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Whole-rock aminostratigraphy of the Coorong coastal plain, South Australia – Further Results.

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Abstract

This paper presents some results from a PhD study into the whole-rock aminostratigraphy and facies architecture of a series of barrier shoreline deposits preserved on the Coorong Coastal Plain in the southeast of South Australia. The aminostratigraphic work is focused on here.

The aim of the aminostratigraphic work is to further develop the whole-rock amino acid racemisation technique, to develop an whole-rock aminostratigraphic framework that encompasses the Coorong Coastal Plain, and to use the whole-rock aminostratigraphy in order to correlate barrier deposits from the north and the south of the plain.

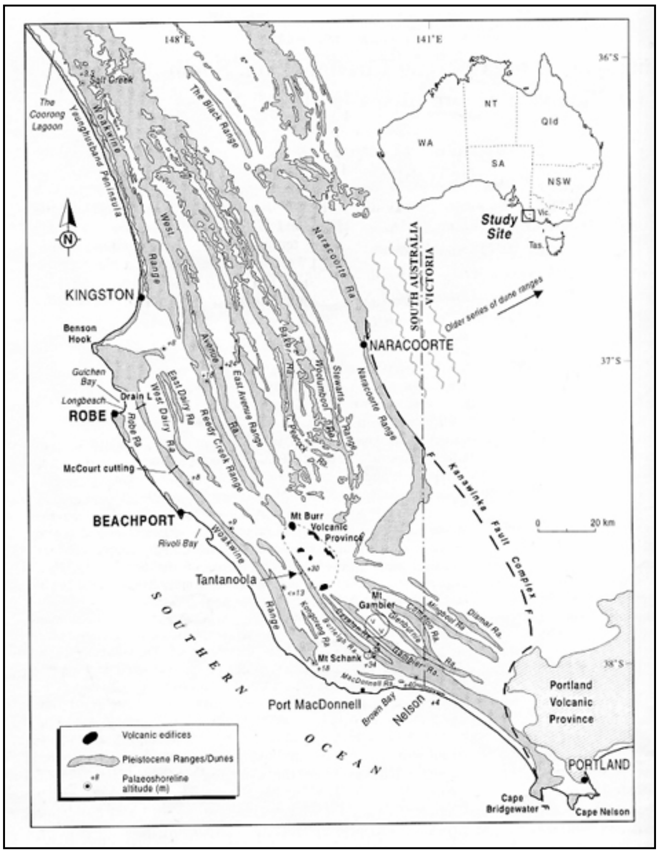

Figure 1. The Coorong Coastal Plain, showing the location of the Pleistocene coastal barriers (Murray-Wallace et al., 2001).

The Coorong Coastal Plain covers an area of about 24 000 km^2 in the southeast of South Australia, extending into western Victoria. A series of Quaternary highstand barrier shoreline deposits are preserved across the uplifted coastal plain (figure 1).

A chronostratigraphic framework of the Coorong Coastal Plain has been established through thermoluminescence dating (Huntley et al., 1994; Huntley et al., 1993; Huntley et al., 2001; Murray-Wallace et al., 1996), palaeomagnetism (Idnurm et al., 1980) and uranium series dating (Schwebel 1984). The current mean annual temperature for the Coorong Coastal Plain ranges from 13.4°C in Portland to 14.7°C in Naracoorte and 14.8°C in Robe.

Amino acids are chiral biological molecules, occurring in two asymmetric forms, L-, or *levo*, and D-, or *dextro*. Proteins in living organisms are composed almost entirely of L-amino acid enantiomers, which after the death of the organism slowly racemises to form a racemic equilibrium mixture, consisting of equal amounts of the D- and L-enantiomers. Whole-rock AAR is the study of the racemisation reaction in bulk carbonate sediment samples.

The utilisation of whole-rock material in AAR research began with measurement of the extent of isoleucine epimerisation in deep-sea core material, composed predominantly of foraminiferal tests (Bada et al., 1970; Bada et al., 1972).

The technique has since been expanded to utilise other amino acids, and used to examine carbonate deposits in the Bahamas (Hearty 1998; Hearty et al., 2000a; Hearty et al., 1995; Kindler et al., 2000), Bermuda (Hearty et al., 1995; Hearty et al., 1992; Kindler et al., 2000), Hawaii (Hearty et al., 2000b), and in Australia on Lord Howe Island (Brooke et al., 2003) and the Coorong Coastal Plain (Murray-Wallace et al., 2001). The technique measures the extent of racemisation, usually reported as a ratio of D-amino acid to L-amino acid (D/L ratio). The measured D/L ratio is an average value of all bioclastic components of the whole-rock sample.

Important considerations of whole-rock AAR research are residence time and reworking. Residence time refers to the time lag between the death of the organism and deposition. Differences in residence time between sites can cause significant differences in D/L ratios, for contemporaneous deposits.

To overcome the differences in residence time between different regions, independent age calibration between regions is necessary. In calculation of numerical ages from whole-rock D/L ratios (Murray-Wallace et al., 2001) took the D/L leucine of modern beach sediments to be t_0 (D/L leucine = 0.225), and this value was subtracted from the D/L ratio of each whole-rock sample. Reworking is very important because the introduction of older material into younger deposits can lead to erroneously high D/L ratios for stratigraphically young deposits. To determine the extent of reworking, qualitative petrographic examination of thin sections is conducted, looking for recrystallisation and physical signs of reworking.

It is also important to consider the event that is being dated. Whole-rock AAR dates the death of the organisms whose remains make up the bioclastic sediment. Thermoluminescence (TL) dating, the most widely applied dating method on the Coorong Coastal Plain, dates the last exposure of sediment to sunlight. Calibration of D/L ratios with TL ages is necessary in order to make age estimates on the basis of D/L ratios.

Preliminary mean whole-rock D/L ratios (aspartic acid and valine) are presented (Table 1) for some of the barrier range deposits on the Coorong Coastal Plain. Aspartic acid is a faster racemising acid, while valine is a slower racemiser. Aspartic acid and valine are presented here as representative D/L results for the area, with leucine and alanine D/L ratios also measured.

The large standard deviation of the modern samples along the coast of the Coorong coastal plain also introduces a problem for correlation of whole-rock D/L ratios over large areas. The deviation is due to differing composition of the sand, and to differences in residence time and amount of reworking. Further work needs to be conducted to determine the range of D/L ratios in modern beach sediment along the coast, and the lateral variation in D/L ratio along some of the older barriers. The variation in D/L ratios measured laterally along the Robe and Woakwine Ranges may be attributable to variations in the amount of reworking and differences in residence time of these samples.

The southern Caveton Range and the northern West Avenue Range are both assigned to Stage 9 (table1), with the West Avenue Range assigned to Substage 9a. Correlation between these ranges is not good, possibly due to the Caveton Range site being deposited earlier in Stage 9 and receiving more heating over the interglacial period, or as a result of lateral variations in sample composition affecting racemisation rates. The reason for the poor correlation is probably a combination of these factors. The preliminary results point to the usefulness of D/L aspartic acid ratios in whole-rock samples younger than the Last Interglacial. Aspartic acid appears to be of little use in samples older than that. Valine appears to be useful over a greater timescale, possibly over the entire age range of the Coorong Coastal Plain. It is evident that much work is still to be done examining the kinetics of the racemisation reaction in whole-rock samples, and into the effects of reworking and residence time on measured D/L ratios on the Coorong Coastal Plain. Analysis of samples from the older ranges is continuing, in order to gain enough data to construct an aminostratigraphic framework.

Barrier Range	**Correlative Highstand**	**Aspartic Acid**	**Valine**
Modern sand	Modern	0.294±0.027 (3)	0.170±0.062 (3)
Robe	Substage 5a/c	0.566±0.044 (6)	0.376±0.029 (6)
Woakwine I	Substage 5e	0.599±0.047 (10)	0.411±0.056 (10)
Burleigh	Substage 7e	0.542±0.047 (1)	0.441±0.051 (1)
Caveton	Stage 9	0.591 (1)	0.517 (1)
West Avenue	Substage 9a	0.530 (1)	0.439 (1)
Stewarts/Cave	Stage 17	0.617±0.055 (2)	0.503±0.062 (2)
West Naracoorte	Stage 19	0.524±0.066 (4)	0.502±0.021 (4)

Table 1. Mean whole-rock D/L ratios (Aspartic Acid and Valine) from the barrier range sequence preserved on the Coorong coastal plain. Samples are taken from the aeolian dune facies.

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