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Project IGCP 437

Coastal Environmental Change
During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

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Quaternary coastal morphology and sea level changes

Project 437

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Aminostratigraphy of Late Quaternary Sea-Level Highstands, Gulf St. Vincent, South Australia

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Keywords: *amino acid racemisation, aminostratigraphy, Holocene, Quaternary, South Australia.*

Abstract

This paper presents preliminary data from a PhD project examining the aminostratigraphy and Late Quaternary sea-level highstands of the South Australian gulf region. Results obtained from Gulf St. Vincent are reported here.

Located in South Australia, Gulf St. Vincent is an elongate shallow marine embayment that extends (ca. 150 km) northwards into southern continental Australia to an apex at Port Wakefield. The gulf covers an area of 7000 km^2 and has a maximum water depth of just over 40 m (fig.1). Gulf St. Vincent lies in a fault bound depression with Yorke Peninsula to the west, Kangaroo Island to the south and Fleurieu Peninsula to the east.

The area experiences low rainfall and high evaporation rates, which results in a hydrologically inverse estuary, the northern waters having little interaction with the open Southern Ocean. These conditions provide an ideal environment for the growth and accumulation of carbonate secreting organisms. Extensive sea grass meadows in the northern gulf trap the small amount of terrigenous sediment input derived from the arid catchment, resulting in sediment that consists primarily of biogenic carbonate (Gostin et al. 1988). Gulf St. Vincent forms a part of the world's largest temperate carbonate province, which extends along much of Australia's southern coast. Conditions in the gulf have allowed for a record of sedimentation to be traced back to the Tertiary.

The South Australian coastline is relatively stable as Gulf St. Vincent lies on an area of the Australian plate removed from tectonic plate boundaries (Cann et al. 1988). The gulf was not glaciated during the Quaternary and has therefore not been subject to glacial rebound over the time of interest. A detailed record of highstand deposition is thus preserved within the gulf.

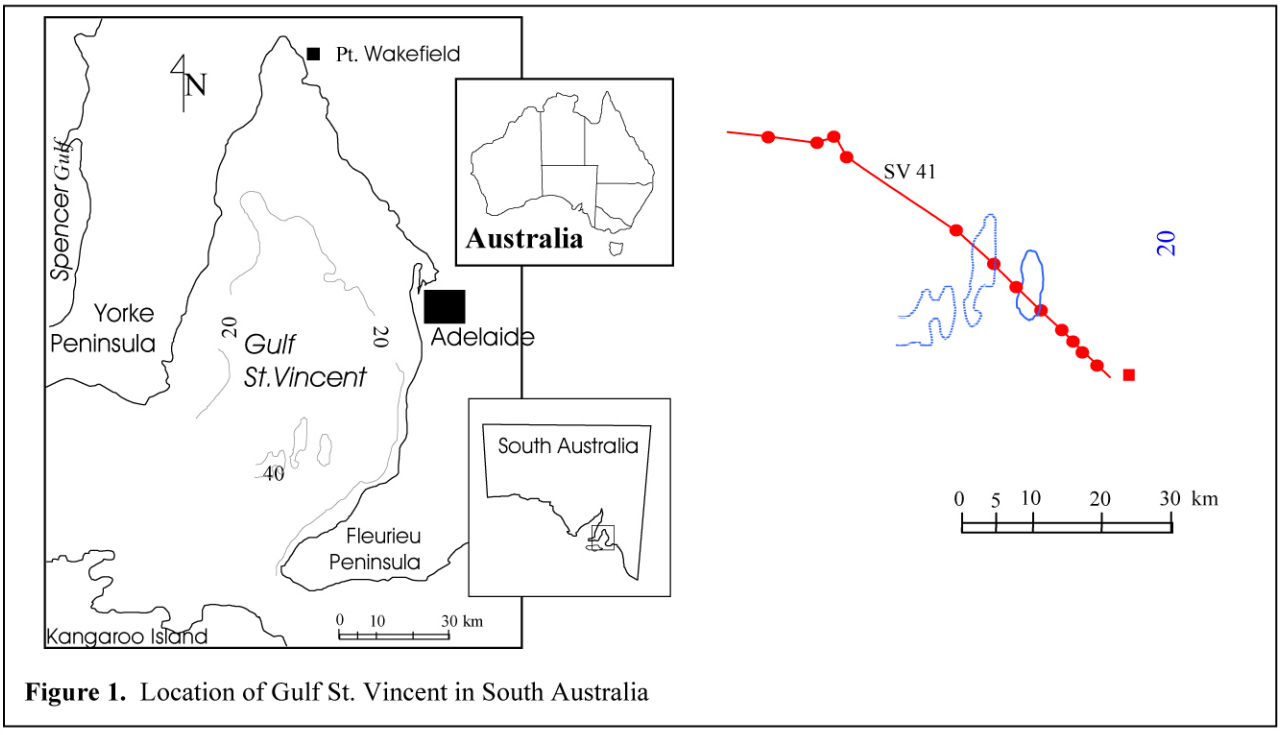


Figure 1. Location of Gulf St. Vincent in South Australia

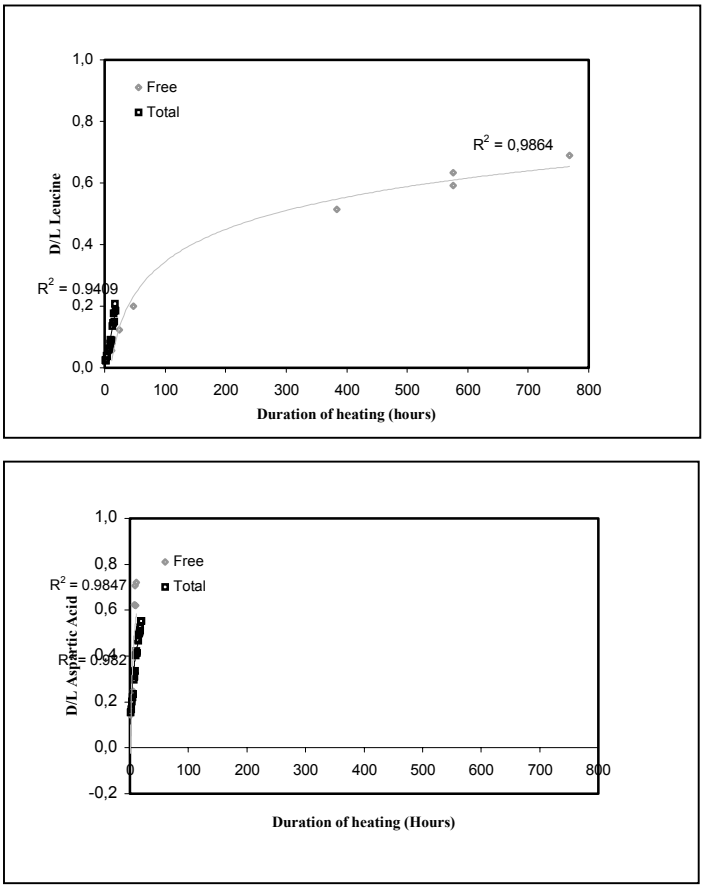


Figure 2. Artificially induced extents of amino acid racemisation (expressed as a D/L ratio) with respect to heating time for the free and total fractions [a] leucine and [b] aspartic acid from the modern mollusc *Pecten fumatus* to simulate the likely changes which occur at ambient conditions during long term diagenesis

Last Interglacial sediments in the Adelaide region are not known to crop out above the present sea level, suggesting that the area has experienced long term subsidence of less than 0.04 mm/year (Belperio et al. 1985). Broad sheets of carbonate sand have been deposited in the gulf as a response to different interglacial and interstadial sea-level highstands.

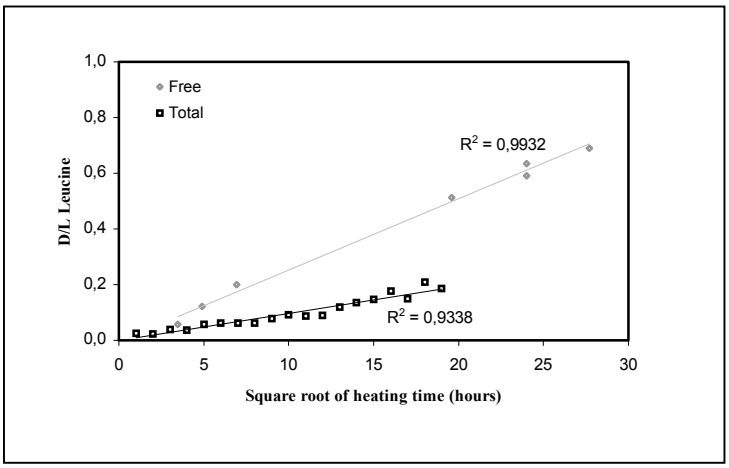
As a result the Gulf St. Vincent basin provides a useful setting for the study of Late Quaternary sea-level highstands. Sediments of the Last Interglacial (Oxygen Isotope Stage, OIS 5e) Glanville Formation consist of yellowish to cream coloured shelly sands and sandy clays. The Glanville Formation is characterized by some warm water species no longer found in local waters, most notably *Anadara trapezia*. During the last glacial cycle, and associated fall in sea level by over 100 m, last interglacial sediments in shallow areas of the gulf were subaerially exposed, becoming oxidized and variably lithified, forming a calcrete cap over substage 5e sediments. In deeper areas of the gulf, lithification is not observed, and a light to dark grey mud and fossil assemblage suggests a lagoon to saline lake environment existed (Cann et al. 1993). The Holocene sediments (greenish to grey shelly sand and calcareous mud), St. Kilda Formation (Firman, 1966), occur as a thin veneer (usually less than 1 m) around much of the gulfs coast

Formation Name	D/L Leucine	D/L Aspartic Acid
Modern	0.01 – 0.03	0.05 – 0.08
St. Kilda	0.05 – 0.16	0.17 – 0.39
Glanville	0.50 – 0.62	0.65 - 0.80

Table 1. Range of amino acid D/L ratios in the total acid hydrolysate of marine shells encountered in the identified formations from Gulf St. Vincent, South Australia

and subtidal areas near Adelaide, overlying the lithified Glanville Formation. It has been well documented that the Holocene and Last Interglacial marine transgressions attained sea-levels comparable with that of today. However, the interstadial sea levels of the Last Glacial Cycle are more complex to delineate. OIS 3, 5a and 5c are not commonly recognized to have reached present sea levels.

The benthic foraminifera in marine sediments of Gulf St. Vincent indicate that there was a marine transgression of OIS 3 into the gulf (Cann et al. 1988). Murray-Wallace *et al*. (1993) used AAR analysis to evaluate the veracity of radiocarbon ages on marine shells from the Gulf interstadial succession, which lie near the practical limits of the radiocarbon method. A sea level of between –22 and – 30 m was assigned to OIS 3 on the basis of this evidence. This estimate conflicts with sea level work carried out in other areas of the world. The most widely accepted sea-level record for this period has been derived from the tectonically uplifted coral terraces of Huon Peninsula, Papua New Guinea, where Chappell et al. (1996) has estimated sea level, at the peak of OIS 3 (45.8 ± 0.7 kyr), to have stood between 53 and 37 m below current sea level. The presence of OIS 3 sediments in Gulf St. Vincent, therefore presents a problem.It is conceivable that the fossil shells analyzed by radiocarbon and AAR dating may have been transported into the gulf during the onset of the post-glacial marine transgression. Over 60 marine cores from Gulf St. Vincent are currently being studied, with an emphasis on the record of the last glacial cycles. Relative ages of fossil shells from these sediments are being determined primarily by AAR. AAR dating is a geochemical technique that requires small sample volumes and is easily and relatively cheaply carried out in most laboratories. AAR dating measures the relative contribution of the L or levo and D or dextro amino acid isomers and is expressed as a D/L ratio. In living organisms only the L isomer is present, after death the L isomer is interconverted over time to the corresponding D isomer, until a racemic mixture is obtained. The racemisation kinetics consists of two linear sections, each with different rates, joined by a non-linear section, and can be modeled using apparent parabolic kinetics (Mitterer and Kriausakul, 1989).



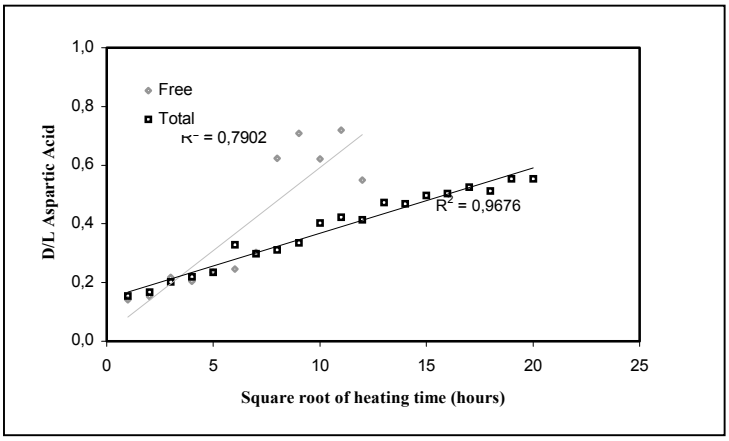


Figure 3. Artificially induced extents of amino acid racemisation (expressed as aD/L ratio) with respect to the square root of time for the free and total fractions of [a] leucine and [b] aspartic acid from the modern mollusc *Pecten fumatus* to simulate the likely changes which occur at ambient conditions during long term diagenesis

D/L ratios can therefore give an indication of fossil age. Aminostratigraphy is the application of the AAR data and subsequent D/L ratios in conjunction with litho- bio- and morphostratigraphic evidence to create a regional geochronological framework.

A series of experiments were conducted to artificially induce racemisation and hence simulate ageing in several species of marine shell common to the study area.

By gaining a more thorough understanding of the reactions kinetic pathways in each species, the amino acid racemisation (AAR) dating method can be confidently utilized to assign ages to the formations present in the gulf region. Presented here are the preliminary results obtained from modern samples of *Pecten fumatus*, a marine mollusc, common also in Last Interglacial and Holocene sediments.

Subsamples of each valve of the mollusc were cleaned and then 30 replicates of 5g were prepared. These were then placed in culture tubes, with quartz sand, 4 mL distilled water and sealed. They were heated at 110°C and removed at pre-determined intervals for up to 128 days.

Both the free (those not bound in a protein chain) and total acid hydrolysate (bound within peptide chains and free amino acids) amino acid fractions were analyzed.

D/L ratios are plotted against time for leucine and aspartic acid (Fig.2). D/L ratios for the free amino acid fraction were substantially higher than that of the total acid hydrolysate and display a log relationship with time.

Aspartic acid, an acid which undergoes rapid racemisation, displays a log relationship for the total fraction. Leucine is a slow racemising amino acid and in samples up to 32 days is still within the first linear section of kinetics, and can be modeled up to this point using first order linear kinetics (fig.2a). Over the same time frame aspartic acid exhibits both the first and second linear kinetics sections (fig.2b). When modeled in terms of apparent parabolic kinetics (fig.3) leucine produces a linear regression with an r^2 value of 0.973 (fig.3a). Aspartic acid has an r^2 value of 0.916 when a linear regression is attempted on the log graph (fig.3b), compared to the log regression r^2 value of 0.982 (fig.2a). Aminostratigraphy has confidently identified the wider distribution of the Holocene St. Kilda and Last Interglacial Glanville Formations within Gulf St. Vincent, based on the degree of aspartic acid and leucine racemisation (Table 1). Sediments have been encountered within these cores containing fossil shells yielding intermediate D/L ratios between the St. Kilda and Glanville Formations suggesting an interstadial age during the last glacial cycle. Further work is in progress utilizing both radiocarbon and electron spin resonance dating to examine the Gulf St. Vincent stratigraphic and associated sea-level highstand records.

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Holocene Sea-level Changes and Coastal Geomorphic Evolution in Bangladesh: Example from Matuail near Dhaka City.

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Keywords: *Coastal Stratigraphy, Holocene Sea-level, Coastline, Bangladesh.*

Abstract

The coastal belt of Bangladesh occupies nearly one fourth of national territories and supports about one quarter of total population. This open coastal system is vulnerable to a number of natural disasters, such as cyclones, storm-surges, saline water intrusion and above all the future potential sea level scenarios (Islam, 2001).

Since geological past, rapid siltation, sediment compaction, differential land uplift and subsidence, local tectonic activities and accelerated tidal force have led this coast as one of the most dynamic ecosystem in the world (Stanley and Hait, 2000; Goodbred Jr. and Kuehl, 2000). In this paper it has been attempted to reveal the geomorphological evolution of the coast, particularly in the context of Holocene relative sea level movements and coastal dynamics.

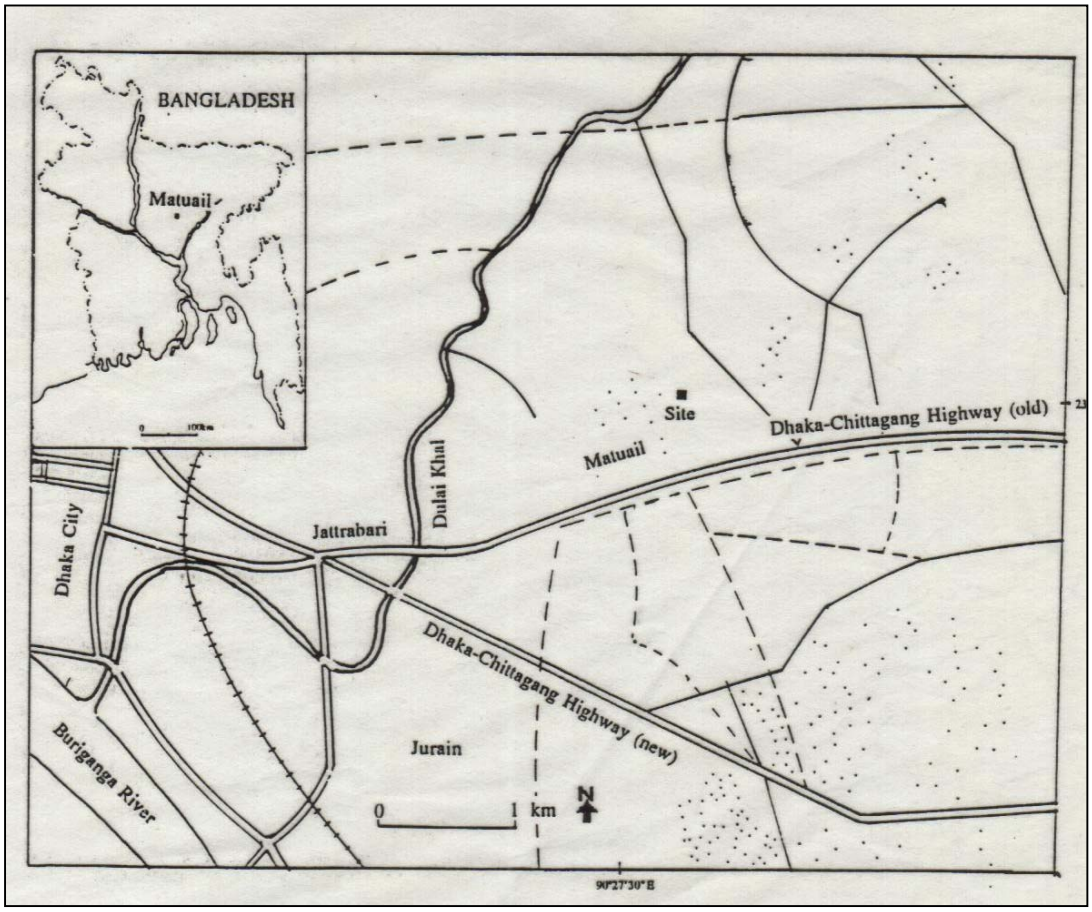

Figure 1. Location of the study area.24 boreholes were made in east-west and north-south transactions at the site Panigati.