

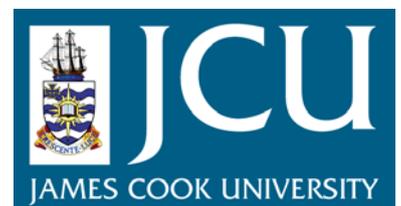
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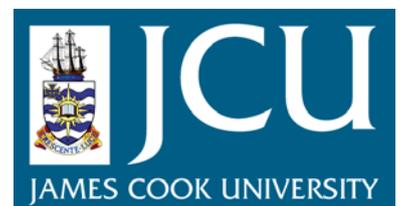
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**THE STRATIGRAPHY AND
GEOCHRONOLOGY OF EMERGENT FOSSIL
REEF DEPOSITS OF WESTERN AUSTRALIA**

Thesis submitted by

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In May 2007

For the degree of Doctor of Philosophy

In the School of Earth Sciences

James Cook University

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STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any other form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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ABSTRACT

Corals provide the most widely used sea-level archive. Many coral species survive only in shallow water, therefore fossil corals emergent or submergent relative to present reefs, along stable coastlines, suggest variations in past sea level. Along the coastal margin of Western Australia (WA) an extensive series of marine isotope stage (MIS) 5e reefs outcrop at 3 ± 1 m above sea level. The consistency of reef elevation along thousands of km of WA coastline demonstrates the tectonic stability of this trailing intraplate continental margin. There is also evidence of erosional terraces or incipient reef development at elevations above this +3 m sea-level benchmark. Some workers reasoned that the higher elevation of these marine units is an artefact of localized tectonism or warping. This rationale fails to address: 1) intertidal deposits at multiple elevations in close proximity; 2) the distinct geomorphological difference between the lower and upper marine units; and 3) the similarity in elevation between WA emergent marine deposits and those found on stable carbonate platforms of The Bahamas and Bermuda. With accurate and precise dating of these emergent reef deposits it may be possible to characterise the nature of sea level during MIS 5e.

Coral skeletons are constructed of chemically unstable aragonite. Older coral material is generally more diagenetically altered, often suffering the addition or loss of uranium or thorium, which leads to inaccurate U-series age calculations. Coral diagenesis is generally determined by changes in carbonate mineralogy, but a more subtle form of geochemical alteration may affect the uranium-thorium age of corals that appear mineralogically pristine.

In an attempt to extract meaningful ages from corals that have undergone isotopic exchange, modeled alpha-recoil processes were used to calculate open-system ages. These open-system ages are based on the assumption that alpha-recoil mobilisation is the only diagenetic process operating within the coral/reef unit. Independent age controls including: 1) the known duration of MIS 5e; 2) stratigraphic superposition; and 3) age equivalence within individual corals, were used to test the reliability and accuracy of uncorrected and open-system corrected coral ages. Despite claims to the contrary, this study found open-system corrections to fail the above prescribed age tests, such that open-system corrections did not reflect the corals true age.

Investigations into the nature of MIS 5e sea levels were focused on two contrasting locations, Cape Cuvier, a high-energy coastal site, and Shark Bay, a low

energy marine embayment. Both sites point to an extended period of widespread coral reef development at +2 to +4 m elevation with incipient reef and erosional terraces at between +6 and +10 m. The incipient nature of the upper coralgall rim and the fact that the lower terrace was not able to utilize the newly available accommodation space points to a brief but rapid sea level excursion to this new elevation. High-precision U-series dating returned coral ages that were inconsistent with the stratigraphic interpretation of the site and other known MIS 5e sea level curves.

In an attempt to fill in the temporal and spatial gaps left by coral dating, the U-series method was applied to crustose coralline algae (CCA). This study shows that living CCA capture a modern seawater equivalent $\delta^{234}\text{U}$ value of 147.02 ± 1.5 ‰, and initial uranium concentrations of 0.2 ± 0.07 ppm. These initial chemistries allow for the examination of uranium and thorium isotopic evolution over geological timescales, however uranium uptake and detrital ^{232}Th contamination limit the usage of this material in U-series dating.

Although we are confident of our interpretation of the sea-level history in WA during MIS 5e, we offer the following considerations: 1) field observations and relationships remain the most reliable means of determining the succession of events in the case of MIS 5e; 2) despite increased measuring precision of “high tech” dating methods, there is not necessarily a concomitant increase in the accuracy of the ages; and, 3) open-system corrections are not a reliable tool for determining a coral’s true age.

STATEMENT OF THE CONTRIBUTION BY OTHERS

This thesis has benefited greatly from the contribution by others to the formulation of ideas, the development of research approaches, and the interpretation and critical review of the data. Paul Hearty and Malcolm McCulloch were instrumental in providing the impetus to investigate the nature of sea level and climate during the peak of the last interglacial as recorded in emergent reef deposits along the West Australian coastline. Many of the fundamental questions that have been addressed in this thesis stemmed from previous work undertaken by these individuals and hypotheses that were generated from the same. Paul Hearty and Malcolm McCulloch acquired the initial Australian Research Council funding which funded this research and my Ph.D. stipend. A James Cook University graduate research scheme grant (MRG) provided extra funding for fieldwork in Western Australia. Both of these individuals have also contributed much to the acquisition and interpretation of the data generated herein, and in the presentation of results. However, both recognise This Author's role as chief investigator in these studies, and as having acquired the majority of the data, formulating the bulk of the interpretations, preparing of drafts, and refining of the manuscripts.

STATEMENT OF CONTENT

The body of this thesis is presented as four separate, self-contained works, which will be submitted to scientific journals of international significance, in a similar format. Due to the completeness of each section a small amount of repetition has been unavoidable. This particularly the case with the methods section, which describes the analytical techniques used in U-series dating of corals. There has also been some overlap in data interpretation.

ACKNOWLEDGEMENTS

The Author would like to acknowledge the contributions of the following individuals and groups towards the work presented herein.

The Canberra crew: A big thanks to Malcolm McCulloch at the RSES, Australian National University for providing support, technical skills and considerable runtime to analyse my corals, Graham Mortimer for his patience and shared office space as well as Bridget, Lois, Eva, Carles. To Pete, and Sarah for providing accommodation and Damian for providing accommodation and homebrew.

The West Australian crew: To all those people who helped me out with field work, a special thanks to CALM in Exmouth and Denham for access to sites and permission to collect corals within National Parks. To Dampier Salt Ltd for access onto their mine lease and finally to Dave Bauer of Arid Landscapes whose logistical support was greatly appreciated.

The Sydney crew: To Tick, Sav and Dom, although your place was a bit like a transit lounge for me thanks for being so accommodating, the bed was always soft and the beer always cold.

The Townsville crew: So many people I would like to thank for their help, friendship and support. First to my best mates Jo Jo, Belinda and Andy; friends and flat mates, de Jersey, Katie, Dave, Aileen, and Ellie; as well as Toni and Kirsten; and Thomas for his constant distractions and wild adventures. Shelley and little Kai my newest (literally) best friend

The Family: To my Mum and Dad you both instilled qualities in me that I am proud and for that I thank you, to my sister Lisa who is embarking on her own adventure and the rest of the Previterra clan.

Academic supervisors official and unofficial: Thanks again must go to Malcolm McCulloch, Jody Webster and Peter Ridd. But most thanks must go to Paul Hearty, friend and mentor, for all your support, guidance, encouragement and patience.

Finally I'd like to thank Caro, although you appeared late in the game, you turned out to be a match winner for me in more ways than one.

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