Late Pleistocene–Holocene deposition of mixed siliciclastic-carbonate sediments on slopes east of the Great Barrier Reef, northeast Australian margin

Thesis submitted by

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ABSTRACT

Continental margins are dynamic systems where the flux and accumulation of sedimentary components varies over space and time. Along passive continental margins, relative changes in sea level and sediment supply to the shelf are the predominant influences on sediment fluxes to slopes and basins and are incorporated in generic models of continental margin evolution. Generic depositional models differ depending on the composition of sediments deposited within the system, and can be classified as siliciclastic, carbonate, mixed siliciclastic-carbonate, or evaporite models. The principles governing generic models for end-member siliciclastic and carbonate systems have been tested widely in modern environments, resulting in the general acceptance of 'lowstand shedding' to the slope and basin for siliciclastic systems, and 'highstand shedding' to the slope and basin for carbonate systems. Conversely, relatively little attention has been afforded modern examples of mixed siliciclastic-carbonate systems. Nevertheless, generic models for the evolution of mixed siliciclastic-carbonate margins, developed mostly via the study of ancient examples in the geological record, are accepted widely, and incorporate the combined paradigms for end-member siliciclastic and carbonate margins to model off-shelf sediment accumulations in response to relative sea-level change. Thus, along mixed siliciclastic-carbonate margins, siliciclastic fluxes to slopes and basins should be highest during sea-level lowstands, when rivers can incise across exposed shelves, and carbonate fluxes to slopes and basins should be highest during sea-level highstands, when flooded shelves provide greatest neritic accommodation space. Lowest fluxes of both components should occur during sea-level transgressions when rivers retreat landward and carbonate production is inhibited by proximal fluvial inputs.

The passive continental margin of northeastern Australia, extending from ~7 to 25°S, is the largest extant mixed siliciclastic-carbonate system. Significant quantities of siliciclastic sediment from rivers draining tropical and subtropical watersheds in Australia and Papua New Guinea are discharged onto a highly productive carbonate shelf that includes the Great Barrier Reef (GBR). Sedimentary successions on slopes east of the GBR are characterised by alternating siliciclastic-rich and carbonate-rich intervals, originally interpreted as forming during lowstands and highstands, respectively. However, recent investigations have demonstrated that the uppermost siliciclastic-rich interval offshore the central GBR province around 17°S formed during the last postglacial transgression. Despite these findings, the late Pleistocene-Holocene deposition of mixed siliciclastic-carbonate sediments east of the GBR remains equivocal, because it is unclear if: (1) siliciclastic fluxes to slopes all along the central GBR province were highest during transgression, (2) off-shelf fluxes of carbonate sediment were highest during highstand, lowstand, or transgression, and (3) the depositional response to relative sea-level change is consistent all along the northeast Australia margin, especially in areas where physiography and climate are different.

This thesis aims to resolve these issues and to thus develop a more complete understanding of the latest Quaternary evolution of the mixed siliciclastic-carbonate margin of northeastern Australia. High-resolution chronostratigraphies were developed for multiple sediment cores from repositories east of the modern GBR via the determination of thirty-one accelerator mass spectrometry radiocarbon ages and stable isotope stratigraphy. Bulk carbonate content, and carbonate mineralogy and geochemistry, were examined in each of these cores and in other cores with previously developed age models. These datasets enabled the determination of mass accumulation rates for siliciclastic and carbonate components of the bulk sediment, and for individual carbonate minerals down each core. Mass accumulation rates unequivocally demonstrate that all along the northeast Australian margin from ~15 to 21°S, fluxes of both siliciclastic and carbonate sediment to repositories in Queensland Trough and on Marion Plateau were lowest during the last glacial lowstand, highest during the postglacial transgression, and moderate to high during the Holocene highstand, regardless of modern differences in physiography, climate and sediment supply. The history of off-shelf sediment fluxes on the northeast Australian margin during the latest Quaternary could be affected by climate change over glacial-interglacial cycles, but is probably heavily influenced by fluvial aggradation on the shelf during lowstand, and basin-ward remobilisation of siliciclastic sediment and subaerially eroded carbonate during transgression. The northeast Australian margin is an outstanding example of the strong influence margin physiography and physical processes, in conjunction with relative sea level and climate change, can have on the development of sedimentary sequences on slopes of mixed siliciclastic-carbonate margins, and may serve as an analogue for other mixed siliciclastic-carbonate systems throughout the geological record, especially tropical platforms rimmed by reefs.

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 data. Acknowledgement of many of these contributors is made at the conclusion of relevant chapters, but is due here to several individuals in particular:

Gerald Dickens and Gavin Dunbar were instrumental in providing the initial impetus to investigate the development of mixed siliciclastic-carbonate sequences east of the Great Barrier Reef. Many of the fundamental questions that have been addressed in this thesis stemmed from previous work undertaken by these individuals and from ideas and hypotheses that were generated from the same. Gerald Dickens acquired the initial funding and support necessary to begin this work based on the recognition of important research avenues. Both of these individuals have also contributed much to the acquisition and interpretation of data generated herein, and in the presentation of results. The importance of their contribution to this research is apparent in their status as co-authors to published papers, or manuscripts submitted for publication, 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 drafts, and refining of the manuscripts.

Paul Hearty, Michael O'Leary, and Darrell Kaufman set the foundations for investigations involving amino-acid racemization in single foraminifera from the northeast Australian margin. Many of the primary hypotheses and groundwork for initiating this research is due to Paul Hearty, while Michael O'Leary provided the first systematic test of the technique (the results of which form the basis of his Honours thesis), and Darrell Kaufman provided analytical and interpretative expertise. The research presented here forms part of a pilot program further evaluating the utility of the method and is inherently collaborative. The contribution of these individuals is recognised by their status as co-authors on the manuscript presented herein, however, all recognise this author's role as chief investigator in this particular avenue of the research.

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