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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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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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PhD Thesis – M.C. Page
TABLE OF CONTENTS

Statement of access .......................................................... i
Statement of sources ......................................................... ii
Abstract ........................................................................... iii
Statement of the contribution by others ........................................ v
Acknowledgements ............................................................ vi

Table of Contents .................................................................. vii
List of Tables ....................................................................... xi
List of Figures ...................................................................... xiii

Chapter 1 – Introduction .......................................................... 1
  1.1. Generic continental margin stratigraphy .............................. 2
  1.2. Mixed siliciclastic-carbonate depositional systems ................. 3
  1.3. Northeast Australian Margin ............................................... 4
  1.4. Recent sedimentation east of the Great Barrier Reef ............. 8
  1.5. Sedimentation east of the Great Barrier Reef through time ... 9
  1.6. Thesis overview ............................................................. 11

Chapter 2 ........................................................................... 20

Tropical view of Quaternary sequence stratigraphy: Siliciclastic accumulation on slopes east of the Great Barrier Reef since the Last Glacial Maximum

Abstract .......................................................................... 21
  2.1. Introduction ................................................................. 22
  2.2. Location, samples and methods ......................................... 23
  2.3. Results ...................................................................... 25
    2.3.1. Carbonate profiles .................................................. 25
    2.3.2. Radiocarbon ages .................................................... 25
    2.3.3. Timing and accumulation of siliciclastic-rich intervals .... 26
  2.4. Discussion ................................................................. 27
Chapter 3

Periplatform carbonate accumulation on slopes east of the Great Barrier Reef since the Last Glacial Maximum: Toward a coherent model for sedimentation in a tropical mixed silicilastic-carbonate system

Abstract

3.1. Introduction

3.2. Background

3.3. Samples and analytical methods

3.4. Compositional variation

3.4.1. Carbonate mineralogy (XRD)

3.4.2. Strontium concentrations

3.4.3. Carbonate grains

3.5. Mass accumulation rates

3.6. Discussion

3.6.1. Origin and problem of carbonate abundance and accumulation patterns

3.6.2. Changes on the shelf and a solution to slope accumulation

3.6.3. Lowstand ca. 25–12 ka

3.6.4. Transgression ca. 12–7 ka

3.6.5. Highstand ca. 7 ka–present

3.6.6. Discrepancies

3.7. Conclusions

Acknowledgements

Chapter 4

Sediment fluxes to Marion Plateau (southern Great Barrier Reef Province) over the last 130 ky: New constraints on ‘transgressive-shedding’ off northeastern Australia
# Table of Contents

Abstract..................................................................................................................86
4.1. Introduction........................................................................................................88
4.2. Location, samples and methods..........................................................................90
  4.2.1. The northeast Australian margin.................................................................90
  4.2.2. Core GC10...................................................................................................92
  4.2.3. Analytical methods.........................................................................................92
4.3. Results.................................................................................................................95
  4.3.1. Bulk carbonate content..................................................................................95
  4.3.2. Carbonate mineralogy....................................................................................96
  4.3.3. Strontium content........................................................................................96
  4.3.4. Chronostratigraphy.......................................................................................97
4.4. Mass accumulation rates...................................................................................98
  4.4.1. Calculation.....................................................................................................98
  4.4.2. Last Glacial Maximum (~25 ka) to mid Holocene (~6 ka).........................99
  4.4.3. Last Interglacial (~130 ka) to Last Glacial Maximum (~25 ka)..............100
4.5. Discussion........................................................................................................101
4.6. Conclusion.........................................................................................................107
Acknowledgements....................................................................................................109

**Chapter 5 - Conclusion** ---------------------------------------------------------124

References Cited .......................................................................................................132

**Appendix A** ........................................................................................................140

High-resolution amino-stratigraphy of cores from Queensland Trough and Marion Plateau: insights into AAR kinetics in the western Coral Sea since the Last Glacial Maximum

Abstract..................................................................................................................141
A.1. Introduction.......................................................................................................143
A.2. Approach and methods....................................................................................144
  A.2.1. Core selection..............................................................................................144
  A.2.2. The AAR method.......................................................................................146
LIST OF TABLES

Chapter 2

Table 2.1: Measured bulk carbonate content in cores 51GC43, FR4/92 PC11, FR4/92 PC12, FR4/92 PC13, FR4/92 PC14, and FR5/90 PC27a..................................................31-33

Table 2.2: Results of accelerator mass spectrometry radiocarbon analyses and calibration of conventional ages for cores 51GC43, FR4/92 PC11, FR4/92 PC12, FR4/92 PC13, FR4/92 PC14, and FR5/90 PC27a. (N.A.—Beyond the range of calibration).......................................................................................................................34

Chapter 3

Table 3.1: Location and other information pertaining to sediment cores FR5/90 PC27a, ODP Hole 820A, FR4/92 PC13, FR4/92 PC16, FR4/92 PC11, and 51GC43........................................................................................................69

Table 3.2: Bulk carbonate content and carbonate mineral abundances in sediment cores FR5/90 PC27a, ODP Hole 820A (1H to 2H-I), FR4/92 PC13, FR4/92 PC16, FR4/92 PC11, and 51GC43.................................................................70-71

Table 3.3: Measured and corrected (for siliciclastic dilution) strontium concentration down sediment cores FR5/90 PC27a, ODP Hole 820A (1H to 2H-I), FR4/92 PC13, FR4/92 PC11, and 51GC43.................................................................72-73

Chapter 4

Table 4.1: Bulk carbonate content of core FR03/99 GC10..............................111

Table 4.2: Carbonate mineral abundances and Sr concentrations in core FR03/99 GC10..............................................................................................................112

Table 4.3: $\delta^{18}O$ and $\delta^{13}C$ in planktonic foraminifers from core FR03/99 GC10......113
Table 4.4: Results of AMS radiocarbon analysis of planktonic foraminifers from core FR03/99 GC10 .......................................................... 114

Table 4.5: Mass accumulation rates of sedimentary components in core FR03/99 GC10 .................................................................................. 115

Appendix A


Table A.2: Sample information, extrapolated ages, and results of RP-HPLC analysis (D/L ratios) for cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a. n – number of tests included in average. ex – number of tests excluded from average .......................................................... 157-158

Table A.3: Results of stable isotope analysis of benthic foraminifera from core 51GC43 ....................................................................................... 159

Appendix B

Table B.1: Bulk carbonate content, ODP Hole 1198A, 0 – 23.69 mbsf ......... 176-179
LIST OF FIGURES

Chapter 1

**Figure 1.1:** Global map showing the location of some modern and ancient examples of mixed siliciclastic-carbonate depositional systems. The location of modern examples is indicated, as is the age of examples in the geological record................................................................. 17

**Figure 1.2:** (A) Eustatic change since 25 ka. (B) Generic depositional model for sediment deposition on slopes of tropical mixed siliciclastic-carbonate systems. (C) Schematic representation of observed sedimentation patterns on slopes of the northeast Australian margin. H/stand – sea-level highstand. Trans – transgression. Lowstand – sea-level lowstand. MAR – mass accumulation rate ....................... 18

**Figure 1.3:** The northeast continental margin of Australia, including mean annual rainfall, the location of major rivers draining the hinterland, distribution of modern reefs of the Great Barrier Reef, and bathymetric features of the western Coral Sea... 19

Chapter 2

**Figure 2.1:** The northeast Australian margin between ~15 and 20°S, including mean annual rainfall, location of major rivers, distribution of modern reefs on the shelf, bathymetry (m) of the western Coral Sea, and location of cores FR5/90 PC27a, ODP Hole 819, 820, 821, FR4/92 PC14, FR4/92 PC13, FR4/92 PC12, FR4/92 PC16, FR4/92 PC11, and 51GC43 ............................................................................................................ 35

**Figure 2.2:** Downcore profiles of bulk carbonate content for cores 51GC43, FR4/92 PC11, FR4/92 PC12, FR4/92 PC13, FR4/92 PC14, and FR5/90 PC27a, and radiocarbon ages (calibrated years before present) of planktonic foraminifera....... 36

**Figure 2.3:** Mass-accumulation rates of siliciclastic and carbonate sediment in cores 51GC43, FR4/92 PC11, FR4/92 PC12, FR4/92 PC13, FR4/92 PC14, and FR5/90
List of Figures

PC27a. Dashed line approximates the time when sea level reached the shelf edge (ca. 12 ka). H/stand – sea-level highstand; Trans – sea-level transgression; Lowstand – sea-level lowstand. 37

Chapter 3

Figure 3.1: The central portion of the northeast Australian margin, bathymetry (m) of the Coral Sea, and mean annual rainfall on the continent. Circles indicate cores examined from Queensland Trough. Triangles indicate cores through reefs on the shelf (BRR – Britomart Reef, Johnson et al., 1984; RBR5 – Ribbon Reef 5, BOR – Boulder Reef, International Consortium for Great Barrier Reef Drilling, 2001). Transects A–A’, B–B’ and C–C’ appear as cross-sections on Fig. 3.10. 74


Figure 3.3: Downcore profiles of carbonate mineralogy and radiocarbon ages (modified from Peerdeman and Davies, 1993; Dunbar et al., 2000; Page et al., 2003) for ODP Hole 820A, 51GC43, FR5/90 PC27a, FR4/92 PC16, FR4/92 PC13, and FR4/92 PC11. Original age models for ODP 820A and PC16 (based on conventional radiocarbon ages) have been calibrated with the CALIB 4.3 freeware (Stuiver et al., 1998) to maintain consistency with the age models of Page et al. (2003). H/stand – sea-level highstand. Trans – transgression. Lowstand – sea-level lowstand. WD – water depth. Dist – distance offshore of the 120 m isobath. 76

Figure 3.4: The sand-sized fraction of sediment deposited in core 51GC43 during: (A–B) The last glacial lowstand, ~21 ka (209 cmbsf), planktonic (PF) and benthic (BF) foraminifers are the dominant components, pteropods (PT) are also common; (C–E) The postglacial transgression, ~11 ka (120 cmbsf) and (F–H) ~9 ka (90 cmbsf), foraminifera are abundant, shell fragments (SF) and LMC clasts are common, LMC
clasts occur as both cemented aggregates (LMC-A) and recrystallised grains (LMC-R); (I–J) The Holocene highstand, ~2.5 ka (5 cmbsf), foraminifers are abundant and shell fragments are common, LMC clasts are present in minor quantities........77-78

Figure 3.5: Relative abundances (A) and mass accumulation rates (B) of low-Mg calcite, aragonite, and high-Mg calcite during lowstand, transgression, and highstand, in cores from ODP Hole 820A, 51GC43, FR5/90 PC27a, FR4/92 PC16, FR4/92 PC13, and FR4/92 PC11, plotted against distance from the 120 m isobath. With increasing distance from the shelf, the relative abundance of LMC generally increases, and the relative abundances of aragonite and HMC generally decrease. Note, however, that with increasing distance from the shelf, the mass accumulation rates of all carbonate minerals generally decrease........................................79

Figure 3.6: Strontium concentration versus the percentage of aragonite in the bulk carbonate fraction of sediment from cores FR5/90 PC27a, ODP 820A (1H to 2H-1), FR4/92 PC13, FR4/92 PC11, and 51GC43. Circles represent samples deposited prior to 12 ka; squares represent samples deposited after 12 ka. Assuming that Sr-rich aragonite contains 7500 ppm Sr, and that Sr-poor aragonite contains 1500 ppm Sr, samples in which the aragonite present in the bulk carbonate fraction is composed entirely of Sr-rich aragonite should plot along the solid line marked Sr-rich aragonite, and samples in which the aragonite present in the bulk carbonate fraction is composed entirely of Sr-poor aragonite should plot along the solid line marked Sr-poor aragonite. Samples in which the aragonite present in the bulk carbonate fraction is composed of equal parts Sr-rich aragonite and Sr-poor-aragonite should plot along the solid line marked 50/50. The linear trendline ($y = 45.5x + 1391; r^2 = 0.74$) indicates that more than 50% of the aragonite present in most samples is composed of Sr-rich aragonite..........................................................80

Figure 3.8: General stratigraphy of cores through individual reefs on the Great Barrier Reef (modified from: Johnson et al., 1984; International Consortium for Great Barrier Reef Drilling, 2001; Webster and Davies, 2001) the location of which are shown on Fig. 3.1. Holocene reefs are founded upon Pleistocene substrates that have been subaerially exposed and altered from aragonite (and high-Mg calcite) to low-Mg calcite, and are separated by erosional ('solution') unconformities. The lowermost age for BRR2 is estimated based on the distance between the lowermost radiocarbon age and the underlying solution unconformity, and published growth rates for Britomart Reef (Johnson et al., 1984).................................82

Figure 3.9: Schematic model of sedimentary processes and off-shelf fluxes on the northeast Australian margin since the Last Glacial Maximum.........................83

Figure 3.10: Bathymetric profiles across the shelf-slope break of the northeast Australian margin (location of transects shown on Figure 3.1) and the approximate position of cores in Queensland Trough and on the shelf. Note that the areas of seafloor within 120 m of the sea surface during lowstand ('LGM productivity window') increase by up to an order of magnitude almost immediately upon sea level rising above the shelf break during transgression.................................84

Chapter 4

Figure 4.1: The central and southern northeast Australian margin showing major physiographic features, the location of core FR03/99 GC10 on Marion Plateau, previous study areas in Queensland Trough (Harris et al., 1990; Peerdeman and Davies, 1993; Dunbar et al., 2000; Dunbar and Dickens, 2003b; Page et al., 2003), and the locations of four previously studied cores mentioned specifically in the text.................................................................116

Figure 4.2: Photograph and physical properties of core FR03/99 GC10, including bulk carbonate content, relative abundance of carbonate minerals, Sr concentration in the carbonate fraction, and δ¹⁸O stratigraphy. Note the position of AMS radiocarbon ages (× 1000 years) and the last occurrence of pink Globigerinoides ruber (⁎) on the right side of the core photograph. Marine isotope stages (MIS) as interpreted from
correlation of isotope stratigraphy with the SPECMAP record (Martinson et al., 1987) appear on the far right.................................................................117

**Figure 4.3:** Age model for core FR03/99 GC10, produced by correlation of $\delta^{18}$O stratigraphy with the SPECMAP record of Martinson et al. (1987). The positions of four AMS radiocarbon ages and the last occurrence of pink *G. ruber* are also noted relative to the isotope data. The bulk continuous sedimentation rate was formulated based on the isotope correlation and calculated by Analyseries v1.1 (Paillard et al., 1996). The bulk linear sedimentation rate was calculated using the AMS radiocarbon ages only. Note that both bulk continuous and bulk linear sedimentation rates increase abruptly during the last postglacial transgression.................................118

**Figure 4.4:** Mass accumulation rates of (A) bulk sediment, bulk carbonate, and bulk siliciclastic material, and (B) low-Mg calcite, aragonite, and high-Mg calcite, over the last 25 ky in core FR03/99 GC10, calculated using the continuous sedimentation rate (Fig. 4.3). Mass accumulation rates of all components were lowest during lowstand, highest during transgression, and moderate during highstand......................119

**Figure 4.5:** Mass accumulation rates of (A) bulk sediment, bulk carbonate, and bulk siliciclastic material, and (B) low-Mg calcite, aragonite, and high-Mg calcite, in core FR03/99 GC10, relative to (C) sea-level changes over the last 130 ky (adapted from Lambeck and Chappell, 2001), calculated using the continuous sedimentation rate (Fig. 4.3). Note the in-phase relationship between all components, and that highest accumulation rates coincide with major sea-level transgressions following MIS 6 and 2.................................................................120

**Figure 4.6:** Mass accumulation rates of bulk siliciclastic and bulk carbonate components of core FR03/99 GC10 (shaded) and selected cores from Queensland Trough (modified from; Peerdeman and Davies, 1993; Dunbar et al., 2000; Page et al., 2003) since the Last Glacial Maximum, calculated using the bulk linear sedimentation rate (Fig. 4.3) to maintain consistency with data from Queensland Trough. Mass accumulation rates of both components were highest in all cores during transgression, however, the magnitude generally decreases with distance from the shelf. Note that in GC10, carbonate mass accumulation rates were comparable to
those in cores at a similar distance from the shelf in Queensland Trough, but mass accumulation rates of siliciclastic material were lower. WD—water depth. Dist—distance from the 120 m isobath. Lat—latitudinal position in degrees south.

**Figure 4.7:** Mass accumulation rates of low-Mg calcite, aragonite, and high-Mg calcite in core FR03/99 GC10 (shaded) compared to cores from Queensland Trough (modified from Fig. 3.7) since the Last Glacial Maximum, calculated using the bulk linear sedimentation rate (Fig. 4.3) to maintain consistency with data from Queensland Trough. Note that mass accumulation rates of all components are lowest and highest during lowstand and transgression, respectively, and generally decrease with distance from the shelf. WD—water depth. Dist—distance from the 120 m isobath. Lat—latitudinal position in degrees south.

**Figure 4.8:** Conceptual model for the evolution of the southern GBR province over the last 130 ky. Bathymetric information modified from Shipboard Scientific Party (2002). Sea-level reconstructions based on the eustatic curve of Lambeck and Chappell (2001). Course of the paleo-Fitzroy River and cross-sections of the shelf adapted from Maxwell (1968). Dark shaded areas on the shelf indicate areas of possible siliciclastic deposition.

**Appendix A**

**Figure A.1:** The continental margin of northeastern Australia. Circles indicate the position of cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a. Bathymetry of the western Coral Sea is indicated in metres.

**Figure A.2:** Generalised temperature profile and water mass boundaries in the western Coral Sea (modified after: Correge, 1993a; Hearty et al., submitted). Circles indicate the modern seabed depth at the location of cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a. SLW — Subtropical Lower Water; SPCW — South Pacific Central Water; AAIW — Antarctic Intermediate Water; UDWM — Undefined deep water mass.
Figure A.3: Age/depth relationships in cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a, based on calibrated radiocarbon dates, and derived age models using least squares polynomial functions.................................................................162

Figure A.4: Covariance relationships between the D/L ratios of Asp and Glu for all samples from core FR03/99 GC10 (left) and for the mean D/L ratios of all intervals from cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a (right). Black circles – GC10 samples. Grey circles – samples from Queensland Trough cores. Grey squares – rejected ratios.................................163

Figure A.5: The relationship between time and the D/L ratios of Aspartic acid in foraminifera from cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a.................................................................164

Figure A.6: Variations in δ¹⁸O and δ¹³C in benthic foraminifera from core 51GC43, relative to sea-level changes on the northeast Australian margin over the last glacial-interglacial cycle. H/Stand – sea-level highstand. Trans – sea-level transgression. Lowstand – sea-level lowstand.........................................................165

Figure A.7: The relationship between time and the D/L ratios of Aspartic acid in foraminifera from cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a, modelled using power functions. Correlation coefficient and equation shown in brackets indicate modelling results for FR03/99 GC10 with one outlier removed.................................................................166

Figure A.8: Comparison of the modelled kinetic pathways for Aspartic acid in cores FR03/99 GC10, 51GC43, FR4/92 PC16, FR4/92 PC11, FR4/92 PC12, and FR5/90 PC27a, over the last 20 to 25 ky. GC10: solid line – all data, dashed line – outlier removed. Grey dashed lines indicate the estimated position of temperature gradients for racemization rates of Aspartic acid in the western Coral Sea.........................167

Appendix B
List of Figures

**Figure B.1:** Major physiographic and bathymetric features of Marion Plateau and the location of ODP Site 1198A.................................................................180

**Figure B.2:** Variations in bulk carbonate content from 0 to 23.69 mbsf in ODP Hole 1198A........................................................................................................181