Late Quaternary Shelf Edge and Upper Slope Deposition in Low Latitude Mixed Siliciclastic/Carbonate Systems:
Lessons from the Gulf of Papua, and the Western Texas Shelf*

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Abstract

Although siliciclastic/carbonate mixed systems are common in the geological record and interesting because siliciclastic and carbonate components can interact over space and time, modern examples of mixed continental margins remain poorly studied. We present a review dedicated to late Quaternary shelf edge and slope deposition in mixed systems, by integrating recent observations from the Gulf of Papua, the Western Texas Shelf, and the Belize Margin. These regions are characterized by large volume of siliciclastic sand and mud juxtaposed to areas of major neritic carbonate production. These modern analogues are used to develop a quantitative understanding of shelf edge barrier reef edification and sediment transport and accumulation across and along adjacent slopes at different segments of relatively well established sea level cycle. Sharp siliciclastic-to-carbonate switch on the shelf edge and carbonate-to-siliciclastic switch on the upper slopes, correspond to times of initial sea level rise following the Last Glacial Maximum (MIS-2) and the initial onset of sea level fall at the end of last interglacial (MIS-5e), respectively.

Onset of rapid sea level rise during the early deglaciation, when siliciclastics are deposited along newly formed coasts on up dip positions, became opportune time windows for coralgal communities to establish themselves on top of maximum lowstand (MIS-2) coastal siliciclastic deposits, such as beach ridges and lowstand shelf edge deltas. Coralgal communities built 30 to 50 m-high edifices during the first part of last deglaciation in 5 to 6 ky, and then drowned, when sea level rose again after the Younger Dryas, a 1 ky-long cooler interval when sea level remain stable.
On the upper slope, almost pure carbonates, a mixture of mostly bank-derived fine aragonite and magnesian calcite and some pelagic calcite, accumulated during maximum sea level highstand (MIS-5e) when the neritic carbonate production was at its maximum. This carbonate unit is overlain by an almost pure siliciclastic mud unit thinning down the slope. During the late interglacial interval (MIS-5d to 5a) following the maximum highstand (MIS-5e), a rapid ~ 50 m sea fall destabilized thick unlithified siliciclastic muds, stored as today on inner/mid shelf clinothems during the penultimate highstand, through exposure, reworking, transport as suspended material across the narrowed continental shelf, to be ultimately delivered along the shelf margin to the upper slope.

References


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Long Beach, April 24, 2012
Shelf Edge and Upper Slope Carbonate to Siliciclastic Switch(es)

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Palma, April 10, 2012
Introduction

Last 150 kyr, well established Sea Level curve

Figure from Chappell, 2002
Sea Level Variations since Last Glacial Maximum

- LGM (Last Glacial Maximum)
- MWP-1B
- MWP-1A
- Younger Dryas
- Oldest Dryas
- 19kyr
Mixed Carbonate Siliciclastic Sedimentary Systems in Low Latitudes

Gulf of Papua

Western Texas Shelf

Sediments from the rivers = 200-300 Mt/y

(Harris et al., 1993; Milliman, 1995)
The Gulf of Papua
PNG BR & Geat BR
Short lived
Drowned Barriers on their northern extremities
R/V Marion Dufresne 2005 PECTEN

Galaxea Coral Colony Retrieved from the bottom of Core MD 45 at 107 m mbsf Dated by AMS Carbon-14: Age: 19 ky Cal. Yr

Dip Line B

Erosional Unconformity

LGM
SL

Drowned Reef -107 m

Lowstand Shelf Edge Prograding Delta Lobes

SW NE
Partially Buried by siliciclastics
Living Coral Reefs
North Ashmore Shelf Edge
Eastern Plateau
Port Moresby
Fly River
Gulf of Papua Shelf
Torres Shelf
Great Barrier Reef
Ashmore Trough
Pandora Trough
Moresby Trough
Living Coral Reefs
A ridge (drowned barrier reef?) as high as 50 m and as long as ~ 50 km
Early Deglacial Drowned Coralgal Barrier Reef

Portlock Reefs

Gulf of Papua Shelf

- 100 m

- 65 m

- 130 m

Ashmore Trough

Pandora Trough

Great Barrier Reef
Early Deglacial Drowned Coralgal Barrier Reef

Portlock Reefs

Gulf of Papua Shelf

- 100 m

Early Deglacial Drowned Coralgal Barrier Reef

Gulf of Papua Shelf

- 100 m

Pandora Trough

Ashmore Trough

- 700 m

MV-73 at the base of the drowned Barrier Reef, 17-16 kyr mixed Siliciclastic carbonate shoreface, On top of which the barrier grew During Melt water Pulse 1A, Drowned During Water Pulse 1B

Established sea Level Curve
Early Deglacial Drowned Coralgal Barrier Reef

Portlock Reefs

Gulf of Papua Shelf

- 100 m

10 km

- 65 m

Early Deglacial Drowned Coralgal Barrier Reef

Pandora Trough

MV-73 at the base of the drowned Barrier Reef, 17-16 kyr mixed Siliciclastic carbonate shoreface, On top of which the barrier grew During Melt water Pulse 1A, Drowned During Water Pulse 1B

Established sea Level Curve
Buried Earlier Transgressive Barrier Reefs
Periplatform oozes are referred to sediments accumulating on slopes and basin floors adjacent to carbonate platforms, barrier reefs, atolls, and shelves.

Arag = Aragonite  
HMC = High Magnesium Calcite  
LMC = Low Magnesium Calcite
Periplatform Carbonates

Sea Level Highstand: Bank Top Flooded, Maximum Neritic Carbonate Production and Export

Sea Level Lowstand: Bank Top Exposure, Minimum Neritic Carbonate Production & Export

Fine Bank-Derived Aragonite, Excellent Proxy for Sea Level if the Bank Top Bathymetry is known!
Last Deglaciation
Re-Flooding Of Carbonate Factory
Average Water Depths of GBR & Offshore Atoll Lagoons 40-60 m
Bank/Reef Top Re-Flooding; Initiation of Neritic Carbonate Production and Export towards Adjacent Slopes

Sea level curve
Last 23 kyr

- 40 to -60 m

MWP-1B

11 kyr

LGM

Preboreal

Meters below present sea level

Time (ky)

0 5 10 15 20

0 10 20 30 40

-120 -80 -40

0 0
MV-74

MAR of <63µm (g/cm²*kyr)

$0 \quad 5 \quad 10 \quad -0.5 \quad -1.5 \quad -2.5$

$\delta^{18}O$ (%)

MV-13

MAR of <63µm (g/cm²*kyr)

$0 \quad 10 \quad 20 \quad 30 \quad -0.5 \quad -1.5 \quad -2.5$

$\delta^{18}O$ (%)

High-Mg Calcite

Aragonite

$\sim 11.5$ kyr

~ 11.5 kyr
Deglacial Re-Flooding of Carbonate Factory & Highstand Neritic Export to adjacent slopes
Variations of Aragonite MAR

δ¹⁸O (vPDB) G. sacculifer

Relative Sea-Level (m) modified after Chappell [2002]

Fine Aragonite MAR (g/cm² ky)

Age (ky)

Last occurrence of G. ruber (pink)

27,105±153 yr BP

38,594±775 yr BP

5.2 5.1 5.3 5.4 5.5

5b 5a 5d 5c 5e

Exposure Flooding

MD05-2949

MD05-2949
Penultimate Highstand ~130 to 115 ka
Current Interglacial Holocene < 11.5 ka
Last 150 kyr, well established Sea Level curve

Figure from Chappell, 2002

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Bank Top
Exposed

50 m change of sea level
2.2
3.3
4.2
5.1
5.2
5.3
5.4
5.5

δ¹⁸O (vPDB)

CaCO₃ (%)

Depth (cm bsf)

MD-49

33.4cm/kyr

27,105±153 yr BP

38,594±775 yr BP

33.4cm/kyr

5.1

5.2

5.3

5.4

5.5

6.2

Depth (cm bsf)

CaCO₃ (%)
Early Sea Level Fall ~115 to 70 ka
Results

3.5 kHz seismic profile
Shelf Edge Late Pliocene ~ 3 My old Transgressive Barrier Reefs

Purutu Well

Tcherepanov et al., 2009
Mixed Cabonate Siliciclastic Sedimentary Systems in Low Latitudes

Western Texas Shelf

South Texas Shelf Edge
Drowned Coralgal Banks
meters below sea-level
Sea Level Variations since Last Glacial Maximum

- MWP-1B
- LGM
- Youngest Dryas
- Preboreal
- Oldest Dryas
- Reef Growth
- 19kyr

Meters below present sea level

Time (ky)
Texas Shelf Mud Blanket

Weight et al., 2011, JSR
Texas Shelf Mud Blanket
Variations of Accumulation in the past 20 kyr

Weight et al., 2011, JSR
Take Home Message:
Mixed Systems along Low Latitude Continental Margins

Early Sea Level Rise/ Deglaciation: a “Window of Opportunity” for the Reef Establishment on top of Lowstand Coastal Siliciclastic Deposits such as Elongated Barrier Islands, Linear Beach Ridges

Sea Level Highstands: Maximum neritic carbonate shedding on adjacent slopes and basins Initial burial of shelf edge drowned reefs by siliciclastic muds

Early Sea Level Fall: Thick wedges of siliciclastic mud plastered on the upper slopes in front of exposed barrier reefs

Thank You for your attention!