PS Late Quaternary Upper Slope Deepening (Fining) Upward Sequences Offshore the Great Barrier Reef, IODP 325 Expedition*

Brandon B. Harper[1], André W. Droxler[1], Eberhard Gischler[3], Jody M. Webster[2], Ángel P. Bernabéu[2], Tania Lado-Insua[4], Alex Thomas[5], Emilio Herrero-Bervera[6], Luigi Jovane[7], Expedition 325 Scientists[8]

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[1]Earth Science MS-126, Rice University, Houston, TX, United States. (brandon.b.harper@rice.edu)
[2]School of Geosciences, The University of Sydney, Sydney, NSW, Australia.
[3]Institut fuer Geowissenschaften, J. W. Goethe-Universitaet, Frankfurt am Main, Germany.
[4]Department of Ocean Engineering, University of Rhode Island, Narranganset, RI, United States.
[5]Department of Earth Sciences, University of Oxford, Oxford, United Kingdom.
[6]Institute of Geophysics, School of Ocean Earth Science and Technology Hawaii, Honolulu, HI, United States
[7]Geology Department, Western Washington University, Bellingham, WA, United States.
[8]British Geological Survey, Edinburgh, Scotland, United Kingdom.

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Abstract

Hole 325-M0058A (58A) is the deepest hole at 172 m in terms of current water depth, drilled during IODP 325 Expedition in spring 2010 along a seven drill site transect SE of Cairns offshore the Great Barrier Reef. The 41.4 m-long sedimentary sequence recovered in Hole 58A is mainly composed of three unconsolidated green mud sections intercalated with two distinct sandy intervals. In the muddy parts of the core, planktic foraminifera are very common in three levels characterized by highest reflectance values (or the lightest colors) combined with the lowest magnetic susceptibility values. The upper sand/grainstone section, at least 2 m thick, consists of fine to medium sand with large rock fragments, as big as cobble-sized, of well cemented grainstone and visible fragments of mollusks, bryozoa, coralline algae, echinoids, 'Larger' benthic foraminifera, and serpulids. The lower sand section is about 7 m thick and characterized by fine to medium sand. The observed lithologic cyclic pattern in Hole 58A is clearly illustrated in the color reflectance and the paleomagnetic magnetic susceptibility data.

The cyclic variations observed up the sedimentary section in Hole 58A are interpreted to represent deepening (fining) upward sequences,

corresponding to the last two and one half glacial-interglacial cycles from Marine Isotope Stage MIS-7 to MIS-1. During glacial intervals, as Last Glacial Maximum and during MIS-6, a live coralgal reef had to be established in close vicinity of Hole 58A where the water depth was approximately 40 m at that time and was shedding coarse neritic material towards the site of Hole 58A. The low values of color reflectance and the high values of the paleomagnetic magnetic susceptibility data can be explained by input of siliciclastics during intervals of sea level lowstands when the Queensland continental shelf was mostly exposed. Once the deglaciations (MIS-2 to 1, and MIS-6 to 5) were initiated, the coralgal reefs had to migrate westward and upward to keep up with the 120 m sea level rise. Coarse grain export from the reefs diminished, and only fine grain sediment produced on the reefs reached the location of Hole 58A, while proportions of pelagic sediment increased. Once the Queensland shelf was re-flooded, siliciclastic sediments, as today, were kept along the Australian shoreline and the sediments at Hole 58A became more carbonate-rich, explaining the high color reflectance values and the low magnetic susceptibility values.

LATE QUATERNARY UPPER SLOPE DEEPENING (FINING) UPWARD SEQUENCES OFFSHORE THE GREAT BARRIER REEF, IODP 325 EXPEDITION

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1. Earth Science MS-126, Rice University, Houston, TX, United States. 2. School of Geosciences, The University of Sydney, Sydney, NSW, Australia. 3. Institut fuer Geowissenschaften, J. W. Goethe-Universitaet, Frankfurt am Main, Germany. 4. Department of Ocean Engineering, University of Rhode Island, Narragansett, RI, United States. 5. Department of Earth Sciences, University of Oxford, Oxford, United Kingdom. 6. Institute of Geophysics, School of Ocean Earth Science and Technology Hawaii, Honolulu, HI, United States. 7. Geology Department, Western Washington University, Bellingham, WA, United States. 8. British Geological Survey, Edinburgh, Scotland, United Kingdom.

ABSTRACT

Hole 325-M0058A (shortened in the poster as Hole 58A) is the deepest hole, at 167 m, in terms of current water depth. Hole 58A was drilled during IODP 325 Expedition in spring 2010 along an eight drill site transect southeast of Cairns offshore the Great Barrier Reef. The 41.4 m-long sedimentary sequence recovered in Hole 58A is mainly composed of three unconsolidated green mud layers intercalated with two distinct sandy layers. In the muddy parts of the core, planktic foraminifera are very common in three layers characterized by highest reflectance values (or the lightest colors) combined with the lowest magnetic susceptibility values. The upper sand/grainstone section, at least 2 m thick, consists of fine to medium sand with large intraclast fragments, as big as cobble-sized, of well cemented grainstone and visible fragments of mollusks, bryozoa, coralline algae, echinoids, Larger benthic foraminifera, and serpulids. The lower sand section is about 7 m thick and characterized by fine to medium sand. The observed lithologic cyclic pattern in Hole 58A is clearly illustrated by the color reflectance, paleomagnetic measurements, and magnetic susceptibility data.

The cyclic variations observed up the sedimentary section in Hole 58A are interpreted to represent fining (interpreted as deepening) upward sequences, corresponding to the last two and one half glacial-interglacial cycles from Marine Isotope Stages MIS-7 to MIS-1. The presence of the planktic foraminifera pink-pigmented *Globigerinoides ruber* in deeper cores beneath the second sand level and lack of *G. ruber* above the second sand level suggests MIS-7 is located in the deeper cores and that the two sand levels are good candidates for MIS-2 and MIS-6 glacial intervals.

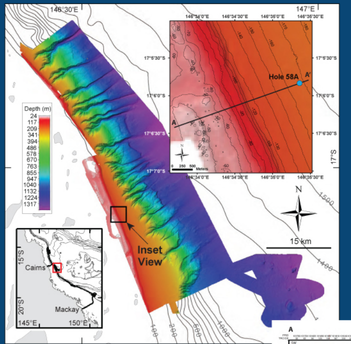
During glacial intervals, as Last Glacial Maximum and during MIS-6, a live coralgal reef had to be established in close vicinity of Hole 58A where the water depth was approximately 40 m at that time and was shedding coarse material towards the site of Hole 58A. High magnesium calcite cemented intraclasts also occur at this time. The low values of color reflectance and the high values of the paleomagnetic magnetic susceptibility data can be explained by input of siliciclastics (quartz, clays, feldspars) during intervals of sea level lowstands when the Queensland continental shelf was mostly exposed.

Once the deglaciations (MIS-2 to 1, and MIS-6 to 5) were initiated, the coralgal reefs had to migrate westward and upward to keep up with the 120 m sea level rise. Coarse grain export from the reefs diminished, and only fine grain sediment produced on the reefs (aragonite, high magnesium calcite) reached the location of Hole 58A, while proportions of pelagic sediment increased. Once the Queensland shelf was re-flooded, siliciclastic sediments, as today, were kept along the Australian shoreline and the sediments at Hole 58A became, therefore, more carbonate-rich, explaining the high color reflectance values and the low paleomagnetic measurements and magnetic susceptibility values.

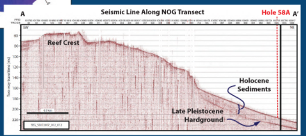
GENERAL SETTING

NOGGIN PASSAGE, GREAT BARRIER REEF, NEAR CAIRNS, AUSTRALIA

Hole 58A was the final hole of ten drilled along the NOG-01B transect south of Noggin Passage 80 km southeast of Cairns, Australia. The water depths along the NOG-01B transect range from 42 m to 167 m at Hole 58A (this study). Hole 58A is unique as it was the only hole drilled on the shelf fore reef slope at such a great depth. Hole 58A is located on the gentle slope following a steep break as shown in the index map and as such is removed from the current reef development by approximately 2.5 km. The slope dips gently to the northeast before steepening into the Coral Sea. 41.4 meters were cored at Hole 58A with a recovery of 82%.



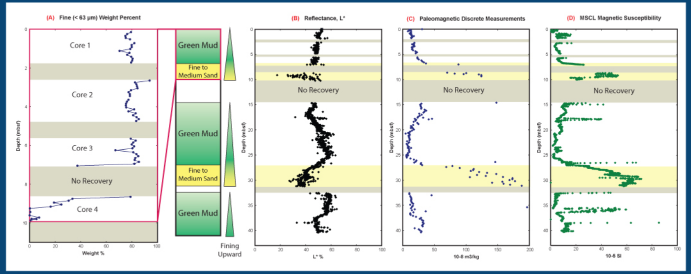
Regional index map of the middle Great Barrier Reef and adjacent slope showing the location of the study area and location of Hole 58A. The seismic line shot along the NOG-01B transect is identified from A to A'.



Regional seismic line shot along NOG-01B transect from A to A'. This line shows the change from barrier reef crest to the slope where Hole 58A is located amid parallel reflections.

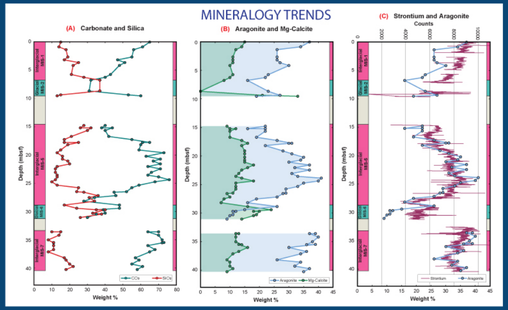
IODP 325 EXPEDITION: HOLE 58A DESCRIPTION

Hole 58A, Core 4, contained very coarse grained material, including intraclasts consisting of cemented grainstone and serpulid tubes. Five such intraclasts are split and imaged (slides in preparation) with locations identified in Core 4 image.



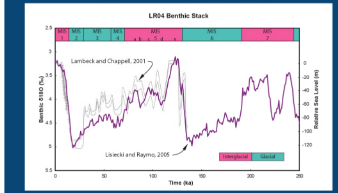
Hole 58A consists of a 41.4 meter-long core section with 82% recovery of sediment material and five distinct sections of no recovery (4 within the upper 15 m). Visibly, there are two alternating lithology layers (green mud, fine to medium sand). Measured properties: fine weight percent, reflectance, paleomagnetic measurements, and MSCL indicate deposition and lithology patterns within Hole 58A. (A) A chart plotting weight percent of fine material through the upper 10 m. For much of the upper 3 cores, fine wt. % hovers around 80%. In Core 4, fine wt. % decreases from ~80% to < 10%. (B) Reflectance, L*, is the percent of light reflected off the split core correlating with light (high %) and dark (low %) color. The green mud tends to be lighter in color than the sandy material. (C) Paleomagnetic discrete measurements show that more magnetically charged material is located in the sandy layers. (D) The magnetic susceptibility reveals that more magnetic material accumulates within the sandy layers than within the green mud. Fining upward patterns (sand to mud) match well be-

MINERALOGY TRENDS



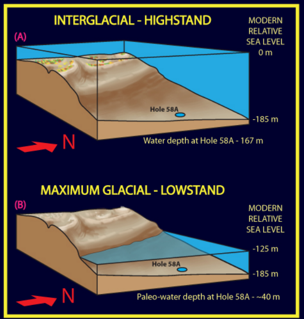
The down hole variations of mineral weight percents of Hole 58A were determined using X-ray diffraction (XRD), and elemental analysis was completed using X-ray fluorescence (XRF). Plot (A) shows carbonate and silica. The trend is increasing carbonate = decreasing silica as expected. Plot (B) shows aragonite and high magnesium calcite (HMC). Both aragonite and HMC trend similarly; however, HMC tends to spike earlier than aragonite likely due to lowstand cementation. Plot (C) shows aragonite and strontium (Sr). Aragonite content values in Hole 58A usually correlate well with Sr counts. Large Sr cations substitute better for Ca cations in orthorhombic aragonite than trigonal calcite (Bathurst, 1976). For this reason, Sr can be used as a proxy for aragonite and carbonate coralgal reef production (Jones and Desrochers, 1992). High aragonite weight percent and Sr counts correlate with interglacials MIS-1, MIS-5, and MIS-7.

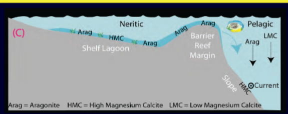
PRELIMINARY RESULTS



The benthic δ18O stacked record (Lisiecki and Raymo, 2005) going back 250 ky defines Marine Isotope Stages (MIS) and their age boundaries. The stacked record acts as a good proxy for relative sea level and is matched well with the relative sea level curve based on the Huon Peninsula reefs, Papua New Guinea (Lambeck and Chappell, 2001). Because age constraint and a δ18O curve have not yet been completely developed for Hole 58A, the identification of glacial cycles is not concrete. Tentatively, interglacials (MIS-1, 5, 7) have been placed in locations where the lithology is muddy, the amount of aragonite is high, and there are high Sr counts, and glacial maxima (MIS-2, MIS-6) are located where the lithology is sandy, the amount of silica is higher, aragonite weight percent is low, and Sr counts are decreased (see the Mineralogy Trends panel). Constraint lies on the occurrence of pink G. ruber located below the second sandy layer, but none above that layer. According to Thompson et al. (1973), pink G. ruber disappeared from the Pacific Ocean at the MIS-6/5e transition ~120 ky. Therefore we, interpret the deeper sandy layer as glacial MIS-6. Therefore, we interpret the two observed sandy layers to correspond to lowstand, glacial deposits and the three green mud correspond to highstand, interglacial deposits. The mixed siliciclastic mineralogy supports this concept; as the carbonate factory turns on optimally once the shelf is re-flooded and continental siliciclastics are no longer able to bypass the platform.

GLACIAL CYCLE SEDIMENTATION MODEL





Model of Shelf Carbonate Factory Based on Mineralogy

INTERGLACIAL

(A) As illustrated in the shelf carbonate factory model (see C); during highstand, neritic production, consisting of mainly fine aragonite and HMC grains, reaches maximum and highstand shedding occurs (Schlager et al., 1994); Extra neritic production is exported onto the Great Barrier Reef slope as seen in the seismic line where a ~10 m package of sediment lies above a hardground reflection. The shelf re-flooding restricts the deposition of siliciclastic material to near the coast (Hopley et al., 2007).

MAXIMUM GLACIAL – LOWSTAND

(B) During the Last Glacial Maximum the shoreline shifted basinward as sea level fell to 125 m below present; exposing the Great Barrier Reef shelf and reducing water depth above Hole 58A to ~40 m. Cementation and dissolution of the carbonate platform reduced carbonate sediment flux from of the shelf into the basin and an increase in siliciclastic bypass sediments, coarse skeletal grains, and benthic foraminifera. Higher energy associated with shallow water depth caused cementation (likely HMC) to form in a top Late Pleistocene hardground visible in the younger sandy layer (Francis, 2007).

DEGLACIATION

Our preliminary research in Hole 58A is not yet sufficient to identify the unexpected peak of siliciclastic input during last deglaciation observed by Dunbar et al., (2003) on the slope offshore the Great Barrier Reef. Finalizing high resolution age control will allow us to test the Dunbar et al., (2003) observation.

CONCLUSIONS

- Three green mud layers separated by two sandy layers
  - Two sandy layers are glacial
  - Three muddy layer are interglacial
  - Second sandy layer based on pink-pigmented *G. ruber* stratigraphy correspond to MIS-6
- Most deposition occurs during interglacials as green mud
  - High carbonate content, low siliciclastic, increased aragonite and Sr counts
  - Carbonate sediment shedding from active shelf factory
  - Increased planktic input due to increased water depth over 58A
- Diagenesis and siliciclastic deposition during glacial maxima – sandy
  - Hardground formed by high magnesium calcite cement in a higher energy environment, forming intraclasts
  - Cementation and karst dissolution on shelf – little detrital carbonate input
  - Shelf bypass – increased terrigenous input

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