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Filling the gap: A 60 ky record of mixed carbonate-siliciclastic turbidite deposition from the Great Barrier Reef

Ángel Puga-Bernabéu [a,b,*], Jody M. Webster [b], Robin J. Beaman [c], Paula J. Reimer [d], Willem Renema [e]

[a] Departamento de Estratigrafía y Paleontología, Universidad de Granada, 18002 Granada, Spain
[b] Geocoastal Group, School of Geosciences, The University of Sydney, NSW 2006, Australia
[c] School of Earth and Environmental Sciences, James Cook University, PO Box 6811, Cairns, QLD 4870, Australia
[d] School of Geography, Archaeology and Palaeoecology, Queen's University Belfast, Belfast, BT7 1NN Northern Ireland, UK
[e] Naturalis Biodiversity Center, PO Box 9517, 2300 RA Leiden, The Netherlands

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ABSTRACT

Late Pleistocene to Holocene margin sedimentation on the Great Barrier Reef, a mixed carbonate-siliciclastic margin, has been explained by a transgressive shedding model. This model has challenged widely accepted sequence stratigraphic models in terms of the timing and type of sediment (i.e. carbonate vs. siliciclastic) deposited during sea-level oscillations. However, this model documents only hemipelagic sedimentation and the contribution of coarse-grained turbidite deposition, and the role of submarine canyons in this process, remain elusive on this archetypal margin. Here we present a new model of turbidite deposition for the last 60 ky in the north-eastern Australia margin. Using high-resolution bathymetry, 58 new and existing radiometric ages, and the composition of 81 turbidites from 15 piston cores, we found that the spatial and temporal variation of turbidites is controlled by the relationship between sea-level change and the variable physiography along the margin. Siliciclastic and mixed carbonate-siliciclastic turbidites were linked to canyons indenting the shelf-break and the well-developed shelf-edge reef barriers that stored sediment behind them. Turbidite deposition was sustained while the sea-level position allowed the connection and sediment bypassing through the inter-reef passages and canyons. Carbonate turbidites dominated in regions with more open conditions at the outer-shelf and where slope-confined canyons dominated or where canyons are generally less abundant. The turn-on and maintenance of carbonate production during sea-level fluctuations also influenced the timing of carbonate turbidite deposition. We show that a fundamental understanding of the variable physiography inherent to mixed carbonate-siliciclastic margins is essential to accurately interpret deep-water, coarse-grained deposition within a sequence stratigraphic context.

1. Introduction

In the last decade, the generic reciprocal and highstand shedding models of margin sedimentation (Wilson, 1967; Droxler and Schalger, 1985; Posamentier and Vail, 1988) were challenged by the transgressive shedding or coeval model (Page et al., 2003; Francis et al., 2007) established in the Great Barrier Reef, the largest extant mixed carbonate-siliciclastic system found on the north-eastern Australia margin. This alternative model, based on the study of hemipelagic sediments from the slope and basin (Dunbar et al., 2000; Page et al., 2003), argues that maximum siliciclastic fluxes to the slope since the Last Glacial Maximum occurred during the late transgression ca. 11–7 ka, rather than when sea level was at lowstand before 18 ka as the generic models predict. Further, the accumulation of siliciclastic and carbonate sediments varies coevally, although the accumulation of carbonates during the sea-level highstand is higher than of siliciclastics (Page et al., 2003).

However, the coeval model is focused exclusively on hemipelagic sedimentation and is thus decoupled from turbidite deposition. Therefore, the model likely overlooks the significant contribution of turbidite deposition to the sediment accumulation on slope and basin settings, as commonly occurs in either carbonate margins (Bornhold and Pilkey, 1971; Crevello and Schalger, 1980) or siliciclastic margins (Covault and Romans, 2009; Ducassou et al., 2009).

* Corresponding author. Departamento de Estratigrafía y Paleontología, Universidad de Granada, 18002 Granada, Spain. Tel.: +34 958 242721; fax: +34 958 248528.
E-mail address: angelpb@ugr.es (Á. Puga-Bernabéu).

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Further, in other mixed carbonate-siliciclastic systems, such as the Gulf of Papua, turbidite deposition is not fully consistent with a coeval model (Jorry et al., 2008, 2010). Recently, Webster et al. (2012) found that canyon turbidite sedimentation in the north-eastern Australia margin is locally different to the existing models of margin sedimentation, highlighting the important role of canyons and shelf morphology in this process. Therefore, a better knowledge of the regional turbidite deposition and timing is needed in order to postulate a comprehensive sedimentation model for mixed carbonate-siliciclastic margins.

In this study, we present a turbidite deposition model for the north-eastern Australia margin based on 38 new and 20 existing radiometric ages and sedimentologic data from sediment cores, together with the accurate geomorphic context of the collected cores provided by high-resolution multibeam bathymetry data. We interpret this model as a result of the interaction of the Late Pleistocene sea-level fluctuations together with the variable margin physiography.

2. Regional setting

We focused our investigation in three study areas characterized by different shelf and slope morphologies within the north-eastern Australia margin between latitudes 14°30′S and 18°30′S: Ribbon Reef, Noggin Passage and Palm Passage (Fig. 1A).

The Ribbon Reef region comprises a narrow (<50 km) flat shelf, rimmed by an extensive shelf-edge reef barrier system (the Ribbon Reefs), with a shelf-break at ~70 m. The steep (>6°) continental slope is deeply excavated by shelf-incised canyons (Fig. 1A, B), named the Ribbon Reef Canyons (Puga-Bernabéu et al., 2011). The connection of the Ribbon Reef Canyons with the shelf is influenced by the Ribbon Reefs and the inter-reef passages between them, which are locally connected to shelf-paleochannels (Webster et al., 2012). In contrast, the broader (60–65 km) gently sloping shelf in the Noggin Passage region exhibits more open conditions at the outer-shelf due to the lack of near-continuous reef barriers. The shelf-break at ~102–109 m (Abbey et al., 2011) connects with a moderately (~4°) steep slope with sigmoidal depth profiles. The slope is shaped by the Noggin Canyons, which mostly comprise slope-confined canyons (Fig. 1A, C; Puga-Bernabéu et al., 2013). In the Palm Passage region, the shelf widens up to 125 km with discontinuous submerged terraces and the shelf-break at ~102–103 m (Abbey et al., 2011). The gently (<2°) dipping slope is wider (up to 40 km) than in Ribbon Reef and Noggin Passage regions (Fig. 1A). This region of the slope is not incised by well-developed canyons, and the few that exist mostly comprise slope-confined canyons especially in the southern part where the slope is narrower (Fig. 1A). However, the slope in the Palm Passage region is shaped by abundant landslides, with widths ranging from a few kilometers to about 20 km (Fig. 1D).

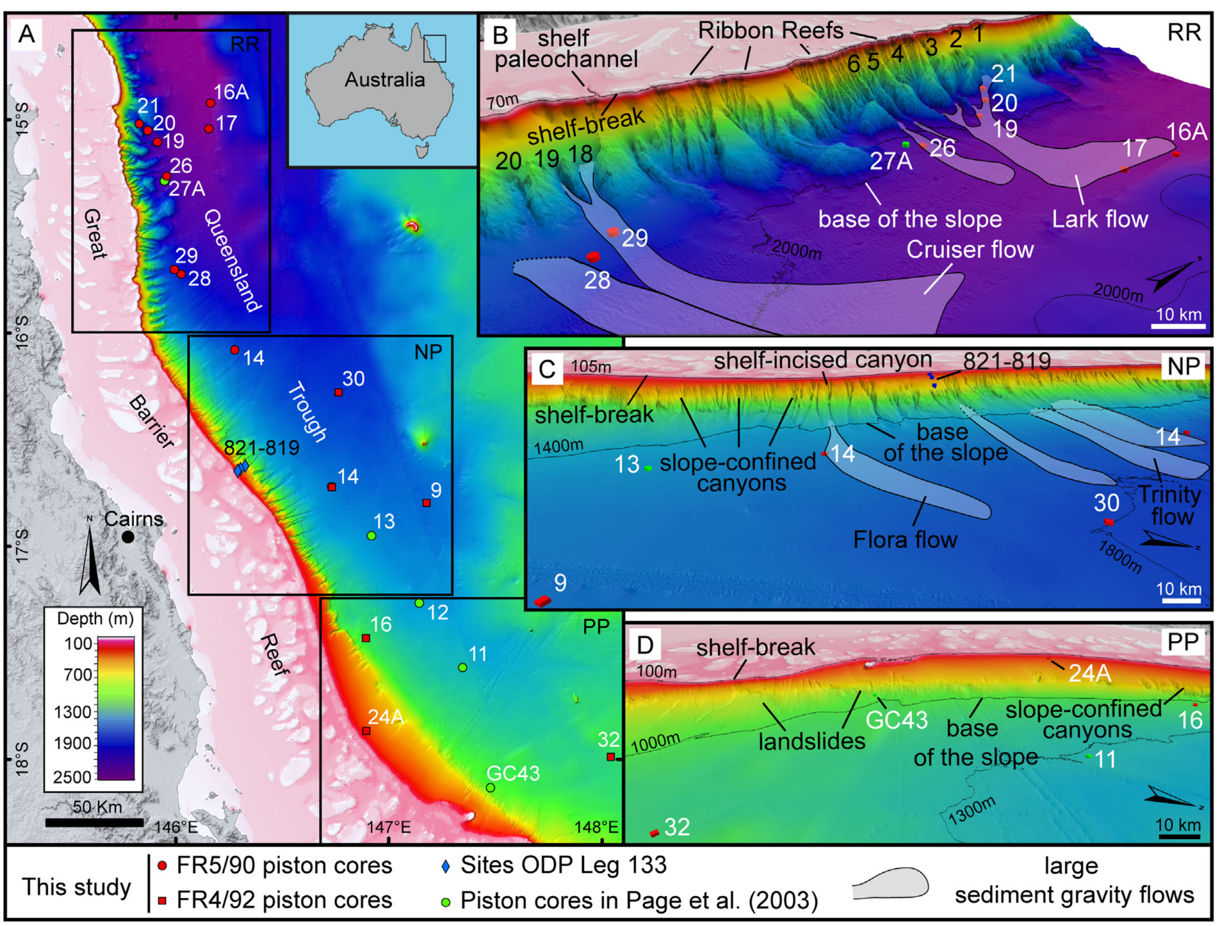

Figure 1. (A) Bathymetry (100 m-resolution DEM) of the north-eastern Australia margin showing the location of the study areas and cores (insets): Ribbon Reef = RR, Noggin Passage = NP, Palm Passage = PP. (B), (C) and (D) illustrate DEMs of the study areas (color scale as in (A); vertical exaggeration is 6). Location of large sediment gravity flows is shown (based on sidescan sonar data from HMAS *Cook* in 1989; names after Dunbar et al., 2000). The location of piston cores studied by Page et al. (2003) used to establish the transgressive shedding model, are also labeled for context. Similarly, the long cores from the Ocean Drilling Program (ODP Leg 133) are also shown. Note the different shelf morphology, canyon types and seabed features along the margin providing detailed the geomorphic context of the different cores. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)