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Mixing of relict and modern tests of larger benthic foraminifera on the Great Barrier Reef shelf margin

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ABSTRACT

The distribution of live, well preserved, and relict larger benthic foraminifera (LBF) in sediment samples collected off the shelf margin near Hydrographers Passage in the Great Barrier Reef, Australia, was studied to document taphonomic processes in this setting. In total, eight living species of LBF were found, mostly of the families Amphisteginidae and Nummulitidae, separated into a shallow (platform) assemblage and a deep (terrace) assemblage. The modern (well preserved) shells in the sediment revealed a good representation of this fauna, but differences in depth distribution were lost. The relict fauna is represented by a more diverse fauna, and is composed mostly of taxa occurring in much shallower conditions. We interpret this pattern as an initial downslope transport of the foraminifera from the shelf into deeper waters, and a mixing of foraminifera derived from nearby Pleistocene coral reef structures.

1. Introduction

Symbiont-bearing larger foraminifera live within the photic zone, both on reefs and on carbonate platforms. The most important environmental parameters influencing the distribution of living larger foraminifera on modern day reefs are temperature, light intensity, substrate type, nutrient availability, and hydrodynamic energy all interrelated with depth (Hottinger, 1977; Hallock, 1984; Hohenegger et al., 1999, 2000; Renema and Troelstra, 2001; Jorry et al., 2006; Renema, 2006a,b). In modern day tropical marine environments, larger foraminifera are important carbonate producers (e.g., Hallock, 1981; Tudhope and Scoffin, 1988; Yamano et al., 2000). For example, Tudhope and Scoffin (1988) estimated that foraminifera contributed up to a third of the total carbonate on the Great Barrier Reef (GBR) shelf. Foraminifera were the most important contributors to Holocene carbonate, followed by the calcareous green algae *Halimeda*, and only in third place came reef building corals. In tropical Cenozoic settings, larger benthic foraminifera can contribute up to 80% of the carbonates (e.g., Wilson, 2012), as well as comprising significant proportions of marly sediments. In these environments foraminifera traditionally have been used for stratigraphical purposes. By definition, larger benthic foraminifera (LBF) are symbiont-bearing and larger than 0.5 mm. They are mixotrophic organisms that at least partly depend on the photo synthetic energy generated by their micro-algae symbionts. Hence, they are restricted to the photic zone.

Recently LBF have increasingly been used to asses environmental change in coral reef systems, either by documenting occurrence patterns in relation to environmental parameters over reef systems (e.g., Hottinger, 1977; Hallock, 1981; Hohenegger et al., 1999, 2000; Renema and Troelstra, 2001; Renema, 2006a), or using an experimental approach (e.g., Briguglio and Hohenegger, 2011; Uthicke et al., 2012b). The study of subsequent samples from the same area through time, or in sediment cores have demonstrated the potential use of LBF as an important monitoring tool (Hallock et al., 2003; Renema, 2010; Uthicke et al., 2012a). Furthermore, Yamano et al. (2000) and Lobegeier (2002) found that LBF were the single most important contributor to the sediment production that maintains sand cay reefs in the northern GBR. They found a high production of foraminifera associated with algae on the reef flat of the islands they investigated. The most important producers were *Calcarina hispida*, *Baculogypsina sphaerulata* and *Amphistegina lessonii*. Most of that work was directed at the most popular and easiest accessible (since they are within safe SCUBA diving depths) reef flat and upper reef slope of patch reefs on carbonate shelves. However, the surface area of reefs forms only 5–10% of the entire GBR shelf, and few studies have focused on the much larger shelf area between the reefs. This is at least in part since sampling is more difficult, since using (gravity) coring and grabs requires a vessel. On the GBR benthic foraminifera sands dominate the bulk of the inter-reef shelf area (Tudhope and Scoffin, 1988). Seven facies along a cross-shelf transect from the inner-shelf to outer-shelf were recognized. Larger benthic foraminifera of the family Nummulitidae were the most important contributors to the assemblages, with high densities of *Operculina* and *Cycloclypeus* especially in the outer part of the shelf (Tudhope and Scoffin, 1988). The distribution of LBF on the outer-shelf margin, or shelf edge, of the GBR has not been documented yet.

In this paper we explore the distribution of LBF tests on the shelf edge from the outer-shelf margin of the GBR. Contrary to other

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investigated areas within the Indo-West Pacific, this has a complex geomorphology, including (submerged) reefs, platforms, and terraces (Abbey et al., 2011; Beaman et al., 2012). We investigate the taphonomic processes acting on the assemblages, as well as potential sources of mixed assemblages.

2. Research area

Hydrographers Passage lies on the outer-shelf continental margin of the world's largest extant tropical siliciclastic/carbonate depositional system, the Great Barrier Reef (GBR) in north-eastern Australia (Fig. 1A, B). The research area includes the shelf edge, ranging from the outermost part of the shelf platform, the barrier reef, seaward terraces, and the upper slope to seaward of the shelf break at about 100 m. The following description is, unless otherwise stated, based on Beaman et al. (2012), who studied in detail the bathymetry and geomorphic features in the same area and using the same grab samples for their sediment composition analysis.

Beaman et al. (2012) recognized five distinct geomorphic features: platform, dunes, reef, terrace, and slope (Fig. 1B). The *platform* is the

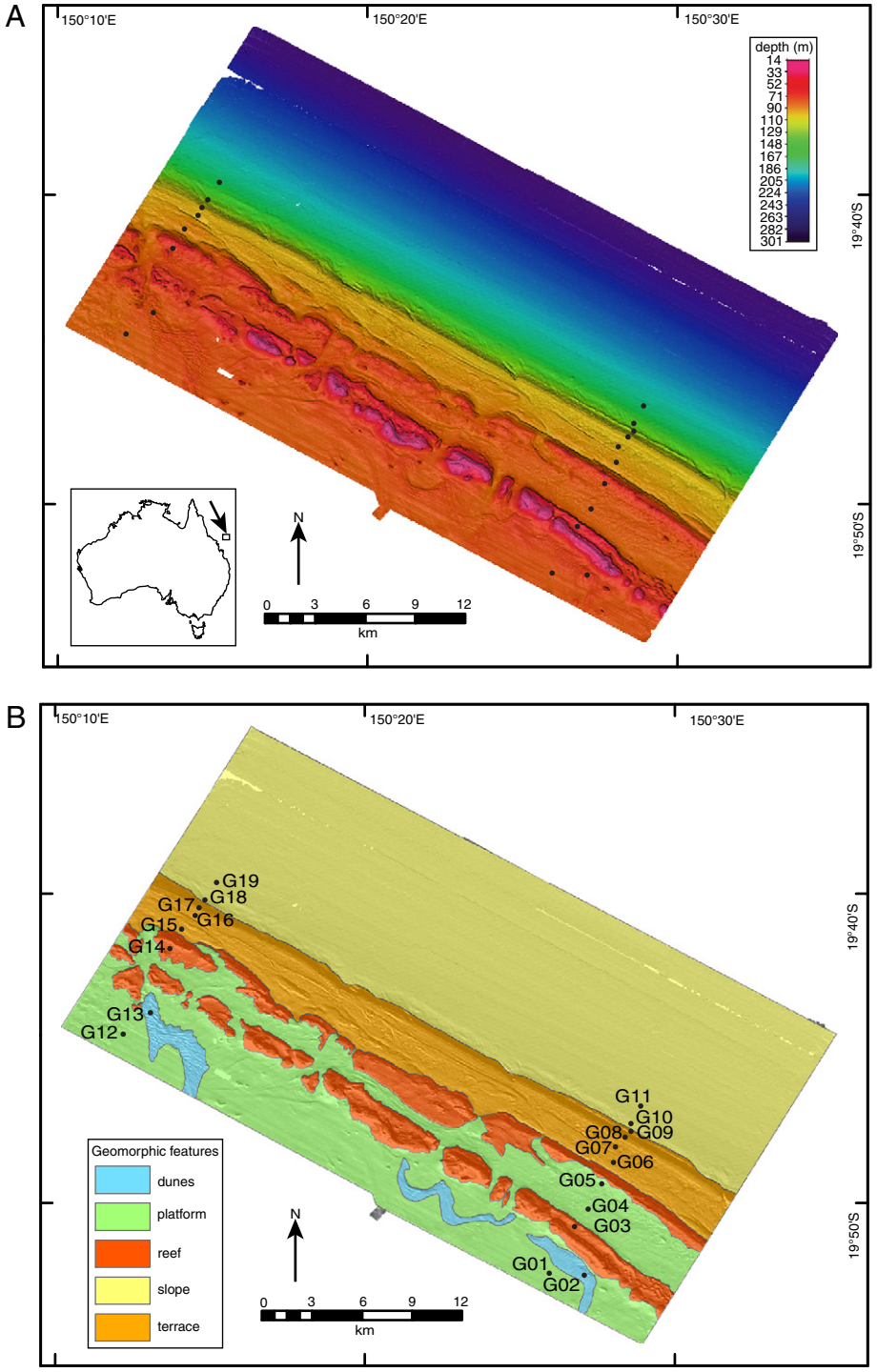

Fig. 1. (A) Multibeam sonar bathymetric map of Hydrographers Passage at a grid pixel resolution of 25 m. (B) Geomorphic features from Hydrographers Passage, including the locations of the grab samples.
Both after Beaman et al. (2012).