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Carbonate mound development in contrasting settings on the Irish margin

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ABSTRACT

Cold-water coral carbonate mounds, formed by framework building cold-water corals, are found in several mound provinces on the Irish margin. Differences in cold-water coral mound development rates and sediment composition between mounds at the southwest Rockall Trough margin and the Galway Mound in the Porcupine Seabight are investigated. Variations in sediment composition in the two mound provinces are related to the local environmental conditions and sediment sources. Mound accumulation rates are possibly higher at the Galway Mound probably due to a higher influx of hemipelagic fine grained non-carbonate sediments. In both cold-water coral mound areas, mound growth has been continuous for the last *ca* 11,000 years, before this period several hiatuses and unconformities exist in the mound record. The most recent unconformity can be correlated across multiple mounds and mound provinces at the Irish margin on the basis of apparent age. On the southwest Rockall Trough margin these hiatuses/unconformities are associated with post-depositional aragonite dissolution in, and lithification of, certain intervals, while at Galway Mound no lithification occurs. This study revealed that the influx and types of material transported to cold-water coral mounds may have a direct impact on the carbonate mound accumulation rate and on post-depositional processes. Significantly, the Logachev Mounds on the SW Rockall Trough margin accumulate slower but, because they contain lithified layers, are less susceptible to erosion. This net effect may account for their larger size compared to the Belgica Mounds.

1. Introduction

Cold-water corals are widely distributed and thrive on continental shelves, continental margins, on seamounts in fjords and on canyon walls around the world (Cairns, 2007; Freiwald and Roberts, 2005; Roberts et al., 2006; Roberts et al., 2009). Under specific environmental conditions framework building cold-water corals such as *Lophelia pertusa* and *Madrepora oculata* can form elevated structures, so called cold-water coral mounds. Vital for reef and mound growth is the presence of a dense coral framework, creating local low energy environments, promoting the accumulation of hemipelagic and bedload sediment between the coral branches (De Haas et al., 2009; Dorschel et al., 2007; Mienis et al., 2009; Roberts et al., 2006; Wheeler et al., 2005a).

Several carbonate mound provinces are reported from the Irish margin (Dorschel et al., 2010; Wheeler et al., 2007), on both sides of the Rockall Trough (RT) (Akhmetzhanov et al., 2003; De Haas et al., 2009; Kenyon et al., 2003; Van Weering et al., 2003a; Wheeler et al., 2005b), on the western Rockall Bank (RB) (Wienberg et al., 2008) and in the Porcupine Seabight (PS) (De Mol et al., 2002; Henriet et al., 1998; Hovland et al., 1994; Huvenne et al., 2002; Huvenne et al., 2003) (Fig. 1). Carbonate mounds in the PS and along the SW Rockall Trough (SW RT) margin occur in a confined depth zone, where strong currents enhance the food supply to the corals and prevent the living corals from getting smothered by sediment (Dorschel et al., 2007; Duineveld et al., 2007; Mienis et al., 2007; White et al., 2005). However, some significant differences exist between the two areas, in mound morphology (Wheeler et al., 2007), local near-bed hydrodynamics (Huvenne et al., 2005; White and Dorschel, 2010), cold-water coral facies distribution (De Haas et al., 2009; Dorschel et al., 2007; Rüggeberg et al., 2007) and the composition of mound sediments (Dorschel et al., 2005; Eisele et al., 2008; Mienis et al., 2009; Titschack et al., 2009). The latter is the focus of this paper.

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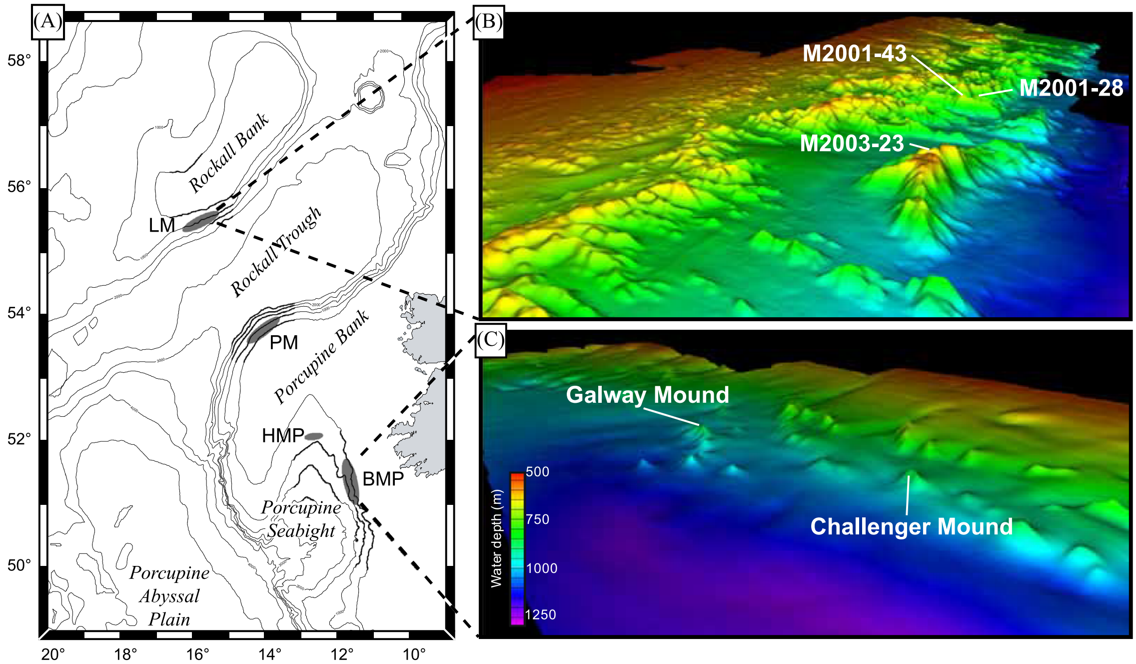

Fig. 1. (A) Overview of mound areas along the Irish margin. LM = Logachev Mounds, PM = Pelagia Mounds, HMP = Hovland Mound Province, BMP = Belgica Mound Province. (B) Multibeam map of part of the carbonate mound area at the SW RT margin. M2001 and M2003 are stations of cruises 64PE182 and 64PE251 respectively. Multibeam data courtesy of Gerard Duineveld (NIOZ) (Cruise 64PE249). (C) Multibeam map of the Belgica Mound Province. Multibeam data from Beyer et al. (2003) via PANGAEA. Multibeam images are three times vertical exaggerated and view to the north.

Most models put emphasis on variations in climate and the associated changes in ocean circulation as the main driving factors for mound growth and variations in mound accumulation rates over time (Dorschel et al., 2005; Kano et al., 2010; Kano et al., 2007; Mienis et al., 2009; Roberts et al., 2006; Rüggeberg et al., 2007; Sakai et al., 2009). Challenger Mound in the PS, which was cored to its base during IODP expedition 307, reveals a 2.6 Ma long development (Kano et al. 2007). Multiple environmental proxy records from the Challenger Mound sequence have highlighted the response of carbonate mounds over glacial–interglacial cycles alternating between current-influenced and ice-rafted deposits (Thierens et al., 2013). However, hiatuses and post-depositional aragonite dissolution (Frank et al., 2010) complicate the Challenger Mound sediment record. Similar post-depositional alterations and erosion of carbonate mound sediments have been observed in shallow cores from other mounds along the Irish margin (Dorschel et al., 2005; Eisele et al., 2008; Foubert et al., 2007; Frank et al., 2005; Pirlet et al., 2010; Rüggeberg et al., 2007; Van der Land et al., 2010).

This raises the question whether the underlying processes controlling the post-depositional alterations have a regional or local mound specific origin. Comparative studies between carbonate mound provinces have the potential to differentiate between the effects of local and regional forcing processes on mound development. By comparing the sediment record of Galway Mound (GM) in the Belgica Mound Province (BMP) in the Porcupine Seabight to mound sediments from the Logachev Mounds (LM) on the SW RT (Fig. 1) we aim to obtain and explain this differentiation. At both sites mound summits are covered by a dense live coral cover and mound growth has been continuous for the last 11,000 years (Eisele et al., 2008; Mienis et al., 2009; Van der Land et al., 2010). Before this period the sediment records in both areas contain several hiatuses. We focus on the most recent hiatus, associated with the last glacial–interglacial transition.

2. Regional and local setting

2.1. Logachev Mounds, SW Rockall Trough margin

Cold-water coral mounds are present along the margins of the Rockall Bank which forms an elongated NE–SW trending topographic high (100–300 m water depth) defined by the Hatton-Rockall Basin to the west. It is isolated from the British and Irish mainland by the Rockall Trough which reaches water depths of up to 3000 m and opens into the Porcupine Abyssal Plain to the south (Fig. 1). At the SW RT margin carbonate mounds have formed kilometres long and wide clusters up to 380 m high, which occur between 600 and 1000 m water depth (Mienis et al., 2006), their summits are confined to a depth range between 500 and 600 m water depth (Mienis et al., 2007) and are embedded in the Eastern North Atlantic water mass (ENAW) (Holliday et al., 2000; New and Smythe-Wright, 2001; van Aken and Becker, 1996). Mound slope inclinations are 25° on average, their flanks are covered with patches of living corals alternating with dead colonies, while the summits of the mounds are characterised by a dense cold-water coral cover (De Haas et al., 2009; Van Weering et al., 2003b). Strong currents, related to internal waves, transport fresh food particles to the mounds (Mienis et al., 2007).

2.2. Galway Mound, Belgica Mound Province, Porcupine Seabight

The BMP is located on the eastern slope of the PS and is characterised by individual mounds that rise up to 150 m above the seafloor (Beyer et al., 2003; De Mol et al., 2007; Wheeler et al., 2007) (Fig. 1). The hydrography of the PS is mainly influenced by ENAW and Mediterranean Outflow Water (MOW). The warm and saline ENAW constitutes the uppermost layer of the water column reaching down to a water depth of 800 m, whereas MOW becomes predominant below this depth (Rice et al., 1991). Galway Mound is part of a mound chain situated in 780 to 900 m water depth.