A Four Dimensional Prospective of the Sedimentary Processes and their Interactions with Ireland's Deep-Water Coral Carbonate Mound Ecosystems: Belgica Carbonate Mound Province, Eastern Porcupine Seabight, NE Atlantic

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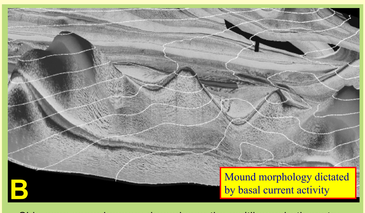
Introduction

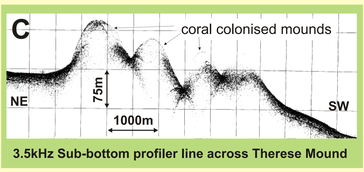
Recent international research activity involving a strong Irish collaboration has shown that coral reefs are not exclusively associated with warm tropical waters, but form unique biological hotspots in deeper and colder Northeast Atlantic.

The eastern Porcupine Seabight south-west of Ireland (Fig. 1) is dominated by the presence of giant carbonate mounds (up to 2km across and 300m above the seafloor) in association with contourite drift sequences. The mounds are colonised by deep-water coral associations, based on species such as *Lophelia pertusa L.* and *Madrepora oculata L.*, which support extensive epifauna of sponges and gorgonians and play an unquantified role of fish nurseries.

New side-scan sonar, multibeam, sub-bottom profiler and underwater video imagery supplemented with sedimentological material (from seabed surface and c.30m core samples) were used to map the seabed sedimentary environment in the Belgica Carbonate Mounds province (800-1000m water depth) in the eastern Porcupine Seabight. The remote-sensed data was integrated within a GIS and provides information on sediment pathways and benthic current patterns within the study area. A facies map (Fig. 2) was produced based on high-resolution side-scan sonar coverage in conjunction with other geophysical, video and sample data, and this highlights differing sedimentary processes (mobile sand sheets, gravel ridges, barchan-like dunes and sediment wave fields). All these sediment bedforms (B-H), as seen on underwater imagery, provide evidence for strong northward benthic currents or palaeocurrents. The images show a strong interaction between benthic currents and the carbonate mounds, suggesting that the currents have an influence on mound growth.



Side-scan sonar imagery draped over the multibeam bathymetry. Showing a three dimensional prospective of the mound structure.



3.5kHz Sub-bottom profiler line across Therese Mound

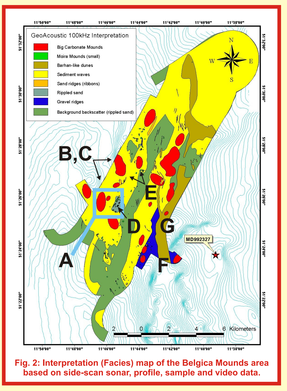
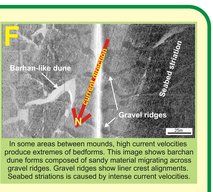
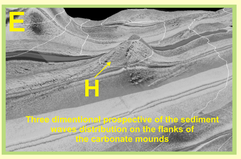


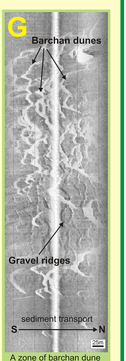
Fig. 2: Interpretation (Facies) map of the Belgica Mounds area based on side-scan sonar, profile, sample and video data.

Fig. 1: Location Map of the Porcupine Seabight study area



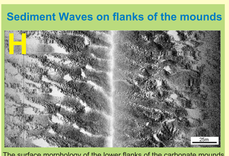
In some areas between mounds, high current velocities produce extremes of bedforms. This image shows barchan dune forms composed of sandy material migrating across gravel ridges. Gravel ridges show liner crest alignments. Seabed striations is caused by intense current velocities.



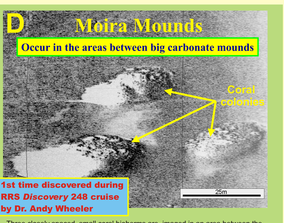


A zone of barchan dune forms in an area between carbonate mounds. Dunes are migrating across a gravel ridge dominated seafloor.

Sediment Waves on flanks of the mounds

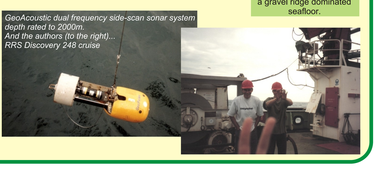


The surface morphology of the lower flanks of the carbonate mounds is strongly controled by sediment waves indicating a northerly sediment transport direction. High backscatter spots on the surface of the waves give a rubbly texture and are caused by coral and associated bio-accumulations as confirmed by video evaluation. Coral preferentially accumulated on waves and crests with limited growth in wave troughs.

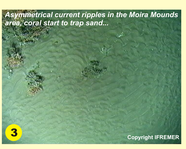


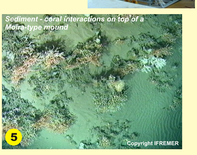
Three closely spaced small coral bioherms are imaged in an area between the carbonate mounds. This is the first time these smaller mounds have been imaged and they have been called "Moira Mounds". The Moira Mounds possess a lumpy structure with spots of high backscatter indicative of coral colonisation. Apparently, Moira Mounds represent a very early stage of carbonate mounds growth and might help to unravel the secret of mound genesis.

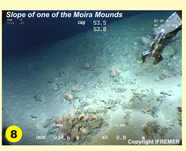
GeoAcoustic dual frequency side-scan sonar system depth rated to 2000m. And the authors (to the right)... RRS Discovery 248 cruise

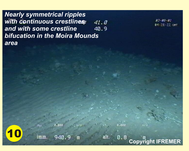


A Remote-Sensing of the Therese and Moira mounds (850-1000 m water depth)





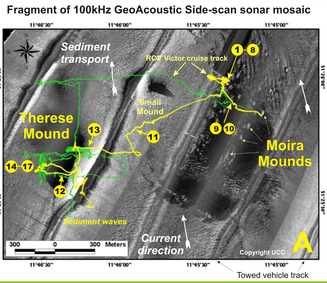




Therese Mound Area
ROV Victor video observations (11-17)

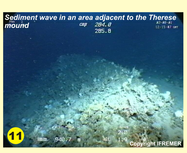
Therese mound is one of the giant carbonate mounds in the Belgica Carbonate Mound province, eastern Porcupine Seabight. Sidescan sonar coverage (A) implies that mound morphology is strongly dictated by prevailing basal current activity. This has been confirmed by video observations. The surface morphological details of the Therese mound show distinct relationships to sediment waves that have become colonised and stabilised by coral and associated communities. On the edge of the mound, corals colonise the crests of sediment waves (11) with limited growth in the troughs, taking therefore advantage of stronger current and nutrient flux. Coral density increases up the mound until sediment waves become fully stabilised and coral continue to grow into coral banks (13-16). Underwater video imagery also provides evidences of the deep-sea fishing activities (12) in the study area, which dramatically effects the coral reef ecosystems vitality.

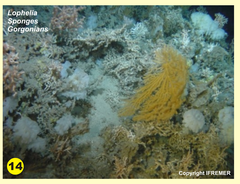
Fragment of 100kHz GeoAcoustic Side-scan sonar mosaic

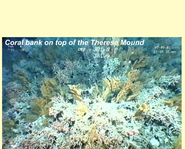


Moira Mounds Area
ROV Victor video observations (1-10)

The Moira Mounds in the Belgica Mound Province, Porcupine Seabight are small coral-colonised mound features (tens of metres across and a few metres high) that represent an early stage of mound development and much younger than their giant carbonate mound counterparts. These features occur in areas of active sand transport, on rippled sand sheets (1-5, 10), and the upstream margins of sediment wave fields (6-8, 9). Once coral colonies gained a foothold in these areas, coral colonies trap sand and build positive features on the seafloor (7-9). In doing so, corals become elevated above the benthic boundary layers gaining access to fast flowing waters (with increased nutrient flux) with a lower sediment load. This allows further biological growth, sand entrapment and increases in mound elevation.





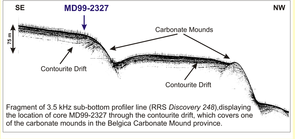


Sedimentological study

Detailed analyses of sediment properties have been derived from seabed surface and 26.23 m long contourite core MD99-2327 taken within an area of the side-scan sonar coverage in order to ground truth the remote-sensed data and quantify benthic current strength through time and sediment mobility thresholds.

MD99-2327 was the subject to laser particle size analysis. Mean size of the sortable silt (10-63 um), for which stronger currents, through both selective deposition and winnowing, yield a coarser mean particle size has been used as a palaeobottom current strength proxy.

MD99-2327 provides a high-resolution palaeoclimate record showing temporal pattern of variations in the bottom current strength during OIS 4 and 5a.



Fragment of 3.5 kHz sub-bottom profiler line (RRS *Discovery* 248),displaying the location of core MD99-2327 through the contourite drift, which covers one of the carbonate mounds in the Belgica Carbonate Mound province.

MD99-2327 / Lat.: 51º23.77´N, Lon.: 11º39.24´W; 26.23 m long / Water depth: 651 m
(Belgica Carbonate Mound Province, Eastern Porcupine Seabight)