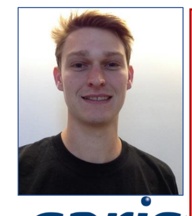
Topographic and Morphologic Variations in Bathymetry Between and Galway Bay Bertraughboy Bay

Luke Hollahan and Dr. Leslie Sautter (Dept. of Geology and Environmental Geosciences, College of Charleston)



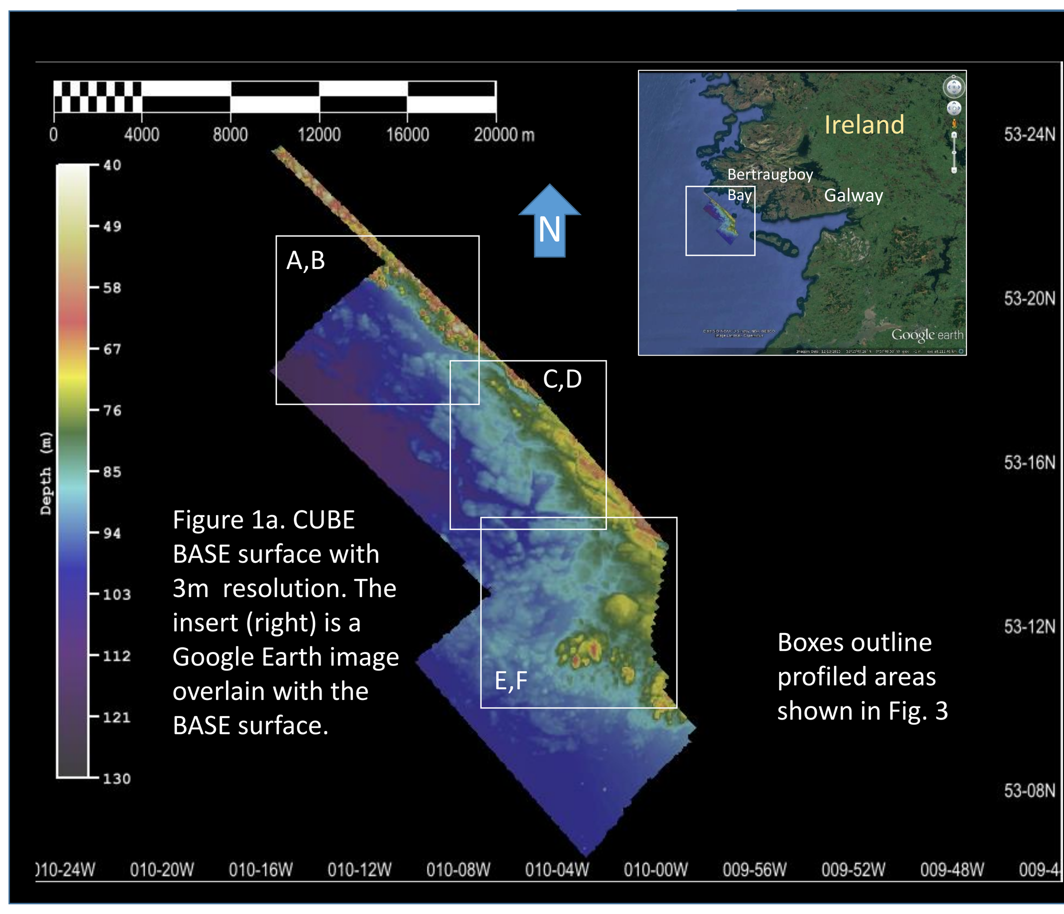


Figure 1a. CUBE BASE surface with 3m resolution. The insert (right) is a Google Earth image overlain with the BASE surface.

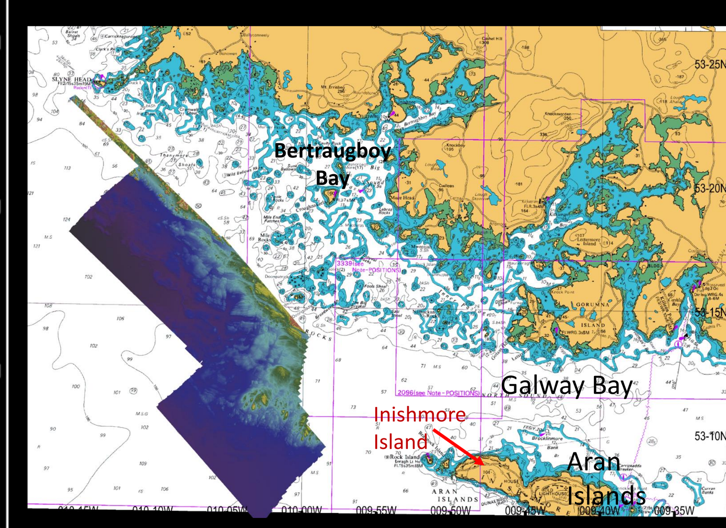


Figure 1b. Study area overlain on Admiralty Chart (above) displays the proximity of the survey site in to Inishmore Island and Bertraughboy Bay.

ABSTRACT

The continental shelf surrounding Ireland has been vigorously surveyed within the last decade by the Marine Institute of Ireland and the Geological Survey of Ireland as part of the INFOMAR program. Bertraughboy Bay, a bay on Ireland's western coast just north of Galway Bay was surveyed from July into early August in 2014 using a Kongsberg EM2040 Multibeam echosounder, aboard the R/V *Celtic Voyager*. The bay's nearby terrestrial geology in Galway County (Fig. 1) indicates a transition in the seafloor geology from Bertraughboy Bay which is primarily comprised of granites and igneous intrusive rocks, ranging to Inishmore Island (one of the Aran Islands) which is comprised of weathered limestone. The hard bathymetric features may be fractured and extruded from layers of softer substrate of unconsolidated sediments similar to the Galway Bay area giving way to complex geomorphological features. Sonar data were post-processed using CARIS HIPS and SIPS 9.1 in order to create bathymetric, slope, and backscatter intensity surfaces in both 2D and 3D. The purpose of this study is to interpret and characterize the geomorphology and possible underlying geology of Bertraughboy Bay.

BACKGROUND

Galway Bay is an INFOMAR priority bay, and has been extensively researched. The bay area has been a point of geologic bewilderment for some time due to its complex geomorphological features. Numerous Devonian granite outcrops have been identified in Galway Bay, particularly in the northern sectors where fractures facilitated granite intrusions (Fig. 5) (Burke, 2009). Northwest of the Aran Islands (Figs. 1a,b) lies Bertraughboy Bay. This bay's offshore geology is particularly interesting as it displays granite bedrock outcrops (Fig. 2), composed of *errisberg townland/Galway Granite*, a granite local to the area (Baxter et al., 2002).

Studies of Galway Bay's seafloor morphology and lithology have been conducted proximal to northern shore of Inishmore (the largest of the Aran Islands) using sonar as well as core samples to classify seafloor lithology (INFOMAR). INFOMAR studies in this region have examined karst geomorphology of the Burren in central western Ireland and have characterized its Carboniferous (~330 Ma) limestone as terraced beds that have moderate backscatter intensity returns (INFOMAR, Morrison et al. 2009).

The purpose of this study is to use the predetermined classifications of seafloor geology established by INFOMAR for Galway Bay to classify and map the seafloor lithological and morphological transition from off of Bertraughboy Bay to Inishmore.

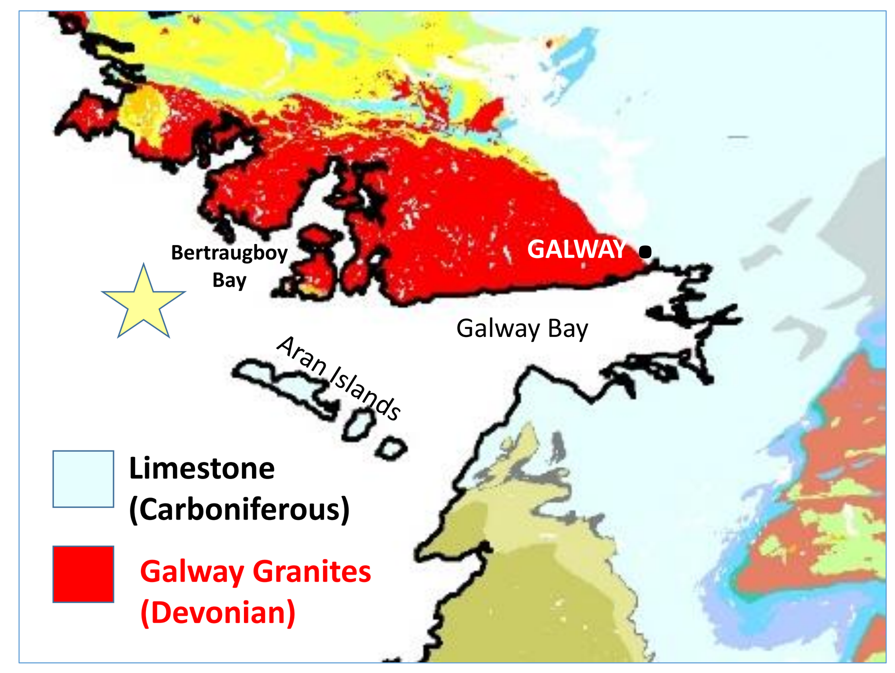


Figure 2. Geologic map of Ireland's west-central coast, including the Aran Islands. Galway Granite (red) and tilted and terraced limestone (light blue) are both proximal to the survey site (shown by the yellow star). (Map courtesy of the Geological Survey of Ireland)

METHODS

- Kevin Sheehan was the chief scientist aboard the R/V *Celtic Voyager* for expedition CV14_02 from late July to early August 2014.
- Multibeam sonar bathymetric and backscatter intensity data were collected using a Kongsberg EM2040 transducer.
- Post-processing was performed with CARIS HIPS and SIPS 9.1 to create 2m CUBE surface, 3D images, profiles, backscatter surfaces and slope maps.
- Equally spaced profiles were made throughout the study site from Bertraughboy Bay to Inishmore Island.
- A 2m resolution backscatter surface was created and classified.

Figure 3. Transect profiles made in sequence from Bertraughboy Bay to Inishmore Island (Fig. 1), with profile location shown at left. All profiles are shown with VE= 8.9x, and seafloor features are indicated. Features of interest are shown to the right of the profiles, including Mounds, Tilted Bed Terraces and Isolated Terraces.

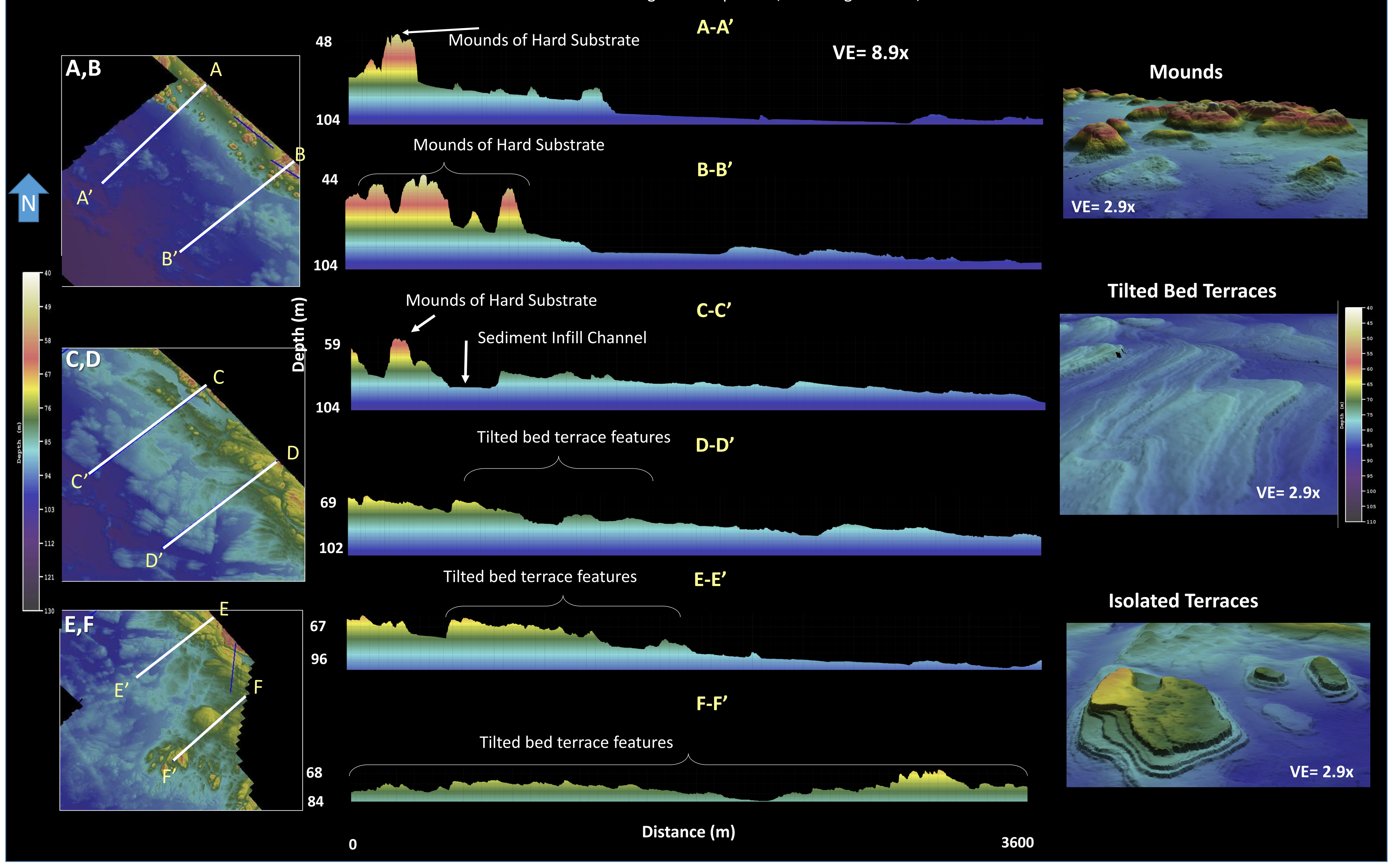
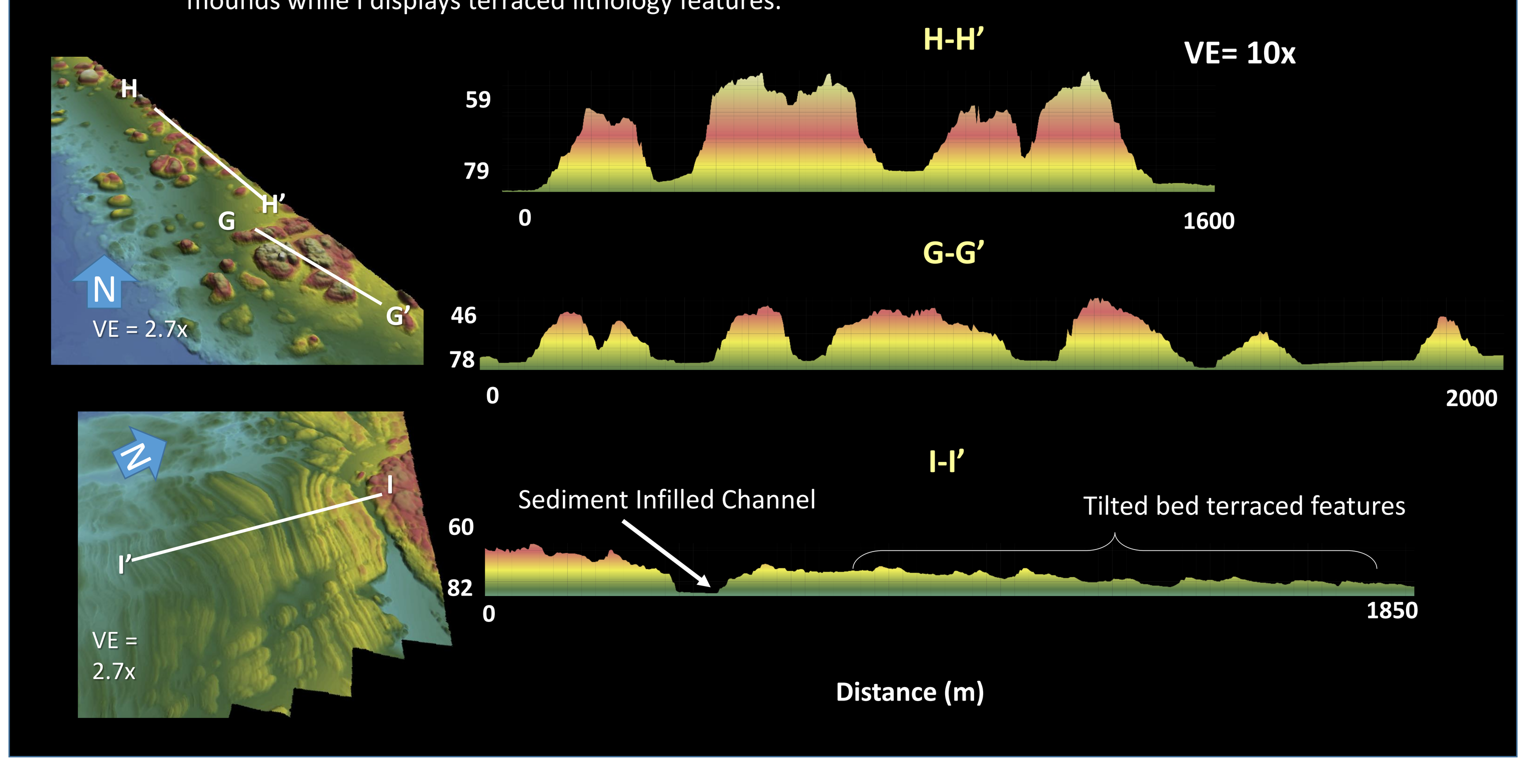


Figure 4. Profiles H-H', G-G' and I-I', made over features of interest (left), with VE= 10x. H and G depict mounds while I displays terraced lithology features.



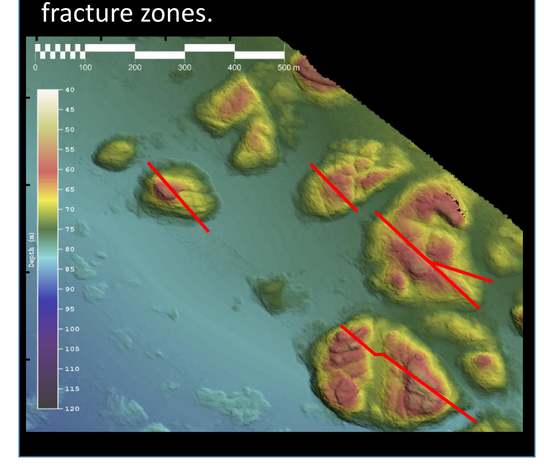
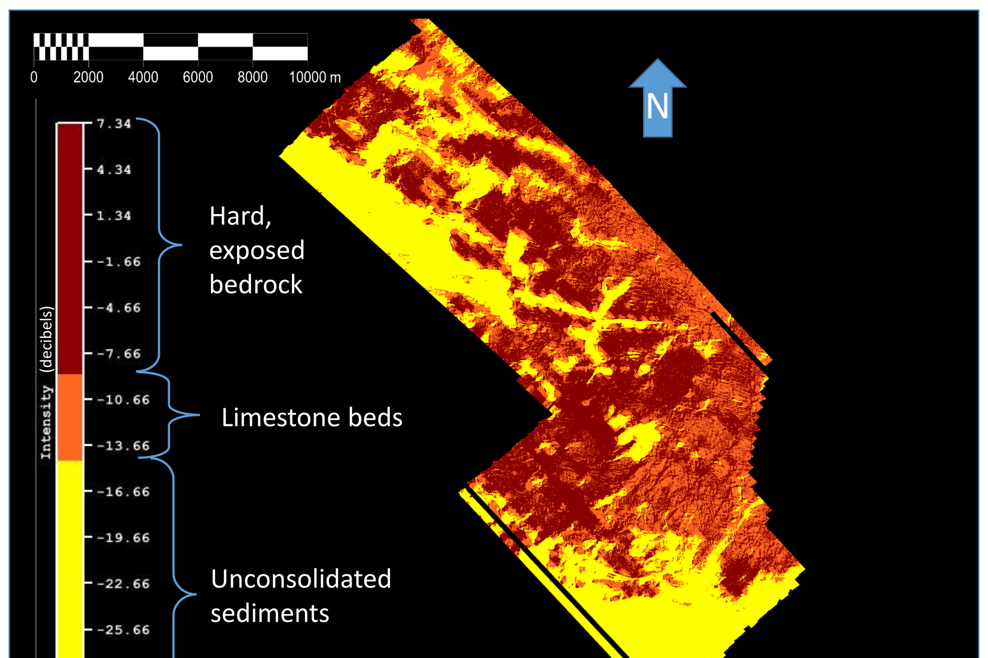


Figure 5. Mounds of exposed bedrock with red lines indicating correlating fracture zones.



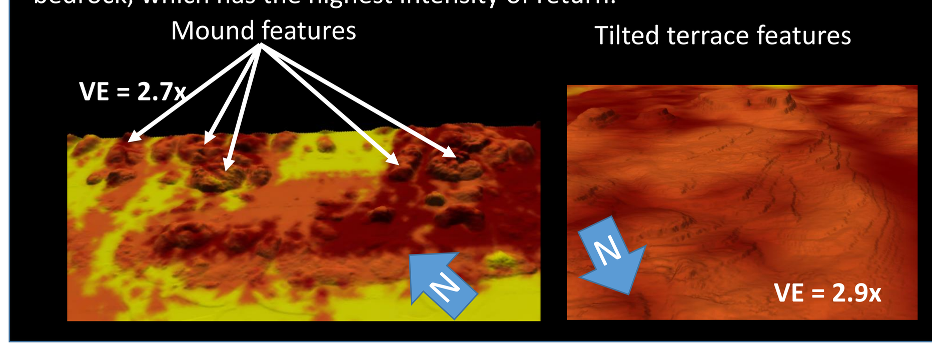


Figure 6. 2D backscatter intensity of the study area (above) has been classified into three classes based on return intensity, and interpreted using known regional geology. 3D images of mounds and terrace features (below) overlain with backscatter intensity shows sediments (yellow areas) in the lower, flat areas. Orange areas are likely tilted terraces limestone beds, and dark red areas are likely exposed bedrock, which has the highest intensity of return.

RESULTS

Profiling shows significant geomorphological changes from Bertraughboy Bay southeastward towards Galway Bay (Fig 3). The geomorphology ranges from mounds of hard exposed bedrock near Bertraughboy Bay to tilted terrace features near Galway Bay (Fig. 4). Backscatter intensity images show different intensity returns for observed hard substrates (Fig. 6) as well as a trend in intensity return relatable to trends in geomorphology (Fig. 6). The slope map (Fig. 7) illustrates different slope patterns associated with different morphologic features. Fractures associated with some of the mounds (Figs. 5,7) are not associated with all mounds and/or local faults (Fig. 5). The mounds near Bertraughboy Bay consist of harder material (based on backscatter intensity) which is likely exposed bedrock, whereas the tilted terrace features are likely the limestone beds proximal to Inishmore Island (Fig. 8).

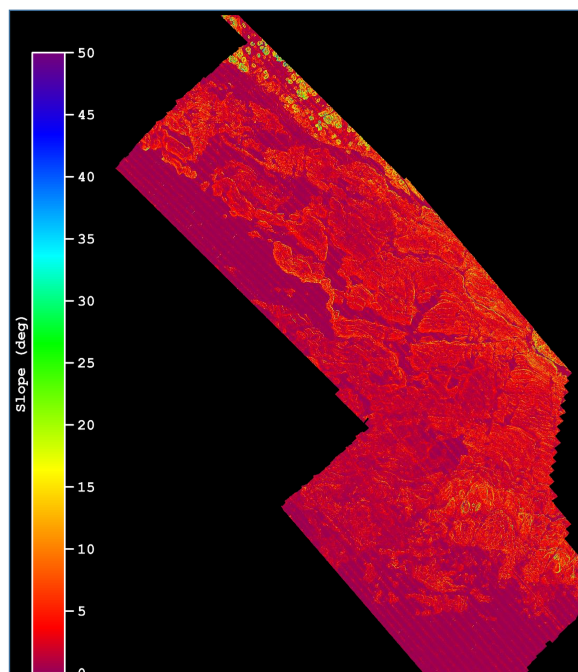
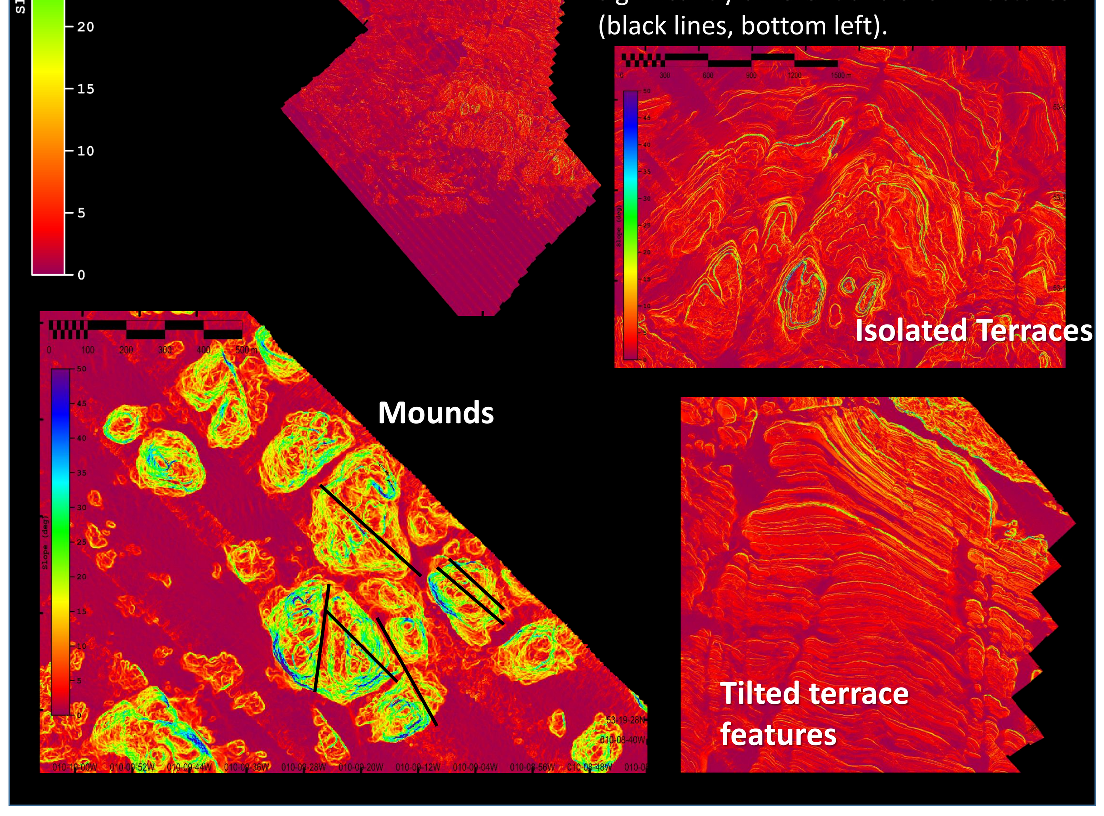


Figure 7 2D slope map of the study area (left). 2D images of mound (bottom left) and terrace features (bottom right) slopes. Flat areas are indicated by purple/red while areas with steep slopes are indicated by green/blue/deep purple. Limestone areas are characterized by isolated and tilted terrace features. Mounds are significantly different and show fractures (black lines, bottom left).



DISCUSSION

The purpose of this study was to map the transition between the limestone beds found on Inishmore and igneous bedrock known as Galway Granite found in Bertraughboy Bay. This lithology transition was identified using backscatter return intensities and differences in morphology and slope. Hard-substrate mounds with fractures (Fig. 5) are likely of igneous origin and inferred to be the Galway Granite. In contrast, areas of tilted and isolated terraced features are likely the limestone units found on Inishmore as well as in the Burren on the west coast of Ireland. Boundaries chosen for the exposed bedrock mound features were based on characteristics of igneous rocks which are more dense and harder than limestone, resulting in higher backscatter intensities. The mounds also contain numerous fractures (Fig. 5). Baxter et al. (2002) suggested that these fractures allowed for the intrusion of igneous granites, but also stated that not all of the mounds exhibit fractures. The fractures associated with the mounds are due to ancient arc-continent collisions which created numerous fault zones, as well as isostatic rebound of the earth with glacial retreat in the Pleistocene Epoch, 18 Ka (Brown et al. 2011, Burke 1957).

Changes in morphology between the granites and limestones were observed using successive transect profiles (Figs. 3, 4). Slope data were used to highlight more subtle changes in morphology and to accentuate the terraced features associated with limestone beds (Fig. 7, 8). All these sonar-derived data were then combined to create a seabed lithology surface (Fig. 8), showing the contact between the major units of the Galway Granite and Limestone. Galway Granite is likely exposed in areas that have experienced significant erosion since the Devonian 410 Ma, whereas the Carboniferous limestone was sheared and smoothed 18,000 years ago by glacial action (Brown et al. 2011).

Our study illustrates the great usefulness of using multibeam sonar to understand the submerged geology of the Irish continental margin.

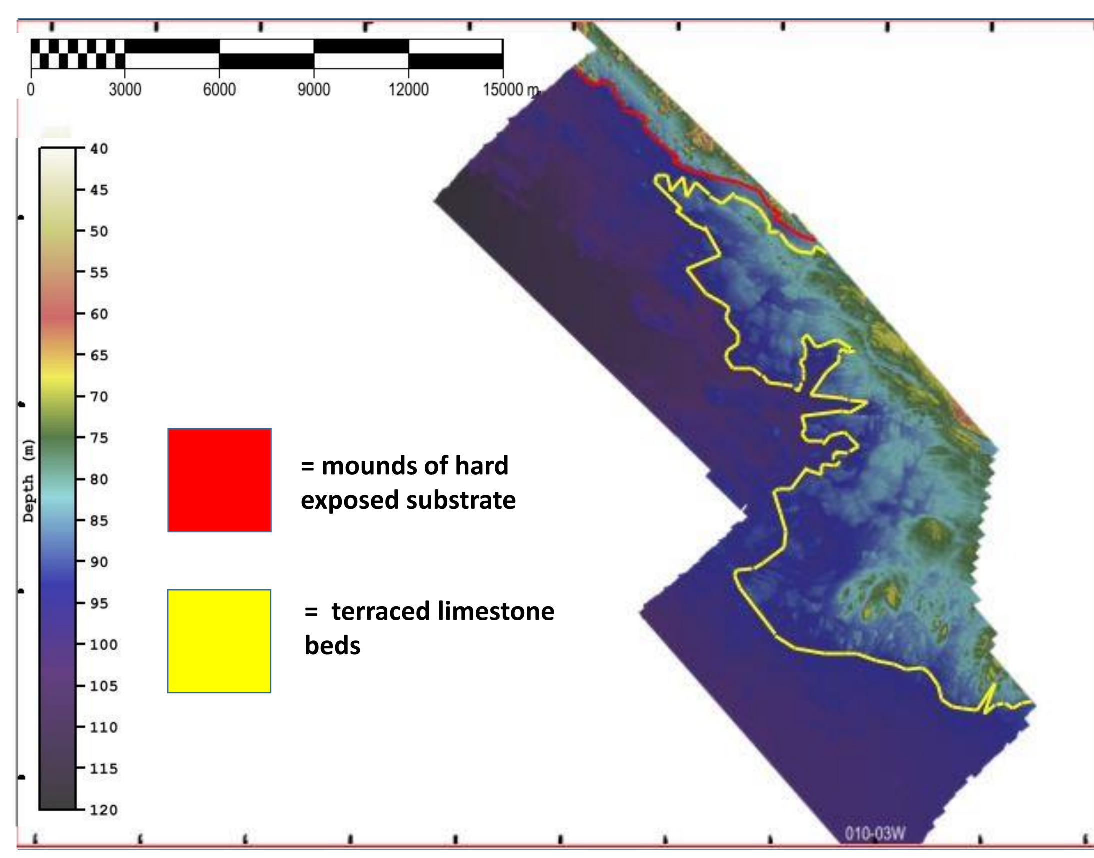


Figure 8. 2D CUBE base surface with 2m resolution with lines indicating the boarders of hard exposed substrate (mounds) with red, and limestone beds with yellow. These categorizations are based on morphological differences are well as slope map and backscatter intensity data. The areas that are not surrounded by these boarders are covered in unconsolidated sediments. These unexposed areas where not included in this benthic geology map.

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