

Deep-Water Seismic Geomorphology, Continental Margin Progradation, and Process Interaction off Northwest Britain*

By

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Introduction

The West Shetland margin and adjacent deep-water Faroe-Shetland Channel, offshore NW Britain, is a bathymetrically complex continental margin that has been shaped by a multitude of sedimentary processes. The study area comprises a basin that was formed through the Mesozoic and has been overprinted by 1) extensive Paleocene igneous activity associated with North Atlantic opening, 2) several phases of Cenozoic inversion, and 3) late Pleistocene glaciation. These events, plus changes in oceanographic regime, have combined to produce variations in accommodation space, sediment supply and depositional style in the last 60 Ma. Many of the features described at the sea bed can be related to multiple glaciations over the past 0.5 Ma, but the sedimentary style of the margin, in particular the formation of prograding wedges, was initiated in the early Pliocene. The construction of the slope apron reflects the inputs from both down-slope and along-slope sources, both of which have contributed to progradation of the continental margin.

The detailed expression of these depositional and erosional processes is revealed on a sea bed image created by using surface picks from 3D seismic data. The image of the sea bed (Figure 1) was generated using ER MAPPER's ‘shiny’ algorithm. This provides shade and reflection highlights and is particularly effective in showing subtle features.

Figure 1 shows the whole of the sea bed image and Figures 2 to 5 are detail panels. All the figures show illumination of the image from the northeast.

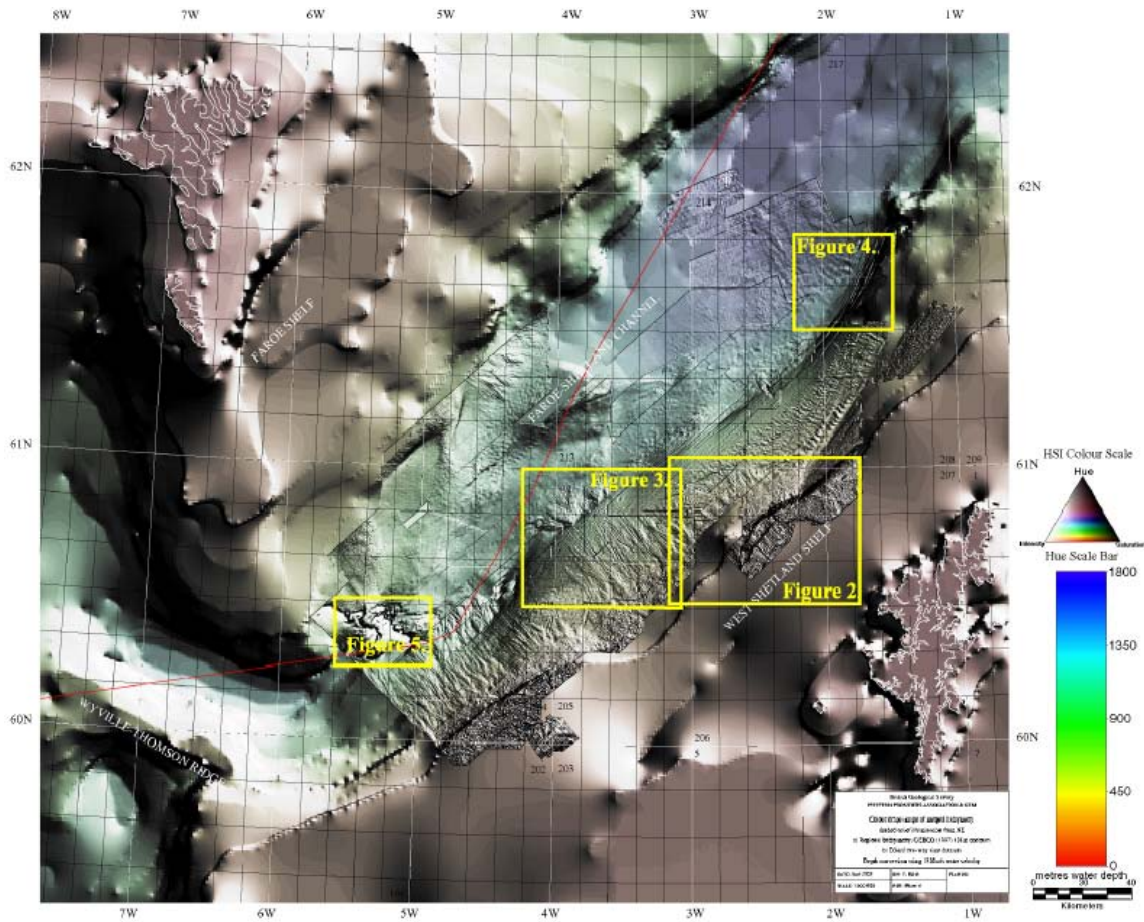


Figure 1. Image of the sea bed, offshore northwest Britain, with detailed expression of depositional and erosional processes. Image generated using ER MAPPER’s ‘shiny’ algorithm from surface picks on 3D seismic data; illumination is from the northeast. Figures 2,3, 4, and 5 are detail panels.

Ice-Marginal Features

Much of the shelf and upper slope in the area of the image is characterised by relict glaciogenic features such as morainal ridges and iceberg ploughmarks. Several features running southwest to northeast in the centre of Figure 2 are interpreted to be morainal ridges. The moraines and associated features suggest that ice extended up to or beyond the shelf break at times during the Pleistocene. Fan shaped bodies in the northeast of Figure 2 may represent an outwash or sandur plain, suggesting sea level at least 200 m below the present datum. Other features appear to be related to high-energy water flows at or near an ice margin, creating a series of small hollows.

Many of the ice marginal features at the shelf break are draped by fine-grained sediments and might not be related to the last (Weichselian) glacial maximum at 18 Ka.

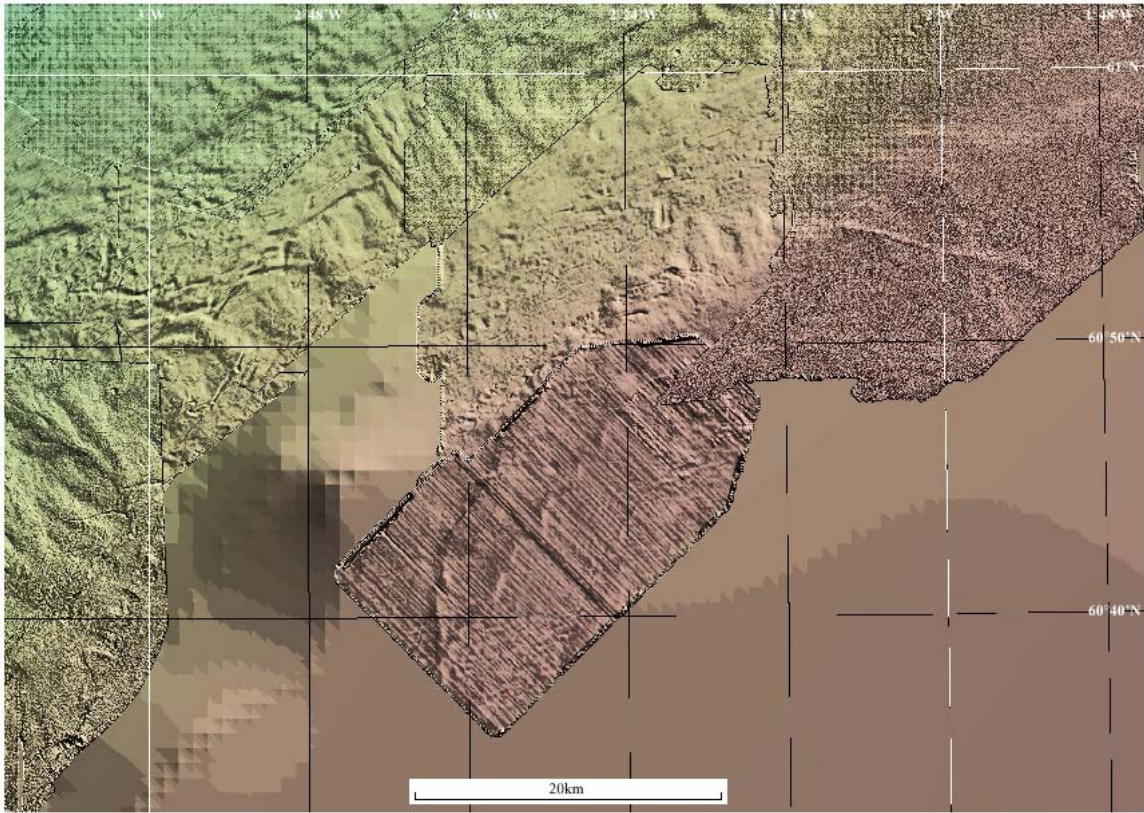


Figure 2. Detail panel of the image of the sea bed from the eastern part of the study area (Figure 1), depicting ice-marginal features on the West Shetland shelf and upper slope.

Down-Slope Features

On the slope the activity of down-slope processes is indicated by the presence of debris flows, linear gullies with base-of-slope fans (Figure 3) and sediment slides. Complexes containing debris flows, channels or gullies and lobe / fans at the base of slope form two distinct depocentres in the study area. These two depocentres represent parts of the continental margin where large volumes of sediment have been supplied to the slope both before and during glacial periods. The shelf break has prograded basinward by up to 40 km in the past 4 Ma. In one depocentre, debris-flow lobes extend from the upper slope to the basin. In the depocentre to the northeast (Figure 3) debris flows give way to incised channels on the lower slope that feed base of slope fans. In both cases there are distinct down-slope changes in character of the features, possibly in relation to subtle changes in topography of the slope. Sediment slides are not common in the study area and appear to be developed in the area of lower slope where debris flow lobes are not predominant.

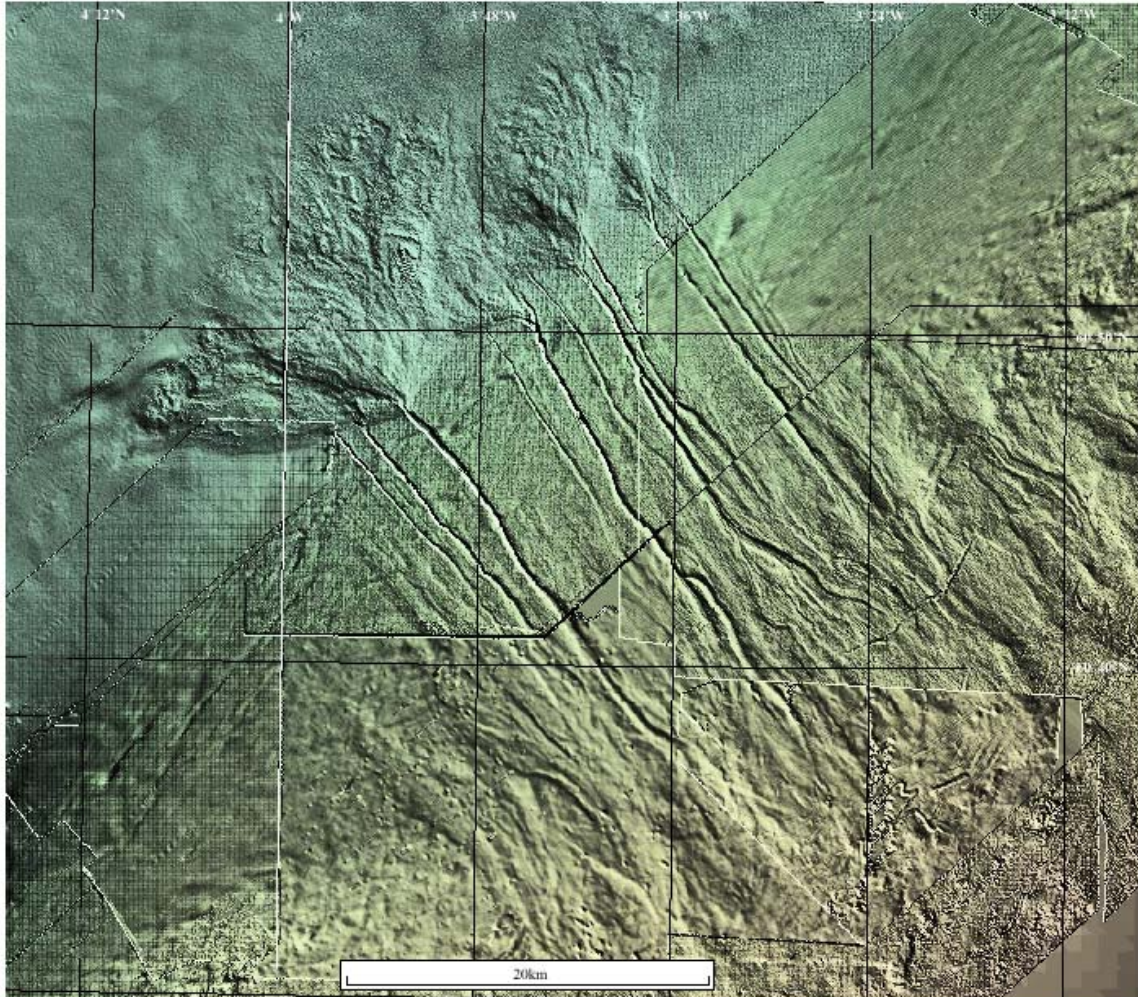


Figure 3. Detail panel of the image of the sea bed from the southern half of the study area, depicting down-slope features. Area adjoins the area shown in Figure 2 (Figure 1).

Along-Slope Features

In the northeast of the study area debris flows do not extend to the basin floor and much of the lower slope comprises relatively planar, parallel laminated sediments with many of the characteristics of a contourite drift. This plastered drift thickens in the mid-lower slope and extends up-slope to a water depth of roughly 500 m, above which debris flows dominate the slope apron. In the basin the plastered drift gives way to sediments with a similar parallel laminated seismic character, more correctly termed as sheeted drift. Within the plastered drift are areas where distinct waves and ridges have formed (Figure 4). Slope-parallel ridges form a field that can be followed along the base of slope for over 100 km. These appear to be migrating both to the southwest and also up-slope, and seismic profiles reveal multiple phases of growth separated by subtle erosive events, reflecting bottom current activity throughout the Neogene, including glacial episodes.

The plastered drift on the southeast side of the Faroe-Shetland Channel has a complex, interdigitating relationship with the debris flows on the upper slope. On the other side of

the channel, and also in the northeast Rockall Trough, drifts have a more typical crest and moat topography near the base of slope.

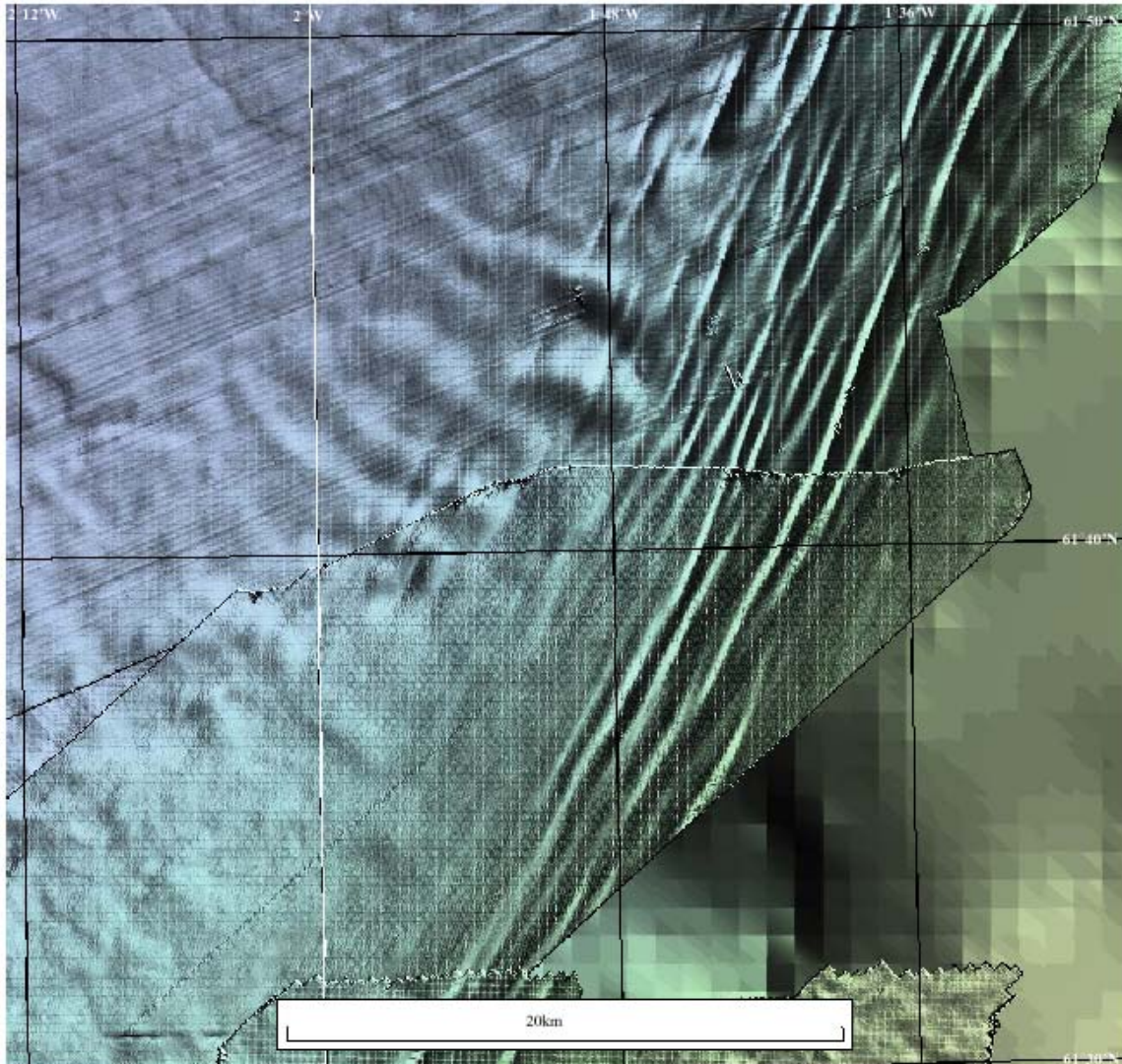


Figure 4. Detail panel of the image of the sea bed in the northeastern part of the study area (Figure 1), depicting along-slope features.

Basinal Features

In the southwest of the Faroe-Shetland Channel, where the channel shallows and narrows, deep currents are erosive and have cut scarps into Neogene and Palaeogene sediments with relief of up to 200 m (Figure 5). These sediments remain exposed at the sea bed through continued winnowing by deep-water currents, possibly combined with uplift and doming during Neogene inversion.

A number of these features have been recognised in the Faroe-Shetland Channel, some partially or wholly infilled by Neogene sediment. In the southwest it appears that the

hollows have remained free of sediment until the onset of shelf glaciation, after which glacially-derived debris flows have begun to infill topography.

On the basin floor to the northeast, where erosion is not predominant, an otherwise planar sea bed shows a polygonal pattern of depressions that appear to be related to diagenetic processes in the Palaeogene succession.

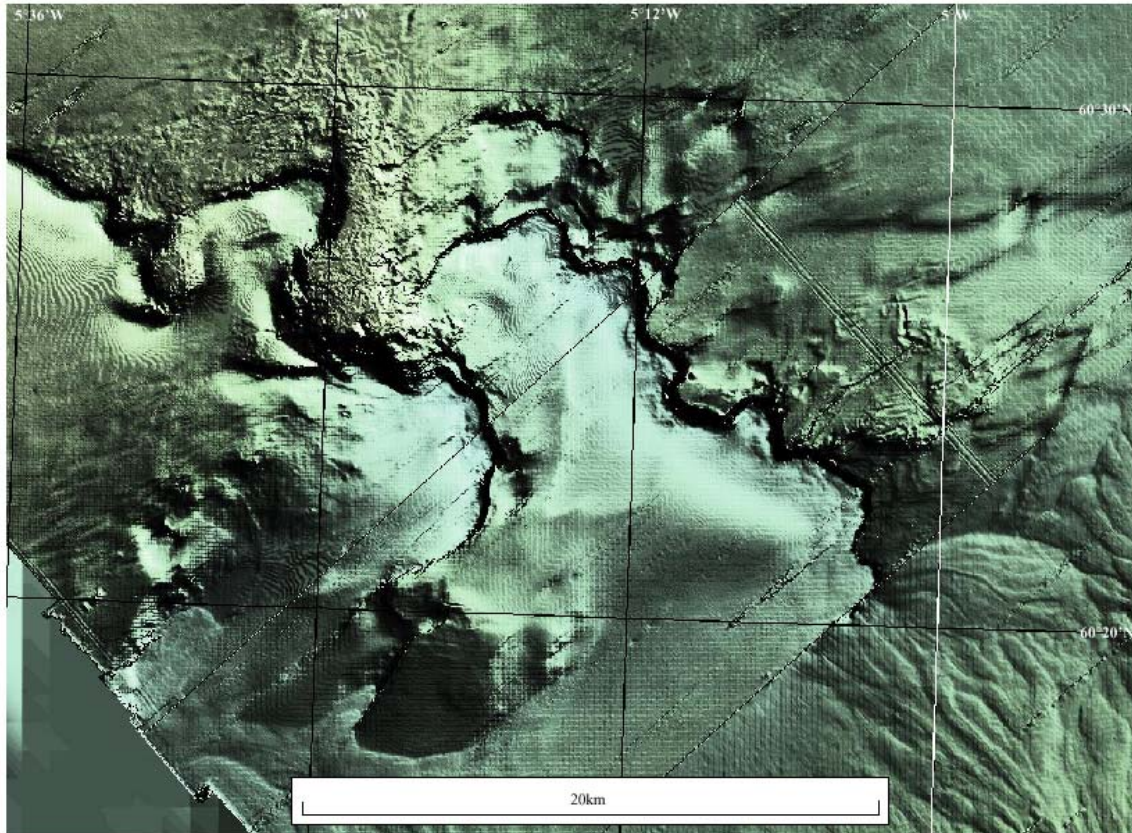


Figure 5. Detail panel of the image of the sea bed from the southern part of the study area (Figure 1), depicting basinal features.

Conclusions

The sea bed image from the West Shetland margin has provided a wealth of detail on sedimentary structures at or near sea bed, allowing the identification of depocentres feeding debris flows to the base-of-slope and contourite drifts covering parts of the lower slope and basin. The influence of deep currents is seen both in the contourite geometries and also in the dominance of erosion in the southwest of the study area.

The construction of the slope apron reflects the interdigitation of down-slope and along-slope deposits, and, significantly, both styles of deposition have contributed to continental margin progradation. By contrast, deep-water erosion has influenced the shaping of the basin floor. While much of the sea bed is characterised by relict glacial features, the depositional style of the study area was established in the Pliocene or earlier, before the onset of shelf glaciation.