

Seismic geomorphological reconstructions at Goban Spur: Implications for Plio-Pleistocene MOW bottom current variability

Stanislas Delivet¹, David Van Rooij¹, Bram Van Eetvelt¹ and Xavier Monteys²

1 Ghent University, Department of Geology and Soil Science, Renard Centre of Marine Geology, Krijgslaan 281 s8, B-9000 Ghent, Belgium.
Stanislas.Delivet@UGent.be

2 Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4, Ireland

Abstract: DSDP Site 548 on Goban Spur has been investigated using high-resolution single channel sparker reflection seismic data. Alongslope bottom currents are thought to be the driving mechanism for large-scale sediment waves development. These currents are driven on their turn by an enhanced internal tide regime that could be attributed to the MOW introduction, which characterized the presence of a strong pycnal gradient. The integration of the seismic stratigraphy with the DSDP Site 548 downhole geophysical data allowed the proposition of a better chronostratigraphic and lithostratigraphic correlation. The early to late Pliocene sequence (from ~4.2 to ~2.7Ma) shows no morphological evidence of bottom current driven sedimentation. However, from the late Pliocene (i.e. ~2.7Ma) to present, large-scale sediment waves have gradually developed in close association with palaeo-seafloor irregularities, inferring that sedimentation resumed with a marked large bottom current energy increase. The late Pliocene and the middle Pleistocene units contain mass wasting intervals. Although the Goban Spur sediment waves cannot be regarded as a contourite drift as such, the stratigraphic evolution shows striking similarities to well-documented MOW induced contourite drift systems along the northeast Atlantic margin, more especially as an intermediate site between le Danois bank and the Porcupine Seabight.

Key words: Goban Spur, sediment waves, bottom currents, Pliocene, Pleistocene, Mediterranean Outflow Water.

INTRODUCTION

The Mediterranean Outflow Water (MOW) constitutes one of the major intermediate water masses of the northeast Atlantic. At Goban Spur, it typically spreads at mid water depths (i.e. ~800 to 1200m) and flows northward toward the Rockall trough, together with the overlying Eastern North Atlantic Water, where they join the Gulfstream north eastern branch (Figure 1). Below the MOW, salinities rapidly decrease to a minimum located at about 1800m water depth, signing the southeastward flowing Labrador Sea Water (LSW). Since the early Pliocene, the MOW controlled sedimentation along its pathway in the form of extensive Contourite Depositional Systems (CDS) that developed at least as far as the Porcupine Seabight. CDS are various in morphology and composition as a result of the interaction between contour currents, associated hydrodynamic processes (e.g. internal tides), and the seabed (Rebesco et al., 2014).

IODP Exp. 307 has proven that MOW established favourable conditions for the development of large cold-water coral (CWC) mounds in the Porcupine Seabight since the late Pliocene (Huvenne et al., 2009; Thierens et al., 2010). However, the precise timing of MOW introduction remains difficult to assess due to regionally large hiatuses at the CWC mound base. DSDP site 548 (i.e. 1256m water depth) on Goban Spur recorded a more complete Pliocene to Pleistocene sequence. It is forming a gentle terraced, sediment starved environment ranging depths from 1000 to 1600m. Currently located at the MOW lower interface; the Goban Spur smooth morphology may have implied limited bottom currents and seafloor interactions.

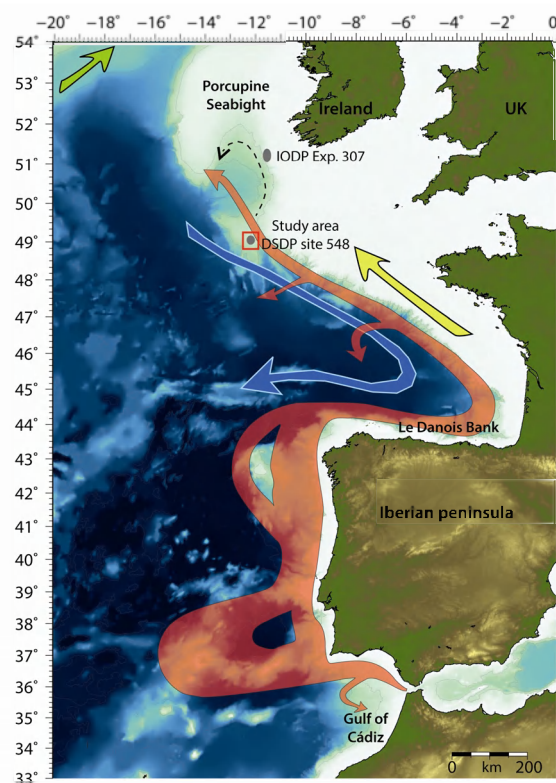


FIGURE 1. North eastern Atlantic map with major water masses (modified from Iorga and Lozier 1999). Green: Gulfstream north eastern branch; yellow: Eastern North Atlantic Water; red: warm and saline MOW; blue: colder and less saline Labrador Sea Water.

DATA AND RESULTS

This study uses a network of ~200km long high-resolution single channel sparker seismic data centred

around DSDP site 548, as well as high resolution swath bathymetry data. Downhole log geophysical data from DSDP site 548 have been correlated with the interpreted seismic stratigraphy to obtain a realistic Time/Depth chart. Three seismic units have been differentiated within the middle Miocene to late Pleistocene sedimentary record, and are separated by erosional amphitheatre like structures respectively correlated to the late Pliocene (~2.7Ma) and middle Pleistocene (~0.5Ma). Seismic unit 3 is fairly homogenous along the study area and has been given an early/middle Miocene to late Pliocene age. Seismic unit 2 is bounded by previously cited erosions attributing an overall early Pleistocene age, and is characterized by the formation of a complex series of sediment waves. Seismic unit 1 is erosion free and late Pleistocene in age, where similar sediment wave field than unit 2 developed (Figure 2).

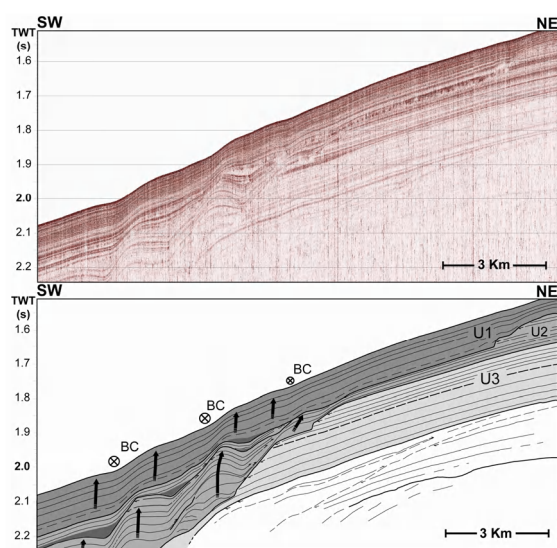


FIGURE 2. Seismic profile GS120610 and seismic stratigraphic interpretation showing sediment waves development within seismic units 1 and 2.

The sediments waves found in units 2 and 1 developed at current depths ranging between 1200 and 1600m. They are asymmetric with an elongated downslope-facing flank. They are ~1.5km in wave length and do not exceed 30ms amplitude. They vary from parallel to somewhat oblique to the slope (less than 20°) and show a clear upslope migration. Waves strictly developed against the steep palaeo seafloor irregularities.

DISCUSSION

Erosional unconformities, limiting unit 2, are interpreted as submarine landslide scars. They are contemporary with the late Pliocene revolution (LPR) and after the middle Pleistocene revolution (MPR). Both periods were characterised by dramatic sea level lowering which may have triggered mass wasting events throughout sediment accumulation and over-steepening induced slope instabilities.

Sediment wave morphology is strongly dependant of steep palaeo-escarpments, they have an overall NNE migration, and amplitudes generally decrease toward the wave field edges. Later observations are rather typical for

bottom current processes. A turbiditic origin is ruled out since turbiditic systems are absent at Goban Spur.

Sediment waves range current depths corresponding to the MOW lower interface where a strong pycnal gradient is formed. Such interface may have developed an enhanced internal tide/wave regime that could be involved in the waves formation. Khelifi et al. (2009) proved that MOW was already present at site 548 (i.e. ~1250m depth) within the course of the middle Pliocene. However, the absence of morphological structures within unit 3 suggests a limited bottom current regime. The base of sediment waves at Goban Spur is correlated to the first occurrence of CWC within the Belgica mounds province (Porcupine Seabight) which was also followed by a lengthy erosional or sediment bypass period (Huvenne et al., 2009). Despite space/time MOW migration must be expected, especially during the late Pleistocene, our results suggest it has considerably influenced both sites from the late Pliocene.

CONCLUSION

The bottom currents variability at Goban Spur is representative for the MOW palaeoceanography the North-East Atlantic Ocean. Bottom currents became energetic enough from the late Pliocene to present to lead to the formation of large-scale sediment waves.

Submarine landslides at Goban Spur are contemporary with global climatic reorganizations during the late Pliocene and middle Pleistocene.

The near-to-complete lower Pleistocene sequence at Goban Spur corresponds to an erosive or non-depositional period within the Porcupine Seabight.

REFERENCES

- Huvenne, V.A.I., Van Rooij, D., De Mol, B., Thierens, M., O'Donnell, R., Foubert, A., 2009. Sediment dynamics and palaeo-environmental context at key stages in the Challenger cold-water coral mound formation: Clues from sediment deposits at the mound base. *Deep-Sea Research I* 56, 2263-2280.
- Iorga, M.C., Lozier, M.S., 1999. Signatures of the Mediterranean outflow from a North Atlantic climatology 1. Salinity and density fields. *Journal of Geophysical Research-Oceans* 104, 25985-26009.
- Khelifi, N., Sarnthein, M., Andersen, N., Blanz, T., Frank, M., Garbe-Schonberg, D., Haley, B.A., Stumpf, R., Weinelt, M., 2009. A major and long-term Pliocene intensification of the Mediterranean outflow, 3.5-3.3 Ma ago. *Geology* 37, 811-814.
- Rebesco, M., Hernández-Molina, F.J., Rooij, D.V., Wählin, A., (2014). Contourites and associated sediments controlled by deep-water circulation processes: state of the art and future considerations. *Marine Geology* 352, 111-154.
- Thierens, M., Titschack, J., Dorschel, B., Huvenne, V.A.I., Wheeler, A.J., Stuut, J.B., O'Donnell, R., 2010. The 2.6 Ma depositional sequence from the Challenger cold-water coral carbonate mound (IODP Exp. 307): Sediment contributors and hydrodynamic palaeo-environments. *Marine Geology* 271, 260-277.