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Seismic geomorphological reconstructions of Plio-Pleistocene bottom current variability at Goban Spur

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ABSTRACT

High-resolution single channel sparker reflection seismic data revealed the presence of large-scale sediment waves nearby DSDP Site 548, located on Goban Spur. They developed in a gentle terraced environment which contrasts with the canyon-incised Celtic margin, and the relatively smooth Porcupine Seabight to the north. Based upon the morphological characteristics of the observed seabed and buried sediment waves, energetic alongslope bottom currents are thought to be the driving mechanism for the sediment wave development. These currents are driven on their turn by an enhanced internal tide regime that could be attributed to the introduction of the Mediterranean Outflow Water. The DSDP Site 548 downhole geophysical data and the seismic stratigraphic analysis allowed the differentiation of three sequences that relate to evolutionary stages since the lower Pliocene. The sequences are bounded by local erosional events, associated with mass wasting events, which seem to occur roughly synchronously to major northern hemisphere glaciations, respectively during the Lower Pleistocene (~2.5 to 2.15 Ma), and the Middle Pleistocene (~0.45 Ma). The lower sequence (from ~4.5 to ~2.15 Ma) shows no morphological evidence of bottom-current driven sedimentation. It is however settled over a smooth erosional surface which could indicate the introduction of the Mediterranean Outflow Water. The intermediate sequence is characterised by large-scale sediment waves that have gradually developed in close association with palaeo-seafloor irregularities. It is inferred that the sedimentation resumed with a relative bottom current energy increase. The youngest sequence recorded active sediment wave formation, similar to the previous sequence. Although the Goban Spur sediment waves cannot be regarded as contourite drifts as such, their stratigraphic evolution corresponds to other well-documented contourite depositional systems, influenced by the Mediterranean Outflow Water.

1. Introduction

Goban Spur is a marginal submarine plateau at a latitude of 49°N in the northeast Atlantic Ocean (Fig. 1), located at the boundary of the northwest trending Celtic margin and the roughly northward trending Porcupine Seabight and Irish margin. Since the drilling of DSDP Site 548 (1256 m water depth) in 1984, it has been of great interest in terms of palaeoceanographic and climatic studies, allowing a certain focus with respect to the investigation of the dynamics of the northeast Atlantic intermediate water masses, especially regarding the Mediterranean Outflow Water (MOW) (Caralp et al., 1985; Poag et al., 1985; Loubere, 1987; Khélifi et al., 2009, 2014; Rogerson et al., 2012). Nowadays, the MOW forms a geostrophic poleward boundary undercurrent after having exited the Gibraltar Strait (Fig. 1). It reaches its most distal extension north of the Porcupine Bank (Iorga and Lozier, 1999a,b; Van Aken, 2000; McCartney and Mauritzen, 2001). Since the lower Pliocene, it has been involved in the formation of large Contourite Depositional Systems (CDS) all along the NE Atlantic margin. From its most proximal to most distal location, this concerns the Gulf of Cadiz CDS (Hernández-Molina et al., 2006, 2011, 2014; Llave et al., 2006, 2011; Toucanne et al., 2007; García et al., 2009; Hanquiez et al., 2010; Roque et al., 2012), the Ortegal CDS (Hernández-Molina et al., 2011), the Le Danois CDS (Ercilla et al., 2008; Van Rooij et al., 2010) and the Porcupine CDS (Van Rooij et al., 2007, 2009; Huvenne et al., 2009).

At its most distal occurrence within the Porcupine Seabight, IODP expedition 307 has evidenced that the MOW introduction locally established favourable hydrodynamic conditions for the development of cold-water coral (CWC) mounds from the late Pliocene (Huvenne et al., 2009; Raddatz et al., 2011), as an important part of the Porcupine CDS. During the present day, it has been shown that the strong bottom currents in the eastern Porcupine Seabight are due to internal waves of tidal period (i.e. internal tides) at the upper interface between the MOW and the Eastern North Atlantic Water (White, 2007; Van Rooij et al.,

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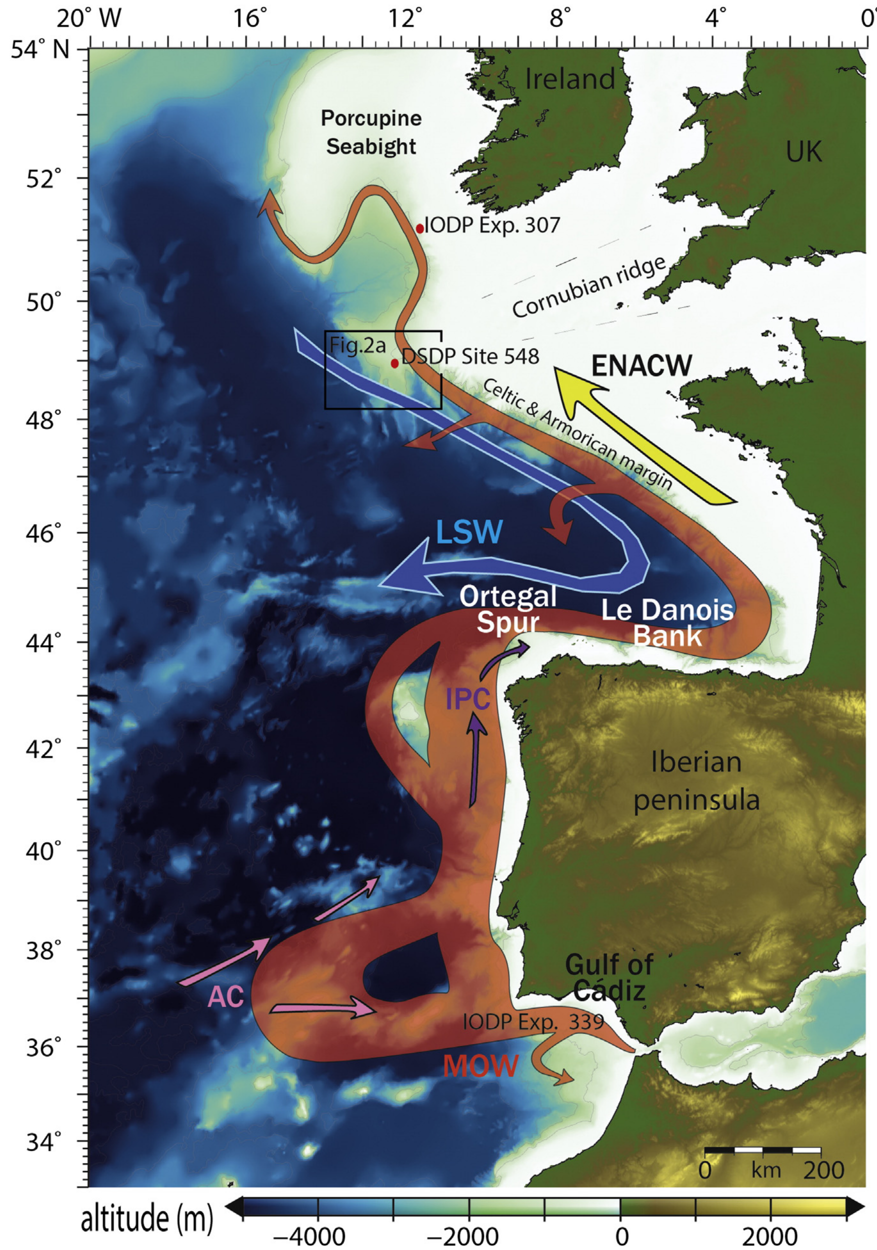

Fig. 1. Location of the study area and other areas referred to in the text. The arrows indicate the main circulation pattern. AC: Azores Current; IPC: Iberian Poleward Current; ENACW: Eastern North Atlantic Central Water; MOW: Mediterranean Outflow Water; LSW: Labrador Sea Water.

2009). The complex palaeotopography of the Porcupine Seabight slope (Van Rooij et al., 2007) may have contributed to enhance the tidally modulated bottom currents, driving the formation of a complex CDS in close association with the CWC mounds. However, the existence of a large erosional unconformity RD1, acting as the base of the Belgica CWC mounds, regionally represents large hiatuses (from 6.6 to 8.2 Myr) and was possibly created by several incision phases (Kano et al., 2007; Louwye et al., 2008; Van Rooij et al., 2009). The sedimentation first resumed in the form of CWC mound accretion at ~2.7 Ma and lagged in off-mound setting, from about 1.24 Ma at site U1318 to about 0.5 Ma depending on the local morphology (Kano et al., 2007; Huvenne et al., 2009). Therefore, the events leading to this Miocene/Pliocene RD1 unconformity are difficult to investigate and a precise timing of the MOW introduction within the Porcupine Seabight is difficult to assess. Hence, also information regarding the past MOW dynamics along its most distal part, from the southern Bay of Biscay (Le Danois CDS) onwards, is missing.

DSDP Site 548 on Goban Spur is relatively isolated from active sedimentary systems and represents a morphologically relatively gentle environment (Fig. 2a, b). It recorded a more complete sequence, especially regarding the Miocene to Pliocene transition (Loubere, 1987), which is mostly missing in the Porcupine CDS. It is currently situated within the MOW lower interface (Fig. 2c, d), which differs with the Belgica CWC mound province within the Porcupine CDS. Only limited amplitude effects of internal tides can be expected due to the local morphology (Rice et al., 1990; Iorga and Lozier, 1999b; New et al., 2001; White and Dorschel, 2010).

Based upon a new dataset of very high resolution single channel reflection seismic data, centred on DSDP Site 548, this study aims to improve the local Plio-Pleistocene stratigraphic framework and to provide an overview of the local and contemporary sediment dynamics, influenced by an already rather distal MOW. As such, this will assist to improve our knowledge of the MOW palaeoceanography in the northern Bay of Biscay, at an intermediate site between the Porcupine CDS