Short-term sediment dynamics on a contourite body (off NW Iberia), Part I: Rapid changes of bottom-flow intensity during the past 50ka deduced from a sediment-core transect

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Abstract: *The sediment dynamics in a confined contourite system off NW Spain are reconstructed using high-res bathymetric mapping, seismic profiling, and sediment core transect. This depocenter and its 150m deep moat surround an 800m high obstacle. Since mid-Eocene, a pre-drift unit and two current-controlled contouritic units have formed. Fine-grained (10µm) basinwide current-influenced deposition was episodically interrupted by short-lasting high-energy conditions during MIS-3. High glacial and later Holocene periods show markedly calm conditions. The deglacial/early Holocene interval shows, in contrast, a pronounced increase in bottom-flow energy (70µm) with a waxing-and-waning dynamic from 17 to 5 cal ka BP. Process-based simulation demonstrates that not a water-mass core or boundary distributed those sands. Instead, pulse-like hydrographic fronts travelling inside the mixing zone of two water masses led to sand mobilization. Compared to paleoceanographic reconstructions, the downward-upward migrating MOW/LSW mixing zone is suggested as driving mechanism. A conceptional model shows how seafloor obstacles redirect and perturbate bottom flows with the special effect of oceanographic-front pulses occurring in the mixing zone. Front-driven secondary eddies on the contourite body itself provide an efficient mechanism for widespread sediment re-distribution.*

Key words: *Ocean bottom currents, current-obstacle interaction, Eastern Atlantic, Late Quaternary.*

INTRODUCTION

The formation of bottom-current induced (i.e. contouritic) depocenters is still a matter of debate with regard to the detailed hydrographic control on the sedimentation processes. This study uses a multi-disciplinary approach to investigate the hydro- and sediment dynamics in a comparably small-sized contourite system by using high-resolution bathymetric data, 2D reflection seismic profiling, sediment-core analyses along a transect, and numerical modelling of ocean-current processes.

DATA AND RESULTS

A classically shaped 150m high contourite body off NW Spain surrounds a pronounced 800m high structural obstacle at the toe of the continental slope, separated from each other by a 1.5km wide moat (Fig. 1). Seismic profiles indicate that the basal sedimentary unit overlying the acoustic basement represents normal hemipelagic basin fill, without evidence for current control (Fig. 2). In contrast, the following two sedimentary units show a mounded climbing-upward geometry in association with a successively filled palaeo-moat.

The sediment cores across this contourite body illustrate that MIS-3 was characterized by a rhythmic swap between calm and high-energy conditions, and MIS-2 and the later Holocene were oceanographically quiet

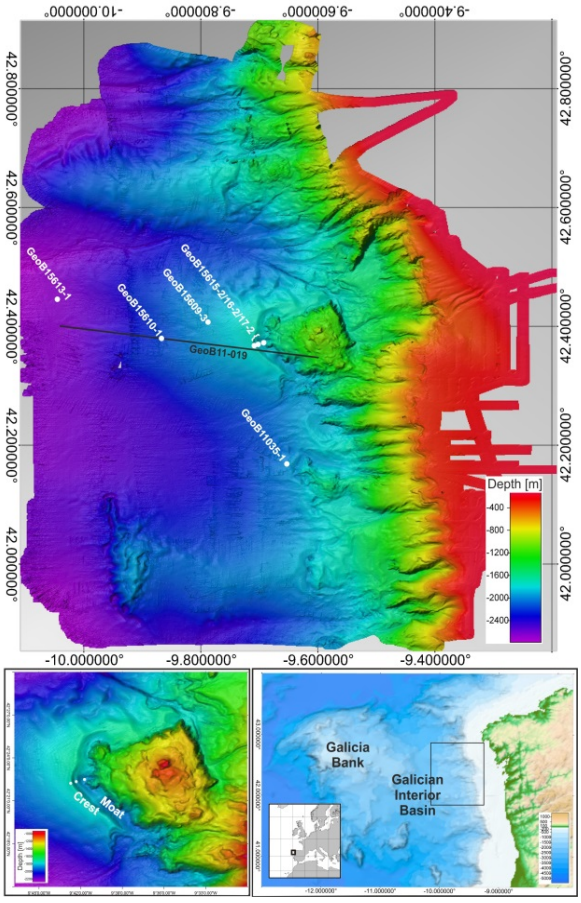

FIGURE 1: Bathymetric map of the study area.

intervals. Most notably is the deglacial to early Holocene time interval, nevertheless; with an episode of remarkable bottom-current intensification rapidly waxing-and-waning dynamics were sensitively recorded across the core transect (Fig. 3).

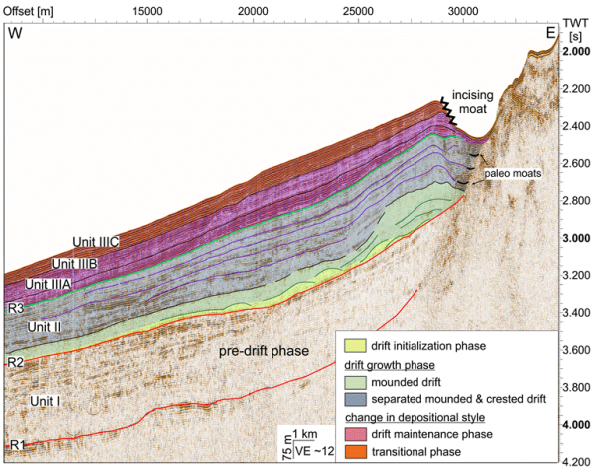

FIGURE 2: Seismic profile across the contourite body.

A 3-D process-based sediment-transport model is applied based on different scenarios in which the two major water masses (MOW and LSW) potentially responsible for sediment dynamics on the contourite body are regulated, mimicking the modern and paleo-oceanographic conditions. Simulation results exclude a water-mass core as force driving an evolution of the system. It clearly indicates, instead, that pulse-like appearing fronts within the approximately 300m thick water-mass mixing zone have the potential to remobilize and distribute fine sands. These fronts cause local bottom currents inside the moat as well as km-scaled eddies on the gentle seaward-directed contourite flank. Such migrating fronts are well known as common elements in the modern hydrographic system, but appear on the steep and bare-of-sediments middle slope off Galicia at present (Fig. 4). Thus, the resulting sandy contouritic sediment record is not mainly controlled by a net increase in front energy within this mixing zone but by the temporary climate-related deepening of this zone of about 300m.

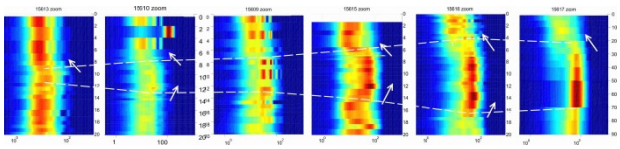

FIGURE 3: Grain-size distribution during the period 20-0 cal ka BP illustrating the offshore gradients as well as duration of the coarsening during the deglacial/early Holocene interval.

The comparison with existing palaeoceanographic data suggests that fine-grained deposition on the contourite body was driven by the Labrador Sea Water (LSW) over major parts of the past 50ka. A short-lasting increase in bottom velocity during Dansgard-Oeschger intervals (Völker et al., 2006) can be observed throughout the basin. The most remarkable interval of sediment transport intensification occurred during the last deglacial to early Holocene times. With the general, climate-driven decrease in salinity leading to a weakening of the lower Mediterranean Outflow Water (MOW) core in the outflow region (the Gulf of Cadiz), the upper MOW core has presumably strengthened and due to an increase in its salinity, temporarily (17-5ka) deepened by the identified 300m in the study area (Schönfeld and Zahn, 2000).

CONCLUSIONS

This study refines the concept how medium-sized seafloor obstacles redirect and perturbate bottom currents on local scale. Sharply defined water-mass boundaries are not necessarily the hydrographic elements to provide high-energy conditions but, instead, a rather transitional zone between two water masses might provide a powerful bottom-flow and, thus, sediment transport regime. The well-sorted sands seem to originate from the moat itself, instead of being delivered from a remote source and transported over long distances. The migrating eddy system on the contourite body itself provides an efficient mechanism to distribute these sediments in suspension equally over the area.

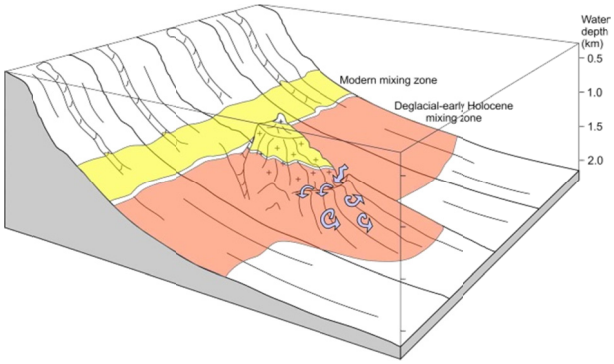

FIGURE 4: Conceptional scheme comparing the modern (yellow) and deglacial/early Holocene (orange) LSW/MOW mixing zones. Whilst the modern mixing zone interacts with the middle slope and the top of the obstacle (possibly producing morphological/erosional terraces), the 300m lower palaeo-mixing zone with its hydrographic fronts and associated eddies had strong impact on the contouritic system sedimentation.

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