The Ortegal spur contourite depositional system (Bay of Biscay): the implications of the Mediterranean Outflow Waters in sedimentary processes and cold-water coral ecosystems


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Abstract
This contribution aims to illustrate the Ortegal Cape Contourite Depositional System (OCCDS), a new example of contourites located on the northern Galicia margin generated by the Mediterranean Outflow Water (MOW) influence. This work is based on several datasets collected during two multidisciplinary cruises, including: single echosounder and swath bathymetry data, high and middle resolution reflection seismic profiles, sediment samples and CTD data. Both depositional and erosive features reflect an intense MOW interaction with the sea floor along the slope that has conditioned the occurrence of important local contouritic processes and the building of cold-water coral ecosystems.

Keywords: Contourite depositional system, Mediterranean Outflow Water, north Iberian continental margin, corals.

1. INTRODUCTION
This study illustrates the occurrence of a Contourite Depositional System (CDS) at Ortegal Spur (northern Galicia margin, Bay of Biscay) (Fig. 1), between 43.7°N-44.35°N and 8.25°W-9.25°W. The study area corresponds with a fishing ground named “A Selva” which extends 70 miles northwest from Ferrol. This area is characterised by a well defined upper and middle slope, under the influence of the Mediterranean Outflow Water (MOW).

This work is based on a dataset collected during two cruises: a) the first multidisciplinary cruise of the inaugural new R/V Sarmiento de Gamboa (ASELVA08, July, 2008) coordinated by the Santiago University (Spain); and b) the Belgica GENESIS Leg-1 cruise (Belgica 09/14a, May, 2009) executed by the Renard Centre of Marine Geology (RCMG), Ghent University (Belgium). This dataset includes: a) bathymetry information collected by single beam echo sounder (Simrad EA-600); and swath bathymetry (Atlas Hydrosweep MD50 & DS and Simrad EM1002) data; b) middle and very high resolution reflection seismic profiles from sparker and parasound (Atlas Parasound P-35) systems; c) sediment and rock samples collected by multicorer, gravity corer, box-corer and rock dred-
ges; d) CTD data and e) photographs and films collected by the Belgica ROVs system.

In the Bay of Biscay most of the water masses are of North Atlantic origin (Pollard et al., 1996; González-Pola, 2006). The uppermost water mass is the Eastern North Atlantic Central Water (ENACW), which extends to depths of about 400 to 600 m. Between 400-500 and 1500 m water depth, the MOW follows the slope as a contour current. Between 1500 and 3000 m water depth the North Atlantic Deep Water (NADW) is recognised, and below it the Lower Deep Water (LDW), which mainly seems to result from the mixing of the Antarctic Bottom Water (AABW) and the Labrador Sea Water (LSW).

After its exit through the Gibraltar Strait, the MOW represents an intermediate water mass, warm and very saline that flows to the NW along the middle slope (Fig. 1) under the Atlantic Inflow (AI) and above NADW. After passing the Gulf of Cadiz, the MOW shows three principal branches (Fig. 1): the main branch flows to the N, the second to the W, and the third to the S, reaching the Canary Islands, and heading finally westward (Iorga and Lozier, 1999). The northern branch flows along the middle slope of the Portuguese margin, being divided in two branches by the influence of the Galician Bank. In its southwestern slope, the MOW exhibits high speed and variability at 1100 m depth (mean of 18 cm/s with peaks of more than 40 cm/s, Ruiz-Villareal et al., 2006). These two branches return to converge and subsequently circulate to the E in the Bay of Biscay following the continental slope contour (Fig. 1). The MOW reaches the Porcupine Bank and partly circulates to the N along the Rockall Trough until reaching the Norwegian Sea (Iorga and Lozier, 1999).

The interaction of the MOW with different sectors of the slope of the Atlantic Iberian margin is well known, generating CDS in the Portuguese margin (Alves et al., 2003), Galicia Bank (Ercilla et al., 2008a) and Cantabrian margin, in the Le Danois Bank or “Cachucho” (Ercilla et al., 2008b; Van Rooij et al., submitted). In the Ireland margin, the MOW has generated a CDS in the middle slope of Porcupine (Van Rooij et al., 2003).

2. THE CONTOURITE DEPOSITIONAL SYSTEM

Preliminary results confirm the circulation of the MOW along the slope of the Ortegal Spur (Fig. 2), between 500/600 m and about 1500/1600 m water depth where the denser core flows about 1200 m depth (Fig. 3). The CTD data obtained during the ASELV08 cruise, indicate that the core (950 m depth) of the eastern vein off Ortegal Cape has S=36.03, θ=10.83, σθ=27.61 (Fig. 3). The interaction of the impinging MOW from west with the Ortegal Spur has generated a contourite depositional system (CDS) composed of erosive and depositional features (Fig. 3). The erosive features comprise terraces of tens of meters of relief and several hundreds of meters long, and moats of tens of meters of relief and of hundreds meters wide. The main depositional features (drifts) are defined by plastered to mounded elongated contourite drifts (tens of meters thick). Sediment samples collected from the nearsurface of these drifts contain fine sands to muddy sandy. The CDS interact with gravitational deposits and the area is crossed by submarine canyons.

3. SPECIFIC ECOSYSTEMS WITHIN THE CDS: CORALS PATCHES

Bathymetric and seismic data have allowed the identification of scattered mound morphology on the seabed of ~100m in diameter and ~2 m in high (Fig. 3). These local features were dredged, photographed and shoot, discovering that they represent cold-water coral ecosystems (Fig. 4). Deeper corals are alive but the shallow species are dead and partially covered by sediments. Corals represent a good substrate for other different groups (e.g. crinoids).
4. DISCUSSION AND CONCLUSIONS

The MOW is one of the best studied water masses in the Atlantic domain. Moreover, numerous studies have been centred in its hydrography, temporal variability and its interaction with the seabed in the Gulf of Cadiz, where has formed a large and complex CDS due to the high outflow bottom current velocities (e.g., Hernández-Molina et al., 2003). However, the influence of the MOW on Pliocene and Quaternary sedimentary processes and ecosystems is not restricted to the Gulf of Cadiz, as is documented around the Galician and Le Danois Banks (Ercilla et al., 2008a, b; Van Rooij, et al., submitted). The Ortegal Spur CDS is a new example of CDS around the Iberia margin as a consequence of the MOW interaction with the sea bottom along the slope. This CDS should record the palaeoceanographic changes that the MOW underwent during the Pliocene and Quaternary. Although this contribution presents preliminary results, the following key factors may have controlled the evolution of the Ortegal Spur CDS:

a) Local morphology of the margin. The particular inherited geological features conditioned the Ortegal Spur as a pelagic platform located on the middle/upper slope in the northern Galicia Margin. This platform produces changes in the regional slope trends providing the best place for local MOW interaction with the seabed.

b) Sediment supply. Main components of the superficial samples of the drifts are planktonic foraminifer’s tests, which could characterize a biogenic sandy contourite. But, a great variety of sediment inputs to the drift generation could be also considered. Local sediment supply could have had an important source in adjacent submarine canyons. Suspended sediments (nepheloid layers) could be pirated eastward by the MOW and deposited along the Ortegal Spur slope. A greater direct (and coarser) sediment supply from the shelf and hinterland sources should be expected during regressive and
Cold-water coral ecosystems can be seen on seismic data as mounded patches with limited lateral extend anomalies on the seabed and swath bathymetry data as minor build-ups with high amplitude migrations (Løseth et al., 2009). These coral patches are very important since during the last decade, several national and international projects have focused on these ecosystems along the European margins due to their (paleo)environmental implications (e.g. Reveillaud et al., 2008). In this sense, in the Bay of Biscay, near the northernmost occurrence of the MOW, and within the Porcupine Seabight, an impressive cold-water coral mound associated to drift is very well known (Van Rooij et al., 2003). Present results support that the Ortegal Spur could be another very good example of MOW influence on cold-water corals development. In addition to the MOW influence, recent studies indicate hydrocarbons leaking to the surface may act as a nutrient that increases biological activity. If the seeps are long lasting, there may be a build-up of large biological masses. The parasound and sparker seismic profiles collected along the Ortegal Spur CDS also show many indirect seismic facies and acoustic anomalies related to fluid and gas migrations (Løseth et al., 2009). Further work should be needed to understand the regional interplay between MOW influence, gas linkage and cold-water coral ecosystem.

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