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Morphogenetic mesoscale analysis of the northeastern Iberian margin, NW Mediterranean Basin

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Abstract

The compilation of several multibeam data sets unveils for the first time the seafloor of almost the entire northeastern Iberian margin, in the northwestern Mediterranean Basin. This is achieved thanks to an international effort involving mainly Spanish and French research institutions. Submarine canyons, turbiditic channels, landslides and a mid-oceanic valley are the main sedimentary features observed. The size and shape of these features vary throughout the margin. However, the morphometric analysis performed leads to the subdivision of the margin in three main segments: North Catalan Margin (NCM), South Catalan Margin (SCM) and Ebro Margin (EM). We address a non-frequently used scale to tackle the question of which are the main mechanisms controlling the morphological variability between these margins. This is the mesoscale (from one to several hundred kilometres), which allows a comprehensive, holistic and detailed analysis of the seascaping mechanisms shaping the continental margin of northeastern Iberia. Preliminary results suggest that factors controlling the seascape involve a combination of tectonics, long-term fluvial sediment flux to the margin, sediment grain size, basin depth and slope gradient. Modelling of these morphogenetic relationships will contribute to a better knowledge of the seascape development in mid-latitude siliciclastic margins.

Keywords: multibeam bathymetry; backscatter intensity; mesoscale; seascape shaping mechanisms; NW Mediterranean

1. Introduction

1.1. Background and objectives

The seascape of continental margins is highly variable. Although continental shelf, slope and rise are common features in nearly all passive margins, their sizes and shapes change from one margin to the next. Steep to gentle slopes, wide to narrow continental shelves and densely to poorly canyonised margins appear in modern continental margins. However, such variability is not infinitely diverse as they share common morphological patterns. Hence, a combination of a limited number of mechanisms appears to determine the seascape of siliciclastic passive continental margins.

In the last decades several studies focused on examining seascape forming mechanisms. The earlier morphogenetic studies appeared with the acquisition of the

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first seismic reflection profiles in the 1960s and, especially, in the 1970s (Emery, 1980). The aim of these studies was to elaborate a genetic classification of continental margins in a world coverage scale. More recently, quantitative morphologic analysis of seismic data sets selected from all over the world were used to identify the main factors governing continental slope geometry (Adams et al., 1998; Adams and Schlager, 2000). Other quantitative morphologic studies based on low-resolution global bathymetric data sets also explored the variability of continental margins from a genetic viewpoint (O'Grady et al., 2000).

Currently, multibeam echosounders are acquiring unprecedented highly detailed seafloor images. The high-resolution given by this technique allows studying modern continental margins at a scale ranging from one to several hundred kilometres here referred as "mesoscale" by assimilation to the size of features currently studied within physical oceanography. Such a scale applied to the seafloor allows a comprehensive and detailed analysis of seascaping processes including not only the ones that produce the largest morphologic impact (e.g. canyon incision, deltaic progradation), but also smaller (e.g. local sediment instability, channel-confined turbidity currents). Despite having a relevant role in determining margin architecture, these relatively small features are ignored within the global scale morphogenetic studies, which are based on low-resolution data sets. Surprisingly, few morphogenetic studies are based on mesoscale multibeam bathymetric analysis (Pratson and Haxby, 1996; McAdoo et al., 2000; Weaver et al., 2000; Cacchione et al., 2002; Mitchell, 2004, 2005).

In this paper we illustrate and describe, for the first time as a whole, the multibeam bathymetry data set covering almost entirely the northeastern Iberian margin, in the northwestern Mediterranean Basin. These high-resolution bathymetric data were obtained in several cruises lasting several months in total. Based on these data we discuss, from an integrative viewpoint, the mechanisms that control the geomorphic variability of this siliciclastic passive margin.

1.2. Mapping the northwestern Mediterranean Basin

The first maps of the northwestern Mediterranean Basin floor were published in the late 1970s and early 1980s, before the advent of multibeam echosounder systems (Gennesseaux and Vanney, 1979; Mauffret, 1979; Monti et al., 1979; Rehault, 1981; Canals et al., 1982; DSNO, 1982). Orsolini et al. (1981–82) made up the first map from high-resolution swath bathymetry data in the eastern part of the deep Gulf of Lions. In the last decade, the rest of the northwestern Mediterranean has been almost totally surveyed with multibeam systems by French and Spanish institutions. Amongst these surveys is outstanding the work done by IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) in the Gulf of Lions, the University of Barcelona in the Catalan margin and Gulf of Valencia, and the Spanish Oceanographic Institute in cooperation with the Hydrographic Institute of the Spanish Navy in the Balearic Promontory. Such an international mapping effort, achieved thanks to COSTA, EUROSTRATAFORM and HERMES EC funded projects jointly with other projects, has been recently compiled and released by the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) in a 1:2,000,000 synthesis map (MediMap Group, 2005).

2. Structural and stratigraphic regional setting

2.1. Structural configuration

After the Eocene–Mid-Oligocene compressional episode that gave rise to the emplacement of the northeast Iberian Peninsula major thrust sheet, the regional stress regime reversed during the Late Oligocene–Early Miocene (Roca et al., 1999). This led to the formation of a cluster of extensional sub-basins that defines the present day configuration of the northwestern Mediterranean Basin. Those sub-basins are defined by systems of NE–SW oriented horsts and grabens (Fig. 1) that form the northwestern Neogene Mediterranean rift system (Maillard and Mauffret, 1999), to which the Valencia Trough belongs to. In the Valencia Trough, crustal thinning was achieved by means of NW–SE transfer zones that guided the opening of the basin and delineated tectonic compartments (Maillard and Mauffret, 1999) (Fig. 1). Such thinning did not reach oceanisation and was not synchronous along the margin. The rifting initiated in the Lower Oligocene at the northeasternmost compartment, where the present day Gulf of Lions is and where the crust thinning is maximum (Maillard and Mauffret, 1999; Roca et al., 1999). Then, during the Late Oligocene–Lower Miocene, the rifting propagated southwestwards and formed the Catalano–Balearic Basin (Maillard and Mauffret, 1999; Roca et al., 1999).

The Valencia Trough is bounded by convergent tectonic elements. These are the Iberian Range to the west, the prolongation of the Betic Range onto the Balearic Promontory to the south, and the Catalan Coastal Ranges and the Pyrenees to the northwest (Fig. 1). These compressive domains evolved synchronously and lately to the Valencia Trough main extensive phase, although