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The morpho-tectonic setting of the Southeast margin of Iberia and the adjacent oceanic Algero-Balearic Basin

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ABSTRACT

Multi-beam bathymetry and high-resolution low-penetration seismic reflection profiles of the offshore extensions of the Bétic Internal Zone off Sierra de Cartagena-La Unión margin along its south side and the Mar Menor margin along its east side, the Mazarrón Escarpment forming its southern boundary and the adjacent oceanic Algero-Balearic basin have provided images of the neo-tectonic structures of the region equal to those provided by subaerial photography. For the first time we mapped with unprecedented detail the Mazarrón Escarpment and the Southeast margin of Iberia.

The first-order structures of the region are due to the consequence of the collision of the African and Eurasian plates during the Alpine orogeny in late Oligocene–Middle Miocene, the westward migration of the Alborán plate in the Middle Miocene and the desiccation of the Mediterranean in the Messinian (Late Miocene) that led to the deposition of evaporites in the Algero-Balearic basin and erosion of the Mazarrón Escarpment, the Sierra de Cartagena-La Unión shelf, the Mar Menor margin and the adjacent coast. Our data images second order tectonic features (neo-tectonic features) superimposed on the larger structures. These include the deformation of the strata in the Algero-Balearic basin by the gliding of the Plio-Quaternary sediments on Messinian halite on the margins of the basin and sediment loading in its center, the Late Miocene–Quaternary deformation of the area north of the Mazarrón Escarpment resulting from the continuous oblique convergence of the African and Eurasian plates in a NNW–SSE direction, the Miocene to Pleistocene volcanic edifices and pinnacles (dikes), the pockmarks formed by the extrusion of gas/water via faults and the massive gravitational failure of the Mazarrón Escarpment triggered by this plate convergence. The data also show in detail features formed on the Mazarrón Escarpment during the Messinian, Pliocene and Pleistocene regressions and those on the shelf formed during the Pleistocene glacially induced regressions/transgression and sediment drifts generated by modern currents.

1. Introduction

The Algero-Balearic Basin and the adjacent Spanish margin consist of two distinct tectonic realms. The Iberian continental margin is the creation of the convergence of the African and Eurasian plates during the Alpine orogeny in Late Oligocene–Middle Miocene. The Algero-Balearic Basin is an oceanic basin formed by the western migration of the Alborán plate in Middle Miocene. The east–west trending Mazarrón Escarpment, a right-lateral transform, separates the two realms.

The objectives of the present investigation were to determine the morphology of the offshore extension of the terminal splay of the Eastern Bétic Shear Zone in the Internal Zone, to define its shallow structure, to integrate these data to determine the geodynamic setting of the offshore extension of the Bétic Internal Zone and finally to compare the onshore and offshore settings of the zone (Fig. 1). The Internal Zone, extending from east of the Strait of Gibraltar to the Mediterranean, is comprised of three nappe complexes of variable metamorphic grade and Triassic to lower Neogene (Azañón et al., 2002). The Neogene deformation was accompanied by subsidence of Neogene basins and uplift of the pre-Neogene basement creating a discontinuous chain of sierras separated by Miocene–Quaternary basins (Huibregtse et al., 1998; Woodside and Maldonado, 1992; Silva et al., 2003, 2004).

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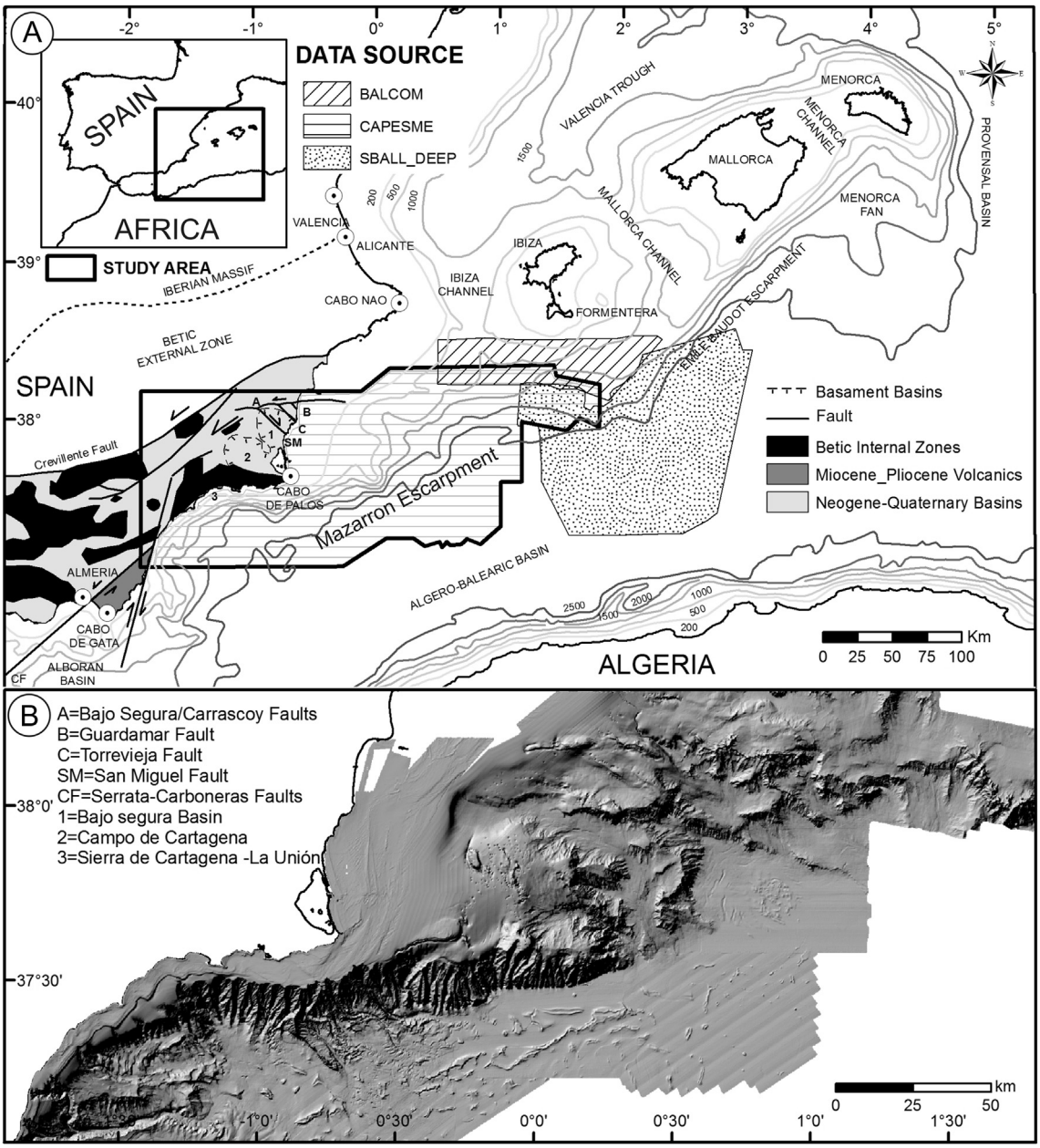

Figure 1. A. Bathymetric-tectonic map of SE Spain showing the location of survey area. Thick black line shows the study area (35,269 km^2). Bathymetric contours in meters. Base map from MediMap Group (2005). Additional data from Alfaro et al. (2002a, 2002b), Bousquet (1979), Gràcia et al. (2010), López-Ruiz et al. (2002), Mauffret (2007), Perea et al. (2009), Silva et al. (2003, 2004), Soria et al. (2008) and Robles-Arenas and Candela (2010). **B**. DTM of the study area.

We extended our study southward as to include the 2800 m deep, 100–120 km wide and 400 km long Algero-Balearic basin. Its oceanic crust, inferred by Panza et al. (2007) to be of Middle Miocene age, is mantled by approximately 1.8 km of Miocene sediments that include less than 1 km of Messinian evaporites (Gallart et al., 1995; Sábat et al., 1995; Mauffret et al., 2004). Deposition of the Messinian evaporites is a result of the closure of the portal between the Atlantic and the Mediterranean by Late Miocene compressional tectonics (Duggen et al., 2004).

2. Area of investigation and methods used

The offshore extension of the Bétic Internal Zone and adjacent Algero-Balearic Basin investigated during the present study are depicted in Figures 1 and 2. It has maximum extensions of 334 (east–west) × 130 (north–south) km. The area was surveyed with two Simrad multi-beam systems. An EM-3000 D system (300 kHz) was used in depths of less than 150 m aboard R/V Emma Bardán in cruises during 2001 and 2003 and a Simrad EM-300 (30 kHz) for greater depths aboard the R/V Vizconde de Eza during cruises in 2003, 2004, 2007, 2010 and 2011 (this last year only working with Topas PS18). Information on the shallow structure of the area was obtained with a hull mounted Topas PS 18 High-resolution parametric profiler system, with integrated transmitter and receivers. Navigation was via a differential GPS Simrad GN33 using satellite corrections from a Fugro system integrated in a MDM 400 software package with an inertial integrated aided Seapath 200 System for an accuracy of 0.7 Rms. The multi-beam data sets from Capesme Project (present paper) is gridded at 50 × 50 m, Espace Project (present paper) is gridded at 5 × 5 m. Sbal Deep Project has