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Architecture and tectono-stratigraphic evolution of the intramontane Baza Basin (Bétics, SE-Spain): Constraints from seismic imaging

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ABSTRACT

The Baza basin is a large Neogene intramontane basin in the Bétic Cordillera of southern Spain that formed during the Tortonian (late Miocene). The Bétic Cordillera was produced by NW–SE oblique convergence between the Eurasian and African Plates. Three seismic reflection lines (each 18 km long; vibroseis method) were acquired across the Baza basin to reveal the architecture of the sedimentary infill and faulting during basin formation. We applied rather conventional CDP data processing followed by first arrival P-wave tomography to provide complementary structural information and establish velocity models for the post-stack migration. These images show a highly asymmetric structure for the Basin with sediments thickening westward, reaching a maximum observed thickness of >2200 m near the governing Baza Fault zone (BFZ). Three major seismic units (including several subunits) on top of the acoustic basement could be identified. We use stratigraphic information from the uplifted block of the BFZ and other outcrops at the basin edges together with available information from neighboring Bétic basins to tentatively correlate the seismic units to the known stratigraphy in the area. Until new drilling or surface outcrop data is not available, this interpretation is preliminary.

The seismic units could be associated to Tortonian marine deposits, and latest Miocene to Pleistocene continental fluvio-lacustrine sediments. Individual strands of the BFZ truncate the basin sediments. Strong fault reflections imaged in two lines are the product of the large impedance contrast between sedimentary fill and basement. In the central part of the Basin several basement faults document strong deformation related to the early stages of basin formation. Some of these faults can be traced up to the shallowest imaged depth levels indicating activity until recent times.

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1. Introduction

Geological studies have revealed the tectono-sedimentary evolution of numerous Neogene Bétic basins in southeast Spain (Fig. 1) and the stratigraphy of the deposited sediments, mainly based on surface geology or geomorphology (Sanz de Galdeano and Vera, 1992, Soria et al., 1998, Rodríguez Fernandez et al., 2012, among others). In the Granada Basin, a dense grid of commercial high-resolution seismic lines have provided detailed insight into the deeper architecture of the sedimentary deposits and the governing faults, and allowed a quantitative study of the history of subsidence and accumulation (Rodríguez-Fernandez and Sanz de Galdeano, 2006). The other examples of multichannel reflection data are from the submerged Alboran (e.g., Jurado and Comas, 1992) and Mula-Fortuna Basins (Rodríguez Fernandez et al., 2012). The architecture and details of the promoting faults in other basins like the Guadix-Baza Basin are not well known, mainly because of Pleistocene and Holocene sediment coverage and the lack of high-resolution seismic data.

Located in the internal zone of the Bétic Cordillera, the Baza and Guadix sub-basins were integrated to form a large Neogene basin of ~6000 km^2 (Fig. 1). Our knowledge of the structure and infilling has been based on outcropping geology around the perimeter, a gravimetric study, and a single seismic line almost parallel to the western bounding fault zone (e.g., Alfaro et al., 2008). Taken together, these data suggest that the Baza Basin could provide a continuous continental sedimentary record from the latest Miocene to the Middle Pleistocene (~6 Ma to 0.6 Ma). Recent data from scientific drilling of the upper 120 m of the lacustrine facies shows a detailed Early Pleistocene paleoclimatic record (Cueva Palomina-1 (CP1) borehole; Gibert et al., 2015; see red star in

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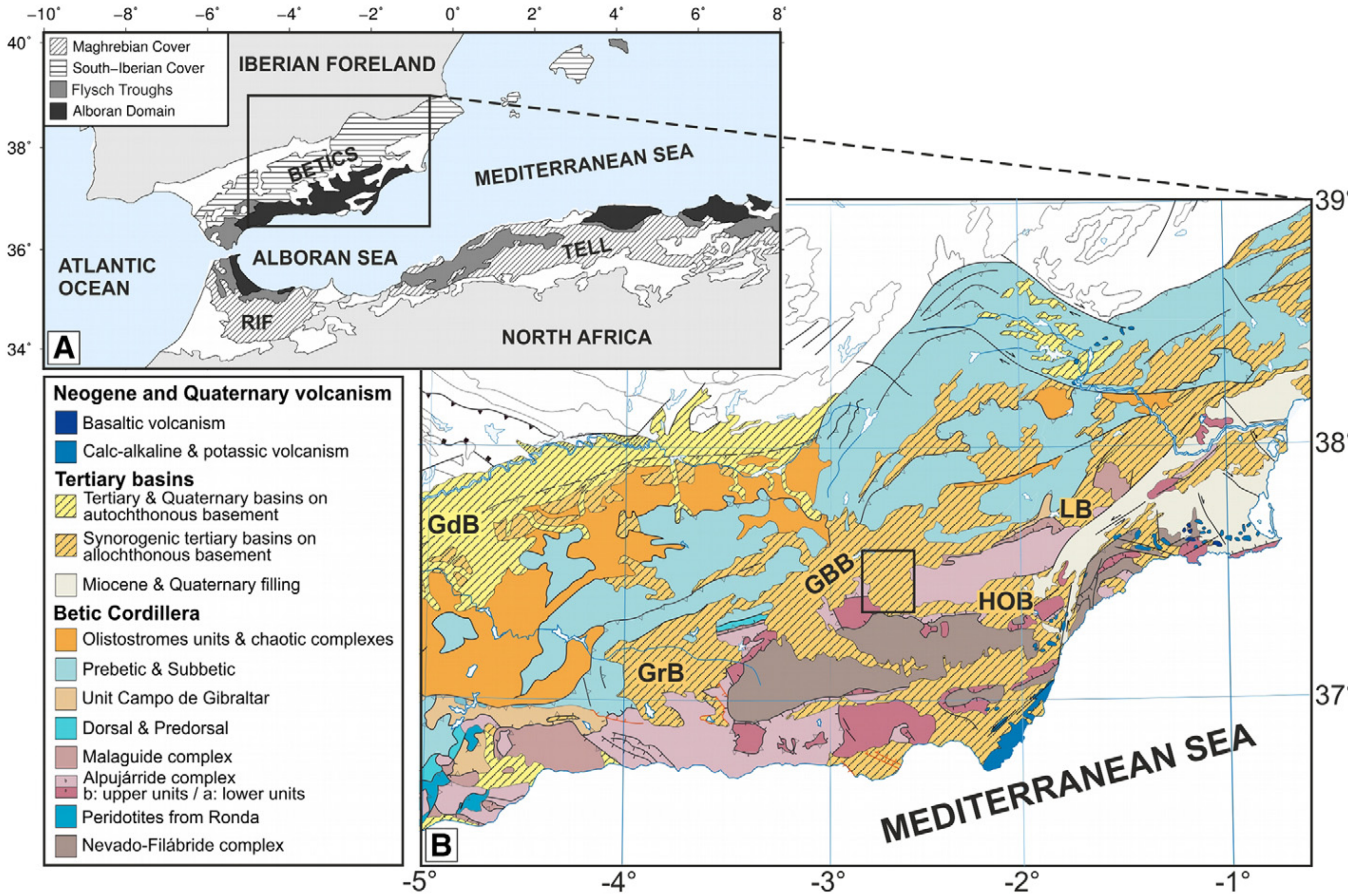

Fig. 1. A: Geological setting of the western Mediterranean region (after Comas et al., 1999). B: Geological map of the central Bétics based on the Tectonic Map of Spain 1:200.000 (Rodríguez-Fernandez et al., 2004) including major Neogene basins (GdB: Guadalquivir basin; GrB: Granada basin; GBB: Guadix-Baza basin; HOB: Huercal-Overa basin; LB: Lorca basin). The study area is indicated by a rectangle, representing the Baza sub-basin of the Guadix-Baza basin. See text for details.

Fig. 2). The extensive subsurface deposits in the Baza Basin have the potential to expand the paleoclimate information into the Pliocene and latest Miocene.

Here, we present the results of a seismic reflection survey in the central part of the Baza Basin. Our focus is: i) reveal the structural elements of the Basin and associated faults, especially the western boundary fault system (Baza Fault Zone, BFZ); and ii) provide stratigraphic information of the imaged sedimentary infill integrating evidence from outcropping Baza Basin units as well as from contemporaneous borehole lithologies described in the nearby Granada and Lorca Basins.

The study area is located in the Baza sub-Basin (in the following termed Baza Basin), between the towns of Baza, Caniles and Cúllar (Fig. 2). Geographically, the Sierra de Baza (SW), Jabalcón Mountain (W), and the Sierra de las Estancias (NE) bound the lacustrine part of the Baza Basin. Geologically, the studied area covers the depo-center and southern margin of the Baza Basin (see Alfaro et al., 2008).

2. Geological setting

The origin of the Bétic Cordillera in the Western Mediterranean is related to the Neogene NW–SE oblique convergence of the Eurasian and African plate boundaries. The Bétic Cordillera together with the North African Rif forms an arc-shaped mountain belt around the Alboran Sea (Vissers et al., 1995; Platt et al., 2013). This arc constitutes the youngest portion of the western Alpine orogenic system (Fig. 1). Two major geological domains can be differentiated in this orogen, the Internal and External Zones. The Internal Zone is located on the inner side of the arc, adjacent to the Alboran Sea, mostly consisting of metamorphic rocks. The External Zone is located on the outer side of the arc essentially comprising sediments deposited on the former passive margins of Africa and Iberia. The contact between the External and Internal Zones developed during the Miocene (Burdigalian; ~19 Ma), initiating the structural features of the Bétic Cordillera (Sanz de Galdeano, 1990). Between 19 and 11 Ma, the cordillera was in the phase of structuration and construction while most of the marine sedimentation occurred in platform and pelagic environments.

During the Serravallian (~14–11 Ma) the Baza region was part of the northern Bétic seaway, where extensive calcarenite deposits occurred. During the early Tortonian (~11 to 9 Ma) the present geodynamic compressive direction (NNW–SSE) was established. Since the late Tortonian (~9 to 7 Ma), this general compression was accompanied by an isostatic readjustment and general uplift of the cordillera with an associated perpendicular extension in the upper part of the crust. This process was responsible for the formation of a mosaic of interconnected corridors and basins separated by an archipelago of islands in the recently formed and progressively emerged Bétic cordillera (Ott d'Estevou and Montenat, 1985; Platt and Vissers, 1989; Sanz de Galdeano, 1990; Sanz de Galdeano and Vera, 1992). During the Late Tortonian, the basins located in the inner part of the cordillera were filled with marine sediments of the Bétic seaway. Then, progressive uplift caused the disconnection of the basins, and their isolation from the ocean until a general basin continentalization occurred (Corbí et al., 2012). Significant evaporitic sedimentation, up to 500 m, occurred during this marine to continental transition in the Granada and Lorca Basins (García-Veigas et al., 2013, 2015). The Baza Basin, located between these two basins, appears to share a similar history (Fig. 1).

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