THE ALBORAN SEA BASIN: NEW INSIGHTS FROM ODP DRILLING AND GEOPHYSICAL DATA

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Abstract

Geophysical data combined with the study of basement rocks and sedimentary cover drilled in the Alboran Sea basin at Ocean Drilling Program Leg 161 sites provide constrains on extensional and contractional tectonics during basin evolution. Site 976 confirms the presence of continental crust and the NS continuity of the stretched Alboran Domain of the Betic-Rif orogen beneath the Alboran Sea basin. Main results are consistent with an early-to-middle Miocene rapid exhumation and associate heating of the basement by late tectonic extension and lithosphere stretching; thus constraining geodynamic genetic models to favor lithospheric delamination.

Key-words : Alboran Sea, Tectonics, Basin Formation

Introduction

The continental crust deformation and lithospheric behavior in extensional basins developed in collisional settings is a long-standing problem in Mediterranean tectonics. The Alboran Basin has been attributed to crustal thinning processes developed from early Miocene onwards within the Eurasia-African plate convergence setting, and the Alboran Sea (Fig. 1) is an ideal target in the Mediterranean to study these extensional processes. A prime objective for Ocean Drilling Program Leg 161- The Western Mediterranean was to sample de crust beneath the Alboran Sea basin (Fig. 1), particularly in regard to: a) the origin of extensional basins developed on former collisional orogens, b) the dynamics of the extension on collisional ridges resulting in basins surrounded by arc-shaped orogenic belts, and d) actual or sub-actual contractional processes (1). Leg 161 was successful in achieving this aims and the Alboran Sea drilling results have immediate applications in establishing geodynamic models on the origin and evolution of Mediterranean-type backarc basins.

Fig. 1.- Bathymetric map of the Alboran Sea showing ODP Leg 161 Sites, DSDP Site 121, and commercial boreholes (Alb-A1, And-A1, G1 and EJ). Insert map: location of the Alboran Sea between the Betic and Rif Cordilleras. ACH= Alboran Channel. AI= Alboran Island. AR= Alboran Ridge. CHB= Chella Bank. DB= Djibouti Bank, and XB= Xauen Bank. Contour lines every 200 m.

Geological and geophysical constraints

The Alboran Sea basin lies behind an arc-shaped orogenic belt formed by the Betic (Southern Spain) and Rif (Morocco) Chains. The roughly N-S Neogene convergence between the Eurasian and African plates at the westernmost Mediterranean has resulted in a region of distributed deformation which encompass the Betic, Rif, and Tell Cordilleras, linked across the Gibraltar Arc, and the basins beneath the Alboran and South Balearic Seas. (Fig. 1, inset map).

Geophysical data indicate the continental crust thins from 38 km in the Betic Chain to about 15-20 km beneath the central Alboran Sea (2, and references therein). Heat flow data suggest an eastward decrease in lithospheric thickness from 60-90 km in the West Alboran Basin to about 35-40 km and concurrent crustal thinning from 14-16 km to 10-12 km in the transition from the East Alboran Basin to the South Balearic Sea (3). There is no witness for the existence of Cenozoic oceanic lithosphere at the Betic-Rif-Alboran region. Multichannel deep seismic data, however, suggest the presence of oceanic crust east of 1° W meridian in the South Balearic basin (4).

A more than 6 km-thick lower Miocene (Burdigalian) to Pleistocene sedimentary sequence occurs in the West Alboran Basin; however, in the central Alboran Sea, and South and East Alboran basins the sedimentary cover is thinner (less than 3.5 km). No direct sample information exists about specific ages of pre-Messinian sediments in the East and South Alboran basins. Several intra-mountain depressions (Fig. 2) and corridors within the Betic and Rif Chains (currently known as Betic or Rifean "Neogene Basins") contain Miocene marine sediments similar to those that fill the Alboran Sea basin, which indicates that during the Miocene the Alboran Basin spread out N-S beyond the present limits of the Mediterranean Sea.

The basement of the Alboran Basin, cropping-out inland, is formed primarily of metamorphic complexes belonging to the Alboran Crustal Domain (the internal complexes of both the Betic and Rif Chains) composed of a syn- and post-metamorphic pre-Miocene polyphase thrust-stack that includes three nappe complexes: the Nevado-Filabride, Alpujarride, and Malaguide (Fig. 2).

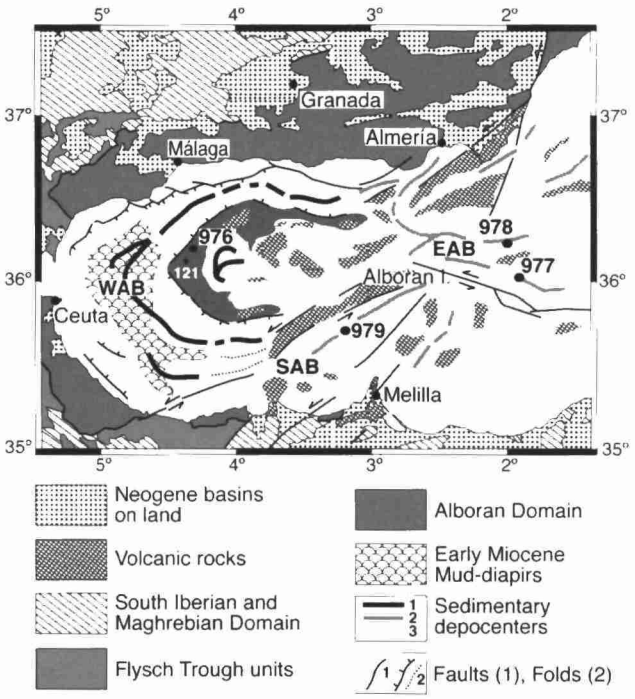

Fig. 2.-. Geologic map of the Alboran Sea basin showing the location of main sedimentary depocenters, DSDP site 121, and ODP Leg 161 Sites. Neogene Betic Basins onshore Iberia and Africa are indicated. Sedimentary depocenters in the Alboran Sea: 1= Depocenters consisting of lower Miocene to Pleistocene deposits; 2= Depocenters consisting mainly of middle Miocene to Pleistocene deposits; 3= Depocenters consisting of Messinian/Pliocene to Pleistocene deposits. EAB= Eastern Alboran Basin, SAB= Southern Alboran Basin, WAB= Western Alboran Basin.

The Alboran Basin was structured by superimposed extensional and contractional tectonics. In the outcropping Alboran Domain, large-scale extensional detachments are superimposed on the continental collisional structures. Rifting and progressive exhumation of the Alboran Domain took place from at least the early Miocene to the early Tortonian, while thrusting in the peripheral arc which surrounds the basin occurred (5, 6, and references therein). A prominent middle to early-late Miocene rifting (from about 16 Ma to 11-10 Ma) is identified in the seismic record of the West Alboran Basin (4, 7, 8). Patterns of middle Miocene extension, as well as areal distribution of metamorphic basement units and sedimentary sequences are consistent with a WSW directed extensional detachment system to produce crustal thinning. According offshore and onshore data the West Alboran Basin is located on the hanging wall of a major crustal detachment. Generalized early Miocene and late-Serravallian-to- early Tortonian magmatism, as well as notable mud diapirism in the West Alboran Basin, have likely resulted from these extensional processes (Fig. 2). This rifting, which is connected to large-scale extension detach-