Contrasted evolution of the western and eastern Mediterranean since Neogene Time

Evolución contrastada de los sectores occidental y oriental del Mediterráneo desde tiempos Neógenos

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RESUMEN

La evolución del Mediterráneo después del climax del orógeno Alpino, se suele explicar por medio de zonas de subducción resultado de la convergencia entre Africa y Eurasia. Sin embargo, los sectores occidental y oriental del Mediterráneo presentan características contrastadas. Mientras en el este subsisten zonas de subducción y una corteza oceánica relicta, en el oeste predomina una tectónica de «detachments» extensionales con generación local de corteza oceánica.

Palabras clave: *Mediterráneo occidental y oriental, subducción, extensión.*

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Introduction

The western Mediterranean comprises five basins generated since Miocene time either with attenuated continental crust (Valencia and Alboran basins) (Torne & Banda, 1988; Doblas & Oyarzun, 1989 a) or oceanic crust (Algerian, Provenzal, and Tyrrhenian basins) (Gealey, 1988). Geophysical data indicate crustal thinning, seismic velocities of anomalous-type mantle, magnetic anomalies, and high heat-flows (Lort, 1977; Moullade, 1977; Torne & Banda, 1988). The eastern Mediterranean is constituted by a relic Mesozoic Tethys oceanic crust (Ionian/Levantine basin), limited to the north by the Calabrian/Sicilian, Hellenide, and Tauride Arc. The younger Aegean basin (Late Miocene) is floored by a stretched continental crust (Angelier *et al.*, 1982; Lister *et al.*, 1984) with high heat-flows and gravity highs. While subduction is well defined in the eastern Mediterranean, the absence of oceanic trenches, ophiolites, or metamorphic zoning since the Miocene poses problems to subductions in the west. Some phenomena such as (1) zoned volcanic belts in SE Spain and northern Africa (Araña & Vegas, 1974; Bellon & Brousse, 1977), (2) asymmetric rifting and off-ridge volcanism (Burrus, 1984), and (3) gravity highs and anomalous-type mantle (Lort, 1977; Moullade, 1977; Torne & Banda, 1988), might be ascribed to extensional detachment tectonics.

The Neogene to present evolution of the Mediterranean

The Oligocene/Miocene building of the Alpine orogen led to a change in the pole of rotation of Africa with respect to Eurasia, and to two contrasted scenarios in the Mediterranean: a western resistant zone resulting from the collision between Europe and Africa (Gealey, 1988), while to the east relic oceanic crust (Tethys, and Paratethys) defined a weak area allowing further convergence/subduction (fig. 1A).

A first stage in the evolution of the Mediterranean covers the whole Miocene (fig. 1 B-D). In the western Mediterranean five basins are created (Burrus, 1984; Lavecchia, 1988; Kastens *et al.*, 1988; Doblas & Oyarzun, 1989 a). The Provenzal, Valencia, and Algerian basins developed mainly during the Early Miocene (Burrus, 1984; Gealey, 1988). The Provenzal basin opened by the counterclockwise rotation of Sardinia-Corsica (Burrus, 1984), while a limited clockwise rotation of the Baleares generated the Valencia basin (Dañobeitia *et al.*, 1990; fig. 1 B). Geophysical data from the Valencia basin (Torne & Banda, 1988; Dañobeitia *et al.*, 1990) reveal crustal thinning toward its axis, a gravity high, and a lensoid-shaped crust/mantle transitional layer. This has been interpreted by Doblas & Oyarzun (1990) as resulting from mantle upwelling and extensional detachment tectonics. Classical rifting models do not account for some features of the Algerian, Provenzal, and Valencia areas, such as: (1) contrasted asymmetric senses of rotation of the Baleares and Sardinia-Corsica, and (2) off-ridge volcanism and asymmetric magnetic anomalies (Burrus, 1984). Some evidences support an extensional detachment setting for this part of the Mediterranean: (1) listric seismic reflectors, (2) tilted blocks, (3) synrift sedimentary deposits in the Gulf of Lion (Burrus, 1984), and (4) a diapir-shaped ultra-low velocity channel between northeast Spain and Sardinia (Berry & Knoppof, 1967). Therefore, while the rifting of the Valencia basin was aborted, in the Provenzal and Algerian basins new oceanic crust was generated. Both the Alpine Betic cordilleras, and the Alboran realm were subject during most of the Neogene to extensional conditions (Balanya & García Dueñas, 1986; García Dueñas *et al.*, 1986). Doblas & Oyarzun (1989a) have proposed that the Alboran basin developed from Middle to Late Miocene along two major breakaway faults (fig. 1C), ultimately leading to the unroofing of metamorphic and mantle core complexes, and to emplacement of volcanics. These processes might be associated either to the gravitational collapse of the overthickened Alpine orogen (Doblas & Oyarzun, 1989a; Platt & Vissers, 1989), or to the westward translation of the Alboran block (Vegas, 1988; Vegas, in press). A maximum extension in the westernmost Mediterranean could be responsible for the formation of the Gibraltar Arc, the closure of the Mediterranean

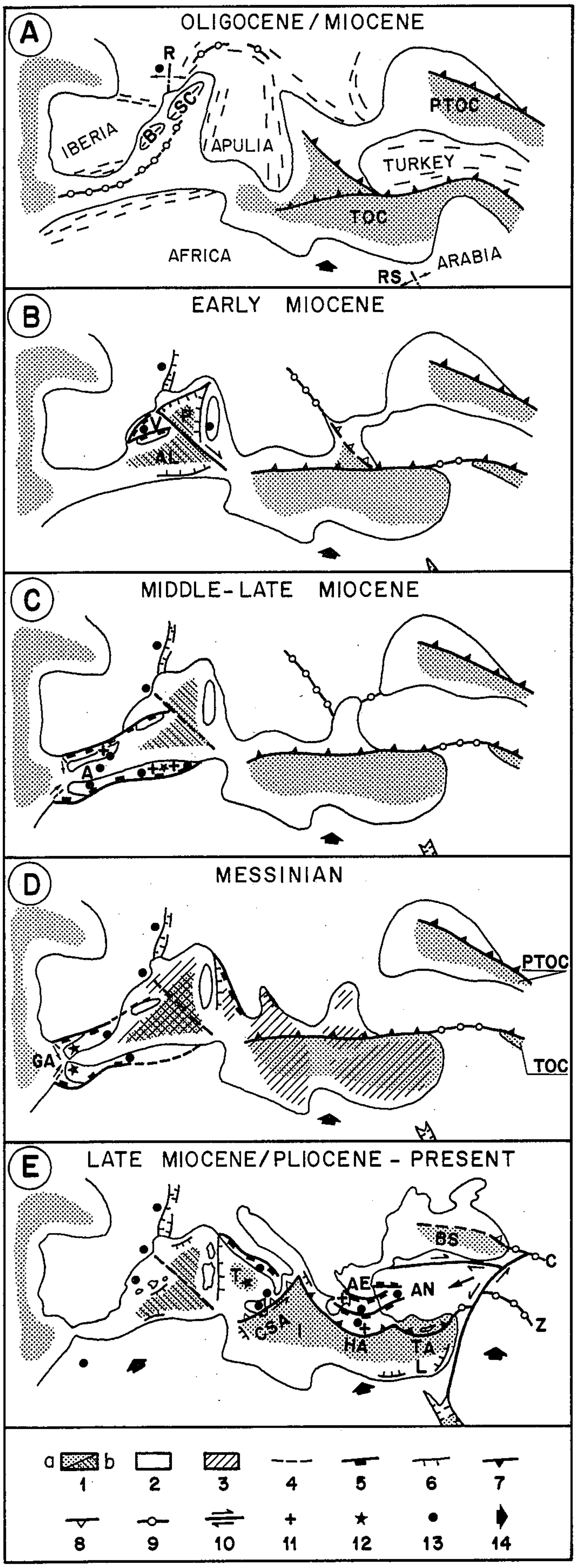

Fig. 1.—Proposed evolution of the Mediterranean since Neogene time. 1: Oceanic crust (a, relic; b, new); 2: Continental crust; 3: Messinian evaporites; 4: Alpine foldbelt trends; 5: Major extensional breakaway faults; 6: Normal faults; 7: Active subduction zones; 8: Subordinate subduction zones; 9: Collisional suture zones; 10: Wrench faults; 11: Metamorphic core complexes; 12: Mantle core complexes; 13: Volcanics; 14: Relative movements of Africa with respect to Eurasia. A: Alboran basin: AE: Aegean basin; AL: Algerian basin; AN: Anatolia; B: Balearic rise; BS: Black Sea; C: Caucasus; CSA: Calabrian/Sicilian Arc; GA: Gibraltar Arc; HA: Hellenide Arc; I: Ionian Sea; L: Levantine Sea; P: Provenzal basin; PTOC: Paratethys oceanic crust; R: Rhone trough; RS: Red Sea; SC: Sardinia/Corsica; T: Tyrrhenian basin; TA: Tauride Arc; TOC: Tethys oceanic crust; V: Valencia basin; Z: Zagros.

Fig. 1.—Evolución propuesta para el Mediterráneo desde el Neógeno. 1: Corteza oceánica (a, relicta; b, nueva); 2: Corteza continental; 3: Evaporitas Messinienses; 4: Directrices de las cadenas Alpinas; 5: «Breakaway» de los «detachments» extensionales; 6: Fallas normales; 7: Zonas de subducción activas; 8: Zonas de subducción secundarias; 9: Zonas de sutura colisionales; 10: Fallas transcurrentes; 11: «Metamorphic core complexes»; 12: «Mantle core complexes»; 13: Rocas volcánicas; 14: Movimientos relativos de Africa con respecto a Eurasia. A: Cuenca de Alborán; AE: Cuenca del Egeo; AL: Cuenca de Argelia; AN: Anatolia; B: Baleares; BS: Mar Negro; C: Cáucaso; CSA: Arco de Calabria/Sicilia; GA: Arco de Gibraltar; HA: Arco Helénico; I: Mar Iónico; L: Mar de Levante; P: Cuenca Provenzal; PTOC: Corteza oceánica del Paratethys; R: Fosa del Ródano; RS: Mar Rojo; SC: Cerdeña/Córcega; T: Cuenca Tirrénica; TA: Arco Taúrico; TOC: Corteza oceánica del Tethys; V: Cuenca de Valencia; Z: Zagros.

and the Messinian salinity crisis (fig. 1D; Doblas & Oyarzun, 1989 a). Meanwhile, in the eastern Mediterranean, a remnant Tethys oceanic crust was being subducted under the European plate (Dewey *et al.*, 1973).

A second stage in the evolution of the Mediterranean occurs from Late Miocene/Pliocene to present (fig. 1 E). The turning point results from the consumption of the Paratethys and eastern Tethys oceanic crusts along the Caucasus and Zagros lines (Dewey *et al.*, 1973; Gealey 1988), thus defining a resistant zone in the east (and changing the pole of rotation of Africa with respect to Eurasia). The westernmost realm was disrupted by transcurrent tectonics (Doblas & Oyarzun, 1989a), and the Tyrrhenian basin opened by counterclockwise rotation. While the Calabrian/Sicilian Arc acted mostly as a transcurrent discontinuity, Italy drifted apart through west-dipping detachments (Lavecchia, 1988), leading to denudation of oceanic crust and peridotites in the Tyrrhenian (Kastens *et al.*, 1988). Meanwhile, the eastern Mediterranean underwent a slower subduction rate, which resulted in a roll-back/sinking of the subducted slab allowing the opening of the Aegean back-arc basin, and the extensional disruption of western Turkey (Angelier *et al.*, 1982; Lister *et al.*, 1984). This extension has been interpreted in terms of low-angle detachments, ultimately leading to the unroofing of metamorphic core complexes and emplacement of volcanics (Lister *et al.*, 1984).

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La ventana tectónica de Morcín (Unidad estructural del Aramo, zona cantábrica, Asturias)

The Morcin tectonic window (Aramo structural Unit. Cantabrian Zone, Asturias)

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ABSTRACT

The existence of a tectonic window in the northern area of the Aramo-Morcin anticlinorium is demonstrated. The thrust sheet is formed of an early Devonian detritical and calcareous succesion called the Raneces Group, whereas the autochton is made up by a Carboniferous sucession of shales and sandstones belonging to the Riosa Unit (upper Westphalian). The occurrence of such a window can be interpreted as the result of superposed folding related to front and lateral ramps and allows the interpretation for this area of a shallower basal thrust plane than the one previously proposed.

Key words: *Tectonic window. Thrusts. Superposed folding. Ramps. Cantabrian Zone*

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Introducción

La zona objeto de estudio forma parte de la Unidad del Aramo (fig. 1A), estructura alóctona compleja constituida por materiales del Devónico y Carbonífero fuertemente plegados siguiendo la directriz del Arco o Rodilla Astur. Esta unidad cabalga sobre la Cuenca Carbonífera Central de Asturias, que la limita hacia el E. Tanto la estructura interna como el frente de cabalgamiento presentan un fuerte arqueamiento, con inflexiones muy marcadas, consecuencia de un plegamiento transversal de gran radio de curvatura.

La transmisión oral, así como algunos informes mineros antiguos, ya sugerían la posible existencia de carbón en la región comprendida entre Riosa y Trubia, es decir, fuera de la propia Cuenca Carbonífera Central. En base a estos hechos se procedió a un reconocimiento detallado de la zona, centrándose la investigación en la zona que parecía reunir las condiciones idó-