ELSEVIER

Marine Geology 243 (2007) 97–119

MARINE GEOLOGY
INTERNATIONAL JOURNAL OF MARINE GEOLOGY, GEOCHEMISTRY AND GEOPHYSICS

www.elsevier.com/locate/margeo

The structure of the Atlantic–Mediterranean transition zone from the Alboran Sea to the Horseshoe Abyssal Plain (Iberia–Africa plate boundary)

L. Iribarren [a], J. Vergés [a,*], F. Camurri [b], J. Fullea [a], M. Fernàndez [a]

[a] *Group of Dynamics of the Lithosphere (GDL), Institute of Earth Sciences "Jaume Almera", CSIC, Lluís Solé i Sabarís s/n, 08028 Barcelona, Spain*

[b] *Dipartimento Scienze della Terra, Universita' di Parma, Parco Area delle Scienze, 157/A, 43100 Parma, Italy*

Received 10 November 2006; received in revised form 16 May 2007; accepted 25 May 2007

Abstract

The diffusive plate boundary between Iberia and Africa has been analyzed by means of already published and new 28 multichannel seismic profiles covering most of the Atlantic margins of SW Spain and NW Morocco. This region includes the prolongation of the Betic–Rifean tectonic units along the Gibraltar Arc. One of the most characteristic units in the study area is the Miocene seismically chaotic unit that has been divided in a tectonic and a gravitational domains in accordance to previous interpretation by Torelli et al. [Torelli, L., Sartori, R., Zitellini, N., 1997. The giant chaotic body in the Atlantic Ocean off Gibraltar: new results from a deep seismic reflection survey. Marine and Petroleum Geology 14, 125–138.]. In this work we redefine the limits of both domains and rename them as the Gulf of Cadiz Imbricate Wedge and the Horseshoe Gravitational Unit. We interpret the Gulf of Cadiz Imbricate Wedge as a west-migrating thick thrust system that build up in a relatively short period of time. This unit constitutes the continuation of the Miocene chaotic units observed onshore to the front of the External Units in the Betics and the Rif (the Guadalquivir Allochthonous Unit and the Rides Prerifaines). The Horseshoe Gravitational Unit, covering an approximate area of 18 000 km^2 with a volume of around 23 000 km^3, is interpreted as giant submarine debris flows sourced from the up-building of the Gulf of Cadiz Imbricate Wedge, surrounding basement highs and the continental Iberian Slope. The fast westward migration of the Flysch units, the External Units and the Gulf of Cadiz Imbricate Wedge, from the Early Miocene to the Late Tortonian corresponds to a different tectonic process than the protracted but slow NNW to NW convergence of Africa. Our interpretation favours the westward slab retreat theory to form the arcuate shape of the Atlantic side of the Iberia–Africa plate boundary. The subduction mechanism as well as potential roll-over was only active from late Early Miocene to Late Miocene spanning about 12 Myr.

Keywords: Gulf of Cadiz; Gibraltar Arc; Betics; Rif; accretionary wedge; olistostromes

1. Introduction

The boundary between Iberian and African plates, in the Atlantic–Mediterranean transition zone, corresponds to a wide deformation band that encompasses the Atlantic margins of SW Iberia and NW Africa from

* Corresponding author. Tel.: +34 93 409 54 10x241; fax: +34 93 411 00 12.

E-mail addresses: liribarren@ija.csic.es (L. Iribarren), jverges@ija.csic.es (J. Vergés), jfullea@ija.csic.es (J. Fullea), mfernandez@ija.csic.es (M. Fernàndez).

0025-3227/$ - see front matter
doi:10.1016/j.margeo.2007.05.011

the Gorringe Bank to the Gulf of Cadiz, the Betic Cordillera and the Rif mountains and the Alboran Sea (Fig. 1). The present structure as well as the Neogene evolution of this segment of the plate boundary is still a matter of debate as a consequence of the complexity of the Late Cenozoic geodynamic processes (e.g., Calvert et al., 2000; Jiménez-Munt et al., 2001).

The Betic and the Rif thrust belts consist of metamorphic rocks of the Internal Zones, passive margin cover of the External Zones and Flysch Units, and both the foreland and the intramontane Neogene basins (Fig. 1). The Internal Zones, which are part of the Alboran Crustal Domain, are made of Late Paleozoic to Triassic rocks that were piled up during Tertiary compression, followed by a pervasive extensional event that started in the Early Miocene (e.g., García-Dueñas et al., 1992; Crespo-Blanc et al., 1994). The External zones of the Betic and Rif thrust belts correspond to the cover sequences of the south-west Iberian and north-west Maghrebian paleomargins that were deformed above a highly arcuate thrust system (e.g., Crespo-Blanc and Campos, 2001; Platt et al., 2003a). The Flysch Units comprise deep marine turbidites that were transported towards the west above an arcuate imbricate system of thrusts along the Gibraltar Arc (e.g., Mauffret et al., 1992; Crespo-Blanc and Campos, 2001; Michard et al., 2002). These imbricate thrust belts (the External Zones and the Flysch Units) prolong offshore to the west, on top of the previously rifted Mesozoic passive margins of Iberia and Africa. The direction of the structure of the External Zones swings from the Betic Cordillera to the Rif thrust belt through the Gibraltar Strait, giving an arcuate shape that have led different authors to refer this area as the Gibraltar Arc.

A large number of well constrained datasets provide, however, contrasting interpretations for the Neogene evolution of this region (Andrieux et al., 1971; Leblanc and Olivier, 1984; Sanz de Galdeano, 1990). Most of them try to explain the arcuate geometry of the Betic–Rif system by convective removal and orogenic collapse (e.g., Dewey, 1988; Platt and Vissers, 1989; Vissers et al., 1995; Platt et al., 2003b) and mantle delamination (e.g., García-Dueñas et al., 1992; Docherty and Banda, 1995; Seber et al., 1996; Mezcua and Rueda, 1997; Calvert et al., 2000). Another group of authors interpret the region using Miocene slab rollback (e.g., Frizon de

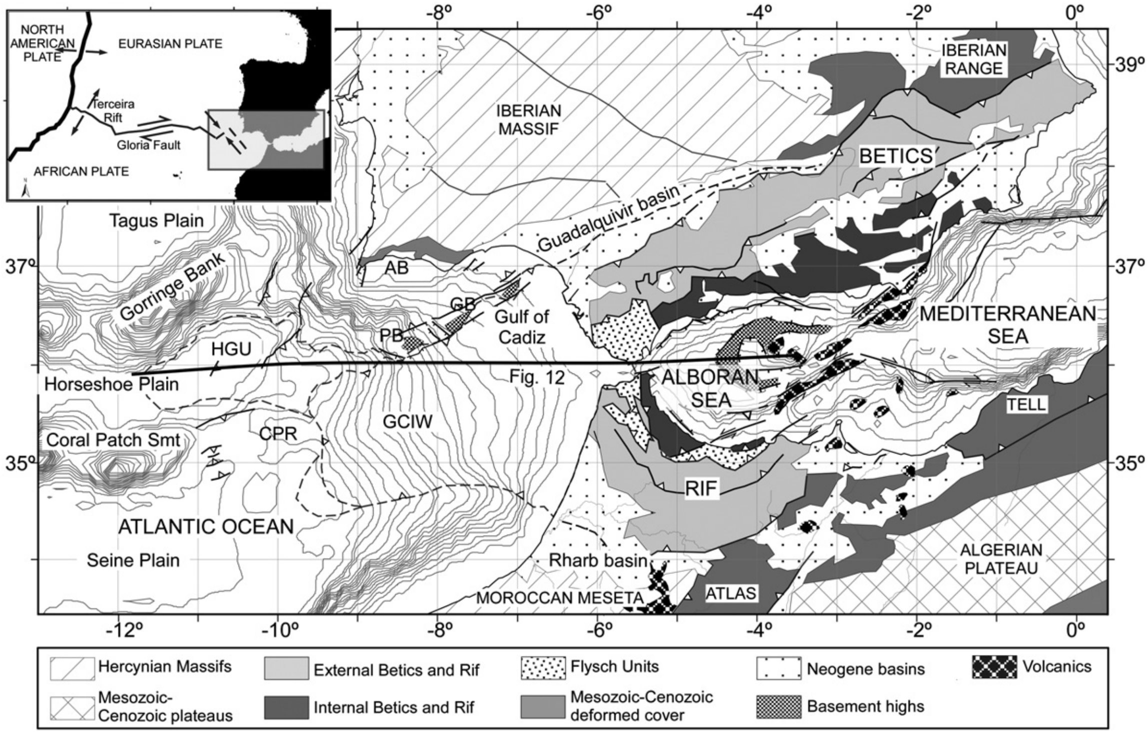

Fig. 1. Main elements of plate boundaries, relative plate kinematics, position of the Gloria fault and situation of the study area. Geologic map of the study area modified after Rodríguez Fernández (2004) for the Iberian Peninsula, after Saadi et al. (1985) for the NW Morocco, and after Comas et al. (1999) for the Alboran Sea. We also used Rovere (2002), Gràcia et al. (2003a) and Gràcia et al. (2003b) for the Atlantic margin. AB: Algarve basin, PB: Portimao Bank, GB: Guadalquivir Bank, CPR: Coral Patch Ridge, GCIW: Gulf of Cadiz Imbricate Wedge, HGU: Horseshoe Gravitational Unit.