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Research paper

Upper crustal structure beneath Southwest Iberia north of the convergent boundary between the Eurasian and African plates

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A R T I C L E I N F O

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A B S T R A C T

The 3-D *P*- and *S*-wave velocity models of the upper crust beneath Southwest Iberia are determined by inverting arrival time data from local earthquakes using a seismic tomography method. We used a total of 3085 *P*- and 2780 *S*-wave high quality arrival times from 886 local earthquakes recorded by a permanent seismic network, which is operated by the Institute of Meteorology (IM), Lisbon, Portugal. The computed *P*- and *S*-wave velocities are used to determine the 3-D distributions of V_p/V_s ratio. The 3-D velocity and V_p/V_s ratio images display clear lateral heterogeneities in the study area. Significant velocity variations up to ±6% are revealed in the upper crust beneath Southwest Iberia. At 4 km depth, both *P*- and *S*-wave velocity take average to high values relative to the initial velocity model, while at 12 km, low *P*-wave velocities are clearly visible along the coast and in the southern parts. High *S*-wave velocities at 12 km depth are imaged in the central parts, and average values along the coast; although some scattered patches of low and high *S*-wave velocities are also revealed. The V_p/V_s ratio is generally high at depths of 4 and 12 km along the coastal parts with some regions of high V_p/V_s ratio in the north at 4 km depth, and low V_p/V_s ratio in the central southern parts at a depth of 12 km. The imaged low velocity and high V_p/V_s ratios are related to the thick saturated and unconsolidated sediments covering the region; whereas the high velocity regions are generally associated with the Mesozoic basement rocks.

1. Introduction

The western Mediterranean region including Iberia and northwest Africa, displays a variety of seismotectonic activities due to the interaction between the African and Eurasian plates (e.g., Serrano et al., 2002; Serpelloni et al., 2007). Active deformation in the Africa–Eurasia plate boundary zone is generally interpreted as the result of the oblique convergence between the African and Eurasian plates, ranging from ~10 mm/yr at the longitude of Turkey to ~4 mm/yr in the Gibraltar Strait according to the NUVEL1A global plate kinematic model (De Mets et al., 1990, 1994). In contrast with the eastern part of the Africa–Eurasia plate boundary zone in Greece and Turkey, with large velocities and strain rates, little is known yet regarding the kinematics of crustal deformation in the western Mediterranean (Nocquet and Calais, 2004). From 14°W to the Gibraltar Strait, the plate boundary is, in general, not well defined and the Africa/Europe convergence is accommodated through a widespread tectonically active deformation zone (e.g. Sartori et al., 1994), where a significant and diffuse seismic activity has long been recognized (Fukao, 1973; Udías et al., 1976; Grimison and Chen, 1986; Buforn et al., 1988, 1995).

Southwest (SW) Iberia is located in the western Mediterranean just to the north of the continental convergence plate boundary between the Eurasian and African plates (Kiratzi and Papazachos, 1995). The Cenozoic evolution of SW Iberia was strongly controlled by the Alpine tectonic phases that affected much of southern Europe (Maldonado et al., 1999). Distinct periods of crustal deformation, fault reactivation, and halokinesis related to multiple episodes of collision between Iberia, Eurasia and Africa (Malod and Mauffret, 1990; Srivastava et al., 1990) are known to have controlled the tectono-stratigraphic evolution of parts of the Iberian Peninsula since the early Cretaceous, including its Atlantic margin (Murillas et al., 1990; Pinheiro et al., 1996; Wilson et al., 1996; Borges et al., 2001; Alves et al., 2003). The initial phase of post-Hercynian breakup during the late Permian to middle Jurassic

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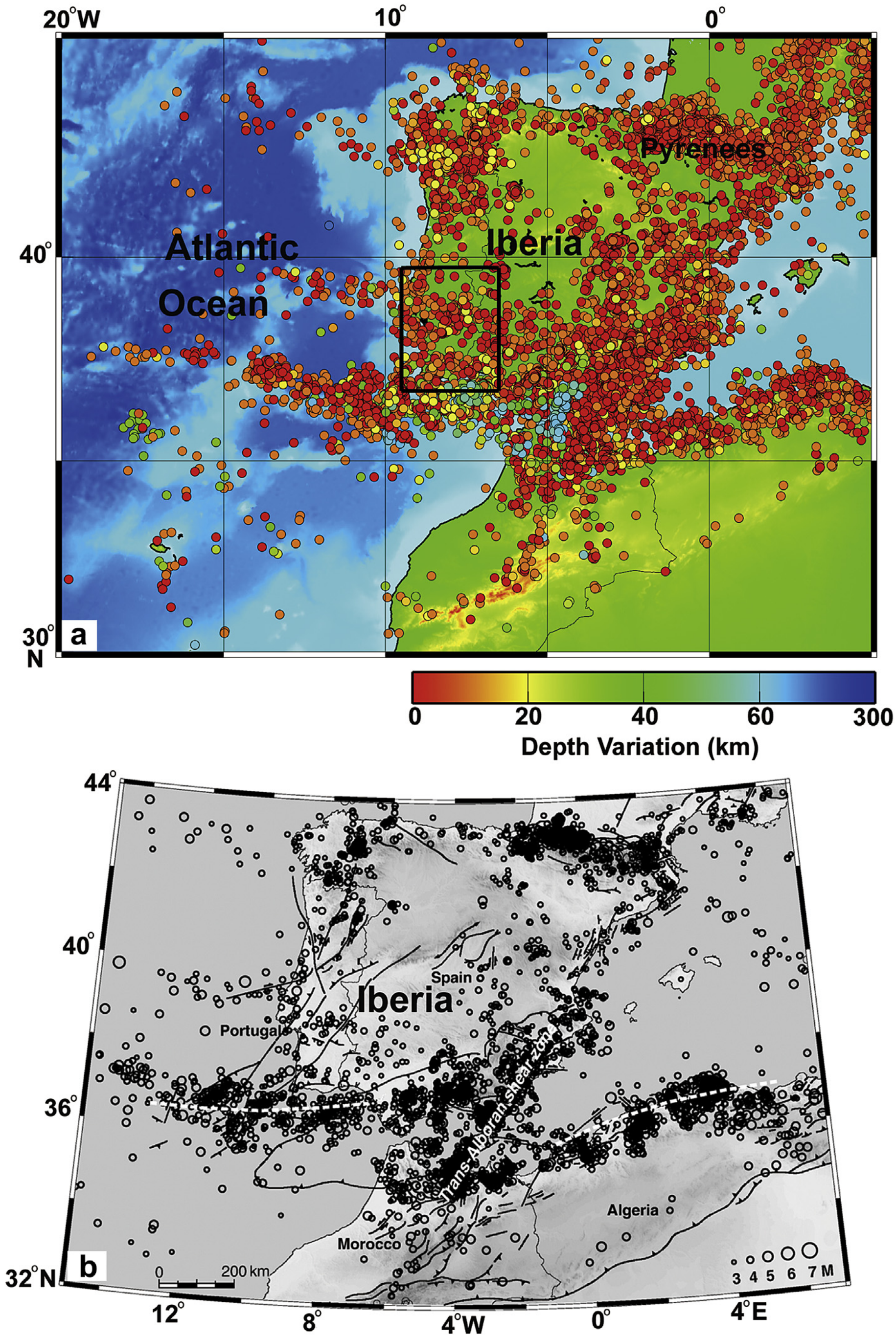

Figure 1. (a) Epicentral distribution of NEIC (US Geological Survey: http://neic.usgs.gov) seismicity in the western Mediterranean region. (b) Seismicity of the Ibero–Maghrebian region projected on the map of active and potentially active faults (after Stich et al., 2006). Epicenters of earthquake with local magnitude ≥3 (scale on lower right) are taken from the NEIC catalog. Neotectonic faults (gray) are redrawn from the Geodynamic map of the Mediterranean compiled in the frame of the Commission for the Geological Map of the World (http://ccgm.free.fr). Intense seismicity is highlighted by dashed white lines. Relevant seismicity is also observed in the Pyrenees and in several intraplate areas on and around the Iberian Peninsula.

produced regional tensional stresses (Dañobeitia et al., 1999). These stresses affected wide areas around the future plate boundaries, as is reflected by Triassic to middle Jurassic rift systems (Ziegler, 1989). This crustal extension produced the South Iberian and Northwest African Triassic horst and graben systems (Manspeizer et al., 1978). Subsidence of these grabens was accompanied by widespread late Triassic and early Jurassic basaltic volcanism. Later, the dominant regional extensional structures of the area were established during the late Jurassic–early Cretaceous. A large area of the central and western Iberian Peninsula is covered by the Variscan Iberian Massif, a large, old and geologically stable block of continental lithosphere (Dallmeyer and Martínez García, 1990).

The SW Iberian margin and the Africa–Eurasian convergence zone form an area of moderate to high seismicity, with sometimes earthquakes of $M \geq 5.0$, and are considered as being under the potential threat of natural hazards linked to seismicity and tsunami generation (e.g., Zitellini et al., 2004; Reicherter and Hübscher, 2007). Earthquakes (Fig. 1a,b) are concentrated along regional-scale WSW–ENE lineaments in northern Algeria and easternmost Atlantic Ocean, presumably marking two segments of the