Seismic tomography and geophysical evidence for a continental subduction below the Betic Cordilleras and Alboran Sea, Spain.

Inmaculada Serrano[1], Dapeng Zhao[2]

[1] Earth Sci., Ehime Univ, Granada Univ, Spain, [2] Earth Sci.,Ehime Univ

P- and S-wave seismic tomography detects a low-velocity anomaly in the upper mantle beneath the Betic Cordillera (Spain) and the Alborán Sea (western Mediterranean Sea) region; the anomaly is associated with the intermediate-depth seismicity in the region. This structure is interpreted as a result of an active continental subduction. Gravity modeling and seismic attenuation also show the continental nature of the low-velocity zone. Stress field determined from the focal mechanisms of the intermediate-depth earthquakes also agrees with the scenario of continental subduction, which is caused by the middle-late Miocene to present-day northwest-southeast convergence of the African and European plates and the continental collision that raised the cordillera.

The Betic (Southern Spain) and Rif (Northern Morocco) Cordilleras and Alboran Sea (the western Mediterranean Sea) were formed by lithospheric collision as a consequence of the convergence between the Eurasian and African plates. This convergence, started in the late Mesozoic, proceeded essentially during the Cenozoic, and has continued from the late Miocene to the present with a northwest-southeast trend and a rate of 4 mm/y (Argus et al., 1989). The Betic-Rif belt is the focus of widespread debates attempting to relate the continental collision, the late extension, and the relationships between these two processes with the intermediate and deep seismicity. In recent years several hypotheses have been proposed to explain the origin, evolution, and present-day structure of the cordillera. Some researchers (Vissers et al., 1995; Lonergan and White, 1997) have discussed these models in detail. In this work we determined tomographic images of the crust and upper mantle below the Betic Cordillera and Alboran Sea region. These images, in addition to gravimetric modeling, the state of stress deduced from intermediate-depth earthquakes (h less than 110 km), and the surface geology, have provided important clues on the structure and tectonics of this region. These results may help to constrain the geodynamic regime of the present-day plate boundary and contribute to our understanding of the processes active in the collisional orogens. To the determine P- and S- wave tomographic images, we selected a data set of local earthquakes recorded inside the area delimited by latitude 35 degrees 30 min. N to 38 degrees 0 min. N and longitude 2 degrees 48 min. W to 5 degrees 0 min. W, during a period of 1983-1998. We selected events with at least 5 P and S arrivals and with hypocentral location with a root-mean-square (rms) travel time residual of less than 0.95 s. We collected a total of 407 earthquakes that satisfy the selection criteria. The accuracy of the hypocentral locations is better than 2 km in the horizontal direction and 0.5 km in depth. The depth of the selected earthquakes ranges from 5 to 110 km. The 407 selected events generated 3025 P- wave and 2958 S- wave arrivals. To analyze the selected arrival times, we used tomographic method of Zhao et al. (1992, 1994). The starting velocity model for the tomographic inversion is a realistic three-dimensional model that was constructed by taking into account results from the analyses of seismic profiles and gravimetric data (Galindo-Zaldivar et al., 1997, 1998). Lateral variations in the Conrad and Moho depths were taken into account in the three- dimensional ray tracing and the tomographic inversion (Zhao et al., 1992). P- and S- wave seismic tomography detects a low-velocity anomaly in the upper mantle beneath the Betic Cordillera and Alboran Sea region; the anomaly is associated with the intermidate-depth seismicity in the region. This structure is interpreted as a result of an active continetal subduction. Gravity modeling and seismic attenuation also show the continental nature of the low-velocity zone. Stress field determined from the focal mechanisms of the intermediate-depth earthquakes also agrees with the scenario of continental subduction, which is caused by the middle-late Miocene to present-day northwest-southeast convergence of the African and European plates and the continental collision that raised the cordillera.