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Stress distribution in a continental collision: the northwestern Betic Cordillera transect

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The deep structure of the Gibraltar Arc is a key feature to reveal the development of the Betic-Rif Cordillera, surrounding the Alboran Sea, in the frame of the western Eurasian-African NW-SE slow convergence area. Seismic tomography models performed in the Mediterranean region had shed light on the deep structure of most of the belts that surround the Mediterranean Sea (Apennines, Dinarides, Maghrebides) confirming the presence of subduction slabs. In the western Mediterranean, subduction has also been invoked as a development mechanism of the Betic-Rif Cordillera although its nature -oceanic or continental-, geometry, polarity, recent evolution and relationships with other mechanisms are not as well established as in other Alpine Mediterranean chains.

We present a stress analysis from focal mechanism for shallow and intermediate earthquakes that occurred between 1968-present within the western Betic Cordillera and Alboran Sea, in order to improve our knowledge of the state of stress for this collisional setting. In addition, very deep earthquakes in the central Betic Cordillera are also analyzed and integrated in the collisional framework. In a NW-SE transect of northwestern Betics, parallel to the convergence direction, the shallow seismicity is preferably located at the Betic Cordillera mountain front, indicating its present-day activity. A general NW-SE horizontal compression is revealed for shallow earthquakes (<40 km) compatible with the convergence between the Eurasian and African plates, although with NW plunging compression axes, in agreement with frontal thrust activity. Meanwhile, toward the Alboran Sea the earthquakes are progressively deep, with intermediate depths near the coast that would support the present activity of a limited subduction.

Intermediate and deep seismicity along the Betic Cordillera could be interpreted to be a consequence of the present-day stress distribution along a remnant subducted slab in the context of a continental collision. The Iberian continental crust concentrates most of the intermediate seismicity (40-110 km) and is forced to sink into the mantle probably linked to the pull of the oceanic lithospheric slab. This down-dip pull produces the slab curvature, extension parallel to the strike direction in the upper/outer part of the continental slab, and down-dip compression in the inner part. The presence of T axes highly dipping to the southeast at 90-110 km depth may coincide with the transition between continental and oceanic lithosphere and is related to the inverse buoyancy of the oceanic lithosphere slab sinking into the mantle. Deep earthquakes (> 600km) show very similar solutions with their compressional axis dipping 40-70º to the east, fitting the general pattern of seismicity at the bottom of slabs when they reach the 660 km discontinuity and experience resistence to further descent.