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GPS tectonic displacements on a main active sinistral blind fault tip: a key to integrate seismic and geological evidences in a collisional setting (Al Hoceima area, Rif belt, western Mediterranean)

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The NW-SE Eurasian-African plate convergence formed the Rif and Betic Cordilleras around the Alboran Sea in the westernmost Mediterranean. Seismicity in this region is notably concentrated along a NE-SW band crossing from the Campo de Dalías, in Betics (Spain), to the Al Hoceima region in the Rif (Morocco), an area affected by the 1994, 2004 and 2016 onshore and offshore seismic series. This deformation zone has been proposed to be a main segment of the plate boundary and corresponds to the northwestern limit of a rigid basement spur of the African plate in a setting of indentation tectonics. The onshore Al Hoceima region was affected by the catastrophic earthquake of January 24, 2004 (M= 6.4, depth 7 to 10 km) and the related seismic series is characterized by strike-slip focal mechanisms supporting the presence of NNE-SSW sinistral or WNW-ESE dextral faults. However, there is not any evidence of surface strike-slip faults in the epicentral area, which instead was affected by minor NE-SW extensional structures evidenced by fractures in Quaternary pebbles, minor conjugate normal faults, and vertical open joints. Geological researches evidence that main normal and transtensional faults are located eastward of the epicentral area, onshore and offshore of the Nekor bay, and westward in the Bokoya Massif.

A non-permanent GPS network consisting of 6 sites has been installed since June 2007, and we have obtained yearly measurements. They provide an accurate result of the present-day deformation field that is helping to solve the apparent disagreement between seismological and geological observations. The three sites located east of the 2004 series epicentral area have motions roughly consistent with the Nubia (African) plate and evidence the very low activity of the prominent Plio-Quaternary Nekor basin faults. Contrasting, the three sites located on the epicentral and western region undergone a very fast motion (between 2 and 3 mm/yr) towards the WSW with respect to stable Nubia. This result supports an ENE-WSW surface extension and is in agreement with the subtle very recent geological deformation and the extensional stress of the earthquake focal mechanisms. The analysis of the 2016 seismic series that occurred in Alboran Sea provide similar results, suggesting a recent westward migration of the deformation. The integration of all these results support that the main sinistral fault zone crossing the Alboran Sea propagates up to the Al Hoceima region basement, while the shallow tectonic units are detached and their deformation and displacement are mainly determined by the orientation of the ENE-WSW extensional stresses. This is a complex setting for paleoseismological studies and seismic hazard assessment because the main recent outcropping faults have become inactive and the new main active structures are blind strike-slip faults. The integration of geodetic data have been proven essential to integrate the apparently disharmonious seismic and geological data.