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Earthquake crisis unveils the growth of an incipient continental fault system

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Large continental faults extend for thousands of kilometres and often form the tectonic boundaries between plates that are associated with prominent topographic features. In these active areas, well-defined faults produce large earthquakes, and thus imply a high seismic hazard. These paradigms are called into question in the Alboran Sea, which hosts an allegedly complex diffuse boundary between the Eurasia and Nubia plates, and we discovered one of the few examples worldwide of the initial stages of these key tectonic structures. On the 25th January 2016, a magnitude M_w 6.4 submarine earthquake struck the north of the Moroccan coast, the largest event ever recorded in the Alboran Sea. The quake was preceded by an earthquake of magnitude M_w 5.1 and was followed by numerous aftershocks whose locations mainly migrated to the south. The mainshock nucleated at a releasing bend of the poorly known Al-Idrissi Fault System (AIFS). According to slip inversion and aftershock distribution, we assume a rupture length of 18 km. Here we combine newly acquired multi-scale bathymetric and marine seismic reflection data with a resolution comparable to the studies on land, together with seismological data of the 2016 M_w 6.4 earthquake offshore Morocco – the largest event recorded in the area – to unveil the 3D geometry of the AIFS. We found that, despite its subdued relief, the AIFS is a crustal-scale boundary. We report evidence of left-lateral strike-slip displacement, characterize their fault segments and demonstrate that the AIFS is the source of the 2016 events. The occurrence of the M_w 6.4 earthquake and previous events of 1994 and 2004 supports that the AIFS is currently growing through propagation and linkage of its segments, which eventually might generate a greater rupture (up to M_w 7.6), increasing the potential hazard of the structure. The AIFS provides a unique model of the inception and growth of a young plate boundary system in the Alboran Sea (Western Mediterranean).

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