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Crust structure across the Rif Cordillera from 'RIFSIS' seismic refraction and wide-angle reflection experiment

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The Rif Cordillera, located in North Morocco forms, together with the Betic Range, the Gibraltar Arc around the Alboran Sea. This asymmetric curved mountain belt originated during a Miocene continent-continent collision as a result of the westward motion of the Alboran domain between northwest Africa and Iberia. The complexity of the area favored the proposition of diverse tectonic models, such as roll-back, accompanied and followed by lithospheric convective down-welling, and delamination. In this study, we present models of crustal structure derived from a seismic refraction and wide-angle reflection experiment which took place in October 2011 within the Spanish project RIFSIS complemented by the US-PICASSO one. Two profiles oriented N-S and E-W respectively were carried out across the Rif domains. Five shots of 1 Tn each were detonated along the lines and at the crossing point, recorded by about 900 stations from US-Iris pool deployed at an average spacing of 750 m. The N-S line was extended northwards by a 70 km long segment in Spain, in the Betic Range. Southwards, this profile connects with the one recorded in 2010 across the Atlas Mountains, within the SIMA project.

The interpreted crustal structure differentiates two sedimentary layers on top of the basement, inferred from the observed first arrivals at short offsets, followed by upper, mid and lower crustal levels constrained by reflected phases visible in the record sections. The bottom of the crust is well defined from PmP phases, although the absence of Pn arrivals prevents to constrain upper mantle velocities. Average velocity values for the different layers in the models are respectively: 3.5 and 4.2 km/s for the sediments, 5.9, 6.3 and 6.6 km/s within the crust, and 8 km/s below Moho. These velocity depth models obtained at the Rif Cordillera hold major variations in crustal thickness, especially along the E-W profile, that shows a rapid change of 15-20 km in Moho depths within 30 km horizontal distances. Maximum depths around 50 km are found below the external Rif Domain, while thinnest values of about 28 km are located eastwards, in the foreland and Atlasic terrances up to Algerian border. The model along N-S profile displays also marked differences in crustal thickness, ranging from 40 km beneath the Betics and internal Rif sampled domains, to 47-48 km beneath external Rif, and a progressive thinning southwards till Middle Atlas domain where the Moho is found at 28-30 km depth. Such strong lateral variations in crustal structure and particularly the importance of the crustal root beneath the external Rif areas, rather unexpected according to surface topography or potential field datasets, is a major finding of this experiment that should be taken into account in further geodynamic modellings.