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Evolution in the knowledge of the origin of the Atlas Mountains topography: from structural geology to seismic wave tomography

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The Atlas Mountain Range is an active intracontinental orogenic belt located to the S of the diffuse plate boundary between Africa and Europe. This orogen has been the target of scientists that over the past two decades have tried to unravel the origin of its high topography in a context of low to moderate shortening, moderately low Bouguer gravity anomaly, high heat flow and low P and S-wave velocities. In this regard, some of the first assessments were presented by Teixell et al. (2003) and Arboleya et al., (2004), who found out, on the basis of balanced sections, that shortening in the High Atlas was below 25%, whereas in the Middle Atlas was even less than 15%. Those results pointed out to a subcrustal contribution to surface uplift and were compatible with Bouguer anomaly values that suggested that the crust, even reaching elevations of 3000-4000 m, had its Moho located at maximun depths of 40-41 km (Ayarza et al., 2005). The crustal models derived from gravity data were used as the input of lithospheric scale potential field based multidisciplinary modeling, which concluded that an astenospheric upwelling places the LAB as shallow as 70 km (e.g. Teixell et al., 2005; Zeyen et al., 2005; Fullea et al, 2010). This feature helps to support the mountain load and is responsable for the mantle-driven uplift that has occurred in the past 5 ma, as proposed by Babault et al. (2008) on the basis of risen marine deposits and geomorphic indicators.

Uncertainties in the exact LAB depth existed and were related to the crustal thickness: a thicker crust would imply a thicker lithosphere. In order to image the Moho topography and depth, and to constrain the seismic velocity structure of the crust in this mountain system, a 700 km long, seismic wide-angle reflection transect, crossing the High and the Middle Atlas, was acquired in 2010 by an international team. Even with a low signal/noise ratio, the data allowed the identification of mantle reflected/refracted phases (PmP and Pn) that indicate that the Moho is an asymmetric feature that locally defines a crustal root characteristic of young orogens. The crust-mantle boundary is modeled at relatively shallow depths (30-41 km) in accordance with other geophysical data, thus supporting the idea of a 'mantle upwelling' as main contributor to the High Atlas topography (Ayarza et al., submitted).

Finally, MT experiments indicated that the Atlas lower crust and upper mantle are highly conductive and might contain partly molten material (Anahnah et al., 2011; Ledo et al., 2011). Seismic wave tomography and receiver function analysis have concluded that low P and S-wave velocities exist in the Atlas upper mantle (Bezada et al., 2013; Miller and Becker, 2014; Palomeras et al., 2014; Thurner et al, 2014), further supporting the existence of this asthenospheric feature and validating the models that emphasized the importance of dynamic topography for the Atlas orogenic belt.