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Magnetotelluric investigation of the lithosphere-asthenosphere boundary beneath the Tajo Basin contrasted with results from seismic and thermal modelling studies - Results of the PICASSO Phase I project in the Iberian Peninsula

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The Iberian Peninsula exhibits two geologically distinguishable regions referred to as Alpine Spain and Variscan Spain, situated to the east and west of the peninsula. The Variscan belt results from oblique collision and interaction between the Palaeozoic supercontinents Gondwana, Laurentia, and Baltica and a number of continental microplates that took place during Neoproterozoic through Palaeozoic times. The Betics and Pyrenees mountain belts were formed during Alpine orogeny, due to successive collision of the Iberian continental plate with Africa and the rest of Eurasia, in Late Mesozoic - Cenozoic times. Alpine and Variscan mountain ranges in the Iberian Peninsula (Spanish Central System and Iberian Ranges, respectively) separate the three major Iberian basins: Duero, Ebro, and Tajo. Such orogenesis should result in significant topology on the lithosphere-asthenosphere boundary (LAB).

An average lithospheric thickness of approximately 110 km has been derived for the interior of the Iberian Peninsula using seismic tomography studies and thermal modelling. Lithospheric thickness diminishes towards the eastern and southern boundaries to depths as shallow as 60 km at the Valencia trough and the Alboran Basin. On the other hand, LAB depths of 160 km have been imaged beneath the Betics and Pyrenees. However, the detailed structure of the upper mantle beneath central Iberia remains controversial due to resolution problems of the different geophysical methods. In particular, the lack of long-term seismic stations in the Atlantic Ocean considerably reduces the resolution of seismic tomography models in the Iberian Peninsula.

DIAS's PICASSO Phase I project comprises magnetotelluric (MT) measurements along a 400 km long, approximately north-south oriented profile. The profile extends from the northern Tajo Basin (approximately 100 km east of Madrid) to the city of Almeria near the Alboran Sea, crossing the centre of the Tajo Basin and the Betics Cordillera. Our MT investigation provides information about the electrical conductivity distribution, which is compared with previous seismic and thermal models of the Tajo Basin. The comparison of the different LAB depth estimates allows us to gain better understanding of the tectonic processes responsible for the present day lithospheric-sublithospheric structure in the Iberian Peninsula.

Our subsurface model exhibits an electrically resistive lithospheric-mantle underlain by an electrically conductive region inferred as the asthenosphere. The transition from resistive to conductive materials, i.e. the electric LAB, is modelled at approximately 110 km depth. However, due to a low signal-to-noise ratio and a general decrease of resolution for the MT method, this depth is not strongly constrained. A striking result of our investigation is the coincidence of a massive electrically resistive body with a region of low seismic velocity extending from the asthenosphere upwards into the lithospheric-mantle beneath the Manchega Plain. Such a correlation is somehow counter-intuitive, as common causes for reducing velocities, like fluids, partial melt, and increased temperature, usually result in a commensurate decrease in electric resistivity. To accommodate a low velocity – high resistivity region, very special geological settings are required, e.g. the presence of isolated fluid pockets in a resistive host medium, for which the electric resistivity remains high, owing to the low degree of connectivity, whereas the seismic velocity is decreased, because of its sensitivity to bulk properties.