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The crustal structure of the continent-ocean transition along the Gulf of Lions from Travel-Time Tomography of MCS and WAS data

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The Gulf of Lions margin is located in the West Mediterranean Sea and opened as a back-arc basin from the end of Eocene to the Miocene. Previous studies of this area modelled and interpreted seismic data to explain the geological processes that lead to the formation of this margin. These works show the presence of a particular continent-ocean transition zone (COT) where crustal velocity structure is atypical for either continental or oceanic crust. Different studies debate the nature of it and suggest lower continental crust exhumed by a landward deep detachment or a mixed of exhumed mantle and crustal bodies. The objective of this study is to use advanced joint refraction and reflection tomography tools to obtain higher-resolution models that allow (1) characterizing the nature of the crust along the Gulf of Lion margin, and (2) defining the geometry of the margin, especially in the COT zone and the nature of the boundaries between the different geological domains.

To achieve these aims, we present a new P-wave velocity (Vp) model obtained from joint refraction and reflection travel-time tomography (TTT) of two different active-source seismic data sets: ocean bottom seismic (OBS) data and long-streamer data, the Multi-Channel Seismic (MSC) data. OBS-derived images show the Vp structure of the crust and uppermost mantle and the geometry of the Moho along the basin axis. Additionally, the long-streamer tomographic image shows the Vp structure of the post-rift section in much more detail than OBS-derived images, providing insights into basin-scale processes that occurred after lithospheric extension. The joint TTT allows us to invert the main geological horizons of the margin identified in the OBS and MCS images and, for the first time in this area, also to jointly invert the geological horizons present and identified in both data sets.

Our results show a Vp velocity model that display three distinct domains. Domain I shows a structure that corresponds to thin continental crust. Here the crust thins from 15 to 5 km by a system of normal faults, clearly imaged by streamer data, over a width of about 70 km. The upper crust has Vp between 5 to 6 km/s and the lower crust with velocities ranging from ∼6.0 km/s to ∼7.5 km/s. The lithospheric mantle has a velocity around 8.0 km/s along the entire modeled profile. Domain II, which is interpreted as the COT zone, displays a well-delimited lens-shaped body with high crustal velocities (6.0-7.5 km/s). This ∼100 km-long body becomes narrow towards the Domain I and Domain III and in the central part, where the body is thickest (around 5-km thick), its top coincides with the top of the basement, so it constitutes the crust. Domain III is characterized by a 4-km thickness crust and velocities ranging from 5.5 to 6 km/s. The Moho is 12 km deep, flat and parallel to the top of the basement along this domain. Based on their markedly different Vp distribution, we argue that Domain II and Domain III might not be genetically linked.