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Unconventional Pn wave tomography of the Western Mediterranean region and the Gulf of Cadiz. Constraints on plausible locations of major future and past historical earthquakes.

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Selected Pn arrival times extracted from the ISC data, from 1964 to present, are used in an unconventional Pn wave seismic tomography, to map with a much improved resolution, the lateral mantle lid velocity variations in the Western Mediterranean region and the Gulf of Cadiz. In a classical tomography study, one defines an initial lithosphere model, determined by fitting a line over all Pn travels times. Its slope and corresponding intercept allows defining an average Pn velocity and an average Moho depth. The average crustal velocity has been fixed to 6.4 km/s; residuals correspond to the difference between times read at the stations and the ray theoretical times, computed from this pre-determined initial lithosphere model. This initial model corresponds to a regional travel time, sampling broad tectonic provinces, with huge velocity variations. Therefore, the residuals projection, lead to poor resolutions of the mantle lid velocity and Moho depths variations.

In the present study first neat observational travel times are established for the 22 major Mediterranean Basin physiographic regions. Second, better ray theoretical times are quantified through this set of pre-determined lithospheres polygons. The obtained residuals are corrected for several effects: (1) the station topography, (2) the Moho depth variations from the source to the receiver, (3) the source depth using a simple efficient approach, and (4) the oceanic and/or continental context of the source and/or station location. As a result residuals have by far, less scatter, and are more meaningfully representative of the lateral velocity variations. This process confines in a much narrower intervals the variations of the sought variables: mantle lid velocity variations in the different polygons and stations delays.

A strong correlation is observed between the mapped lateral velocity, Moho depths variations, and the tectonic features observed at the surface. The most important new observations are:

(a) a remarkable tectonic feature, trending roughly East-West and extending from off-the Apennines coast, in the Tyrrhenian Sea, up to the Gulf of Cadiz. A continuous increase in Pn velocity from 7.6 km/s up to 8.3 km/s is observed. At the Gulf of Cadiz a very well delineated arc of high velocity of 8.3 km/s, represents the cold shadow of the underthrusted oceanic slab beneath the Gibraltar Arc. This imaged regional tectonic feature strongly supports the delamination of an underthrusted East dipping oceanic slab, beneath the Mediterranean Sea (Thiebot and Gutscher; Gutscher et al., 2006).

(b) all 228 crustal earthquakes of magnitudes larger or equal to 5.5 which occurred since 1964, are not randomly distributed, but are located above cold mantle lid ([U+F03E] 7.9 km/s), and associated to large variations in Pn velocities at their immediate vicinities (heterogeneities, patches etc.). The 1755 Lisbon earthquake (Mag[U+F07E]8.5-9.0), as well as future large earthquakes, could be further constrained using the results obtained by this mantle lid mapping.