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Non-conventional seismological constraints on subduction zone structure: Preliminary results from the Alboran Sea between Spain and Marocco

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We study the European/African plate boundary region around the Gibraltar arc, for which there is no consensus concerning its structure and evolution yet. A variety of tectonic models have been proposed to explain the most important geological and geophysical observations, and there are currently two groups of geodynamic models that are dominating the discussion, namely “oceanic” versus “continental” models. The oceanic models explain geological and geophysical observation via subduction of oceanic lithosphere, that either dips toward the North or toward the East, the latter for a slab rolling back to the West. In contrast, continental models propose either convective removal or delamination of the continental lithospheric mantle. It appears that both types of models can explain the majority of geological and geophysical observations in the area, and that it is therefore difficult to distinguish between them.

The key to distinguishing the different models clearly lies in the mantle. Tomographic studies of the region show a fast-velocity anomaly that seems to dip toward the East, but the precise spatial extent and orientation of the structure is difficult to determine due to the limited ray coverage. Also the nature of the anomaly, “oceanic” versus “continental”, is not easily determined using classical tomographic techniques, since the resolved (spatially averaged) velocities are rather similar for oceanic and continental lithosphere. Questions of interest are therefore: What is the nature of the high-velocity anomaly under the Alboran Sea? Does it represents continental or oceanic lithosphere, and what is its orientation?

We introduce new seismological constraints on the structure of the upper mantle of the region, based on dispersion of body waves, arrival directions of body waves, and

seismic anisotropy, and we present some preliminary results here. Body waves traveling through the upper mantle under the Alboran Sea show dispersion (frequency-dependent arrival times) that is consistent with the presence of subducting oceanic lithosphere under the Alboran Sea region. That technique may therefore provide a basis for directly distinguishing whether the nature of the anomaly under the Alboran Sea is oceanic or continental. We also study arrival directions of body waves, since they directly constrain lateral velocity gradients in the subsurface. Such information is complementary to that of travel times, and it should be especially useful for better constraining tomographic images in subduction zones. We present results from 3D ray tracing through the Alboran Sea region that illustrate that effect, and compare with observations. We will also briefly discuss new constraints from seismic anisotropy on mantle flow under the region.