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Seismic evidence for the nature of the Vrancea zone of the Eastern Carpathians: an oceanic subduction zone

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The Vrancea region of the southeastern Carpathians is one of the most active seismic zones in Europe and it is well-known for its strong intermediate depth earthquakes. Seismic tomography had revealed a high-velocity body beneath Vrancea and the Moesian platform that extends to a depth of at least 350 km and can be interpreted as descending lithosphere. The strong earthquakes occur within the northeastern part of this high-velocity body, in a very limited seismogenic volume at intermediate depth (70-180 km). Several geodynamic models have been proposed for this area. They can be split into two main categories, in terms of the nature of the high-velocity anomaly, which may (a) be associated with descending relic oceanic lithosphere beneath the bending zone of the SE-Carpathians, either attached or already detached from the continental crust; or (b) it may represent continental lithosphere that has been delaminated, after continental collision and orogenic thickening. Based on currently available information, it appears difficult to distinguish between these two types of models. In this paper we attempt to shed more light on the nature of the seismic anomaly, as well as that of the origin of the intermediate depth seismicity in the Vrancea zone, by investigating the waveform character of P-waves excited by local earthquakes beneath this area, and in particular the dependence of group arrival times on frequency. We present observations of such a dispersion from stations situated at the bending zone of the SE-Carpathians. On the other hand, signals from the same earthquakes, but observed at reference stations outside of the anomalous zone do not show that frequency dependence. A natural explanation for these observations is that they are caused by the presence of a low-velocity (oceanic crustal) channel at the top of the seismic anomaly, which is too thin to be resolved by classical seismic tomographic techniques. Similar observations of dispersed first-arriving P-waves have been made above subduction zones around the world, in which low-velocity layers with a thickness of several kilometers are known to exist. This suggests that a tabular slab of subducted oceanic crust is present within the seismic anomaly under the Vrancea region, and that the anomaly consists of subducted oceanic lithosphere rather than continental lithosphere, at least at depths shallower than the seismically active zone.