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LAB as boundary between fossil and present-day mantle seismic anisotropy

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We present a uniform updated model of the European lithosphere-asthenosphere boundary (LAB) recalculated from data collected during our regional studies of seismic anisotropy and other tomographic experiments. Thanks to a long memory of the fabric of the deep continental lithosphere, we can define the LAB as a boundary between a fossil anisotropy in the mantle lithosphere and an underlying seismic anisotropy related to present-day flow in the sub-lithospheric mantle (Babuška and Plomerová, 1992; 2006; Plomerová et al., 2002). Both depth and lateral variations of anisotropy, its strength and orientation derived from radial ξ and azimuthal **G** anisotropy of surface waves, time delay δt and polarization ψ of split shear waves, directional variations of body-wave travel-time deviations, located major part of the variable anisotropy within the mantle lithosphere (e.g., Babuška et al., 1998; Plomerová et al., 1996; Vecsey et al., 2007).

Primary association of the relative P-wave residuals (the static terms) with the lithosphere thickness was done through linking the thinnest lithosphere with the most delayed relative arrivals in the Belgo-Dutch Platform and the thickest lithosphere with the early arrivals in the central part of the Western Alps (Babuška et al., 1987). This empirical relation between the thickness of the lithosphere and the static terms of relative residuals, did not require any assumption on the velocity-depth distribution except of that $v_{lith} > v_{asth}$. Gradient of the empirical relation is 9.4km/0.1s. Standard deviations of the static terms are usually ±0.1 or better, therefore, the accuracy of the LAB determination is estimated at ±10 km in most of provinces. Because the lithosphere represents the first order high-velocity layer in the uppermost mantle, the relation reflects either a lack or an abundance of high-velocity material in regions with a thin or a thick lithosphere, respectively. The high velocity contrast across the LAB ($\delta v_P \sim 0.6$ km/s) resulting from the gradient cannot be accomplished in isotropic velocities of materials forming the upper mantle (Babuška and Cara, 1991). But, considering dipping high P velocities in the mantle lithosphere and mostly sub-horizontal high velocities (lineation) below it meets the requirement on the velocity contrast. In such a configuration, teleseismic P waves steeply crossing the LAB propagate at about 7.7 km/s below the LAB and at ~8.25km above it, assuming composition and fabric of prevailing mantle xenoliths (Ben-Ismail and Mainprice, 1998). Taking into account an additional 0.1km/s reduction due to a possible partial melting in the asthenosphere (Anderson, 1989), the resulting velocity contrast across the LAB is $\delta v_P \sim 0.65$km/s, which gives an estimate of the gradient at about 9.6km/0.1s. The estimated gradient is almost identical with the gradient of the empirical relation. We keep the relation constant, though inclination of the mantle lithosphere fabrics differ in provinces of different tectonic setting and ages (Babuška et al., 1998).

The LAB topology is more distinct beneath the Phanerozoic part of Europe compared with its Precambrian part. The LAB shallows up to about 60 km beneath major European basins and deepens down to ~220 km beneath the two Alpine roots, the South Carpathians and eastward of the TESZ (Fig. 1). Expressiveness of this velocity boundary, where velocity contrast increases thanks to differences in orientation of seismic anisotropy, is pointed out also in detection of Sp phases converted at depths associated with the LAB (Geissler et al., 2009). In general, the LAB depths from the two independent data sets match well, especially as to relative thickenings and thinning of the lithosphere. The stacked radial Sp receiver functions do not consider inclination of the boundary and back-azimuth distribution of rays and often contain several dominant peaks of the same intensity. Moreover, the S-receiver function method is sensitive to sharpness of the LAB, which may vary from a diffuse (>50km thick) to a relatively very sharp (<20km thick) transition (Eaton et al., 2009).

In general, there are similarities between the LAB models derived from various geophysical parameters and techniques, as well as diversities, which might reflect differences in resolution and accuracy of individual methods. On the other hand, different physical parameters can ‘see’ different LABs and diverse lithosphere structures. Therefore, we advocate a necessity of combining different methods and data, and especially 3D approaches allowing us to consider seismic anisotropy with general orientation (plunging symmetry axes).

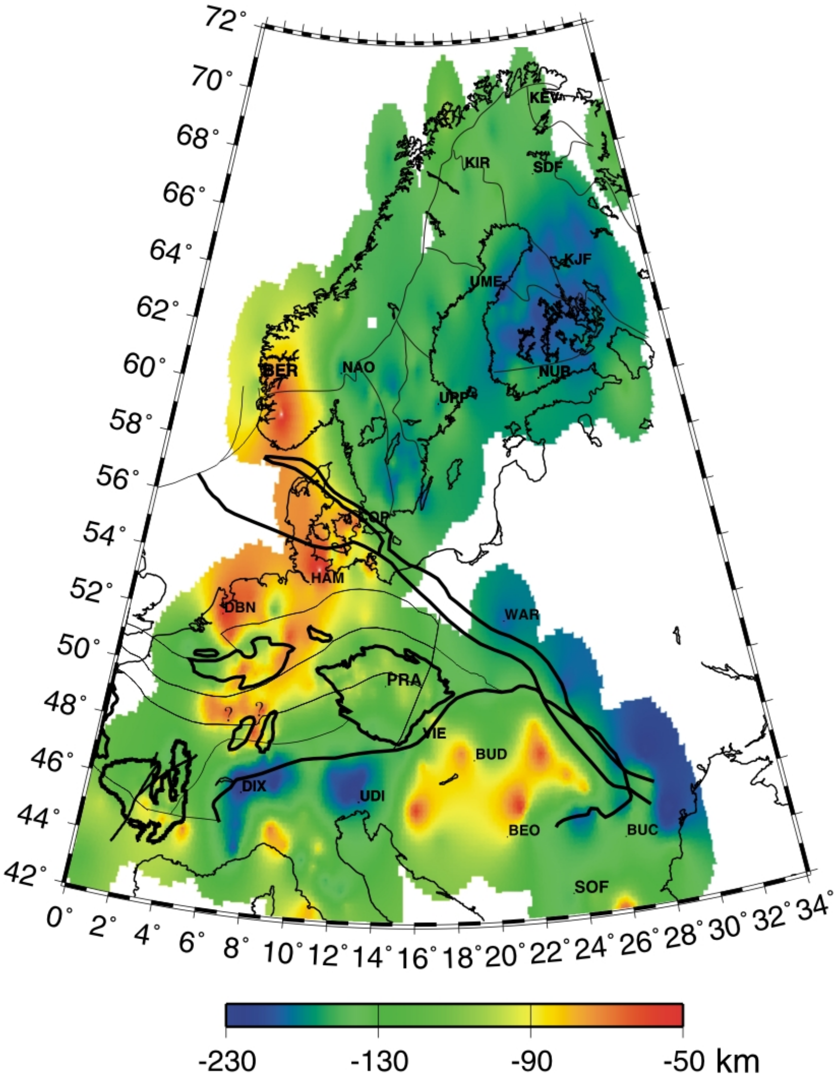

Figure 1. Model of the LAB depths beneath Europe derived from static terms of relative residuals (Plomerová and Babuška, Lithos 2009, submitted).

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