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Fabrics of the Northern Fennoscandian lithosphere inferred from 3-D seismic anisotropy

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Passive seismological experiment LAPNET (May 2007–September 2009) provided data for structural studies of the upper mantle beneath the northern part of Fennoscandia. We concentrate on evaluating the large-scale anisotropy fabrics in the upper mantle modelled from (1) splitting of SKS waves and their particle motions (PM) (Vecsey et al., Tectonophysics 2008), (2) directional terms of relative P-wave travel time residuals and (3) joint interpretation of body-wave anisotropic parameters (Plomerová et al., Solid Earth 2011). An advantage of using PM analysis is its ability to employ events with lower signal-to-noise ratio (SNR) that are otherwise not usable for splitting analysis. To improve results of splitting analysis, we carefully check signals for seismometer mis-orientations and include directions of SKS wave propagations with null or close to null splitting. Moreover, we stack individual splitting measurements from waves propagating closely through the mantle to eliminate noise effects.

Our study of anisotropy confirms that the mantle lithosphere of northern Fennoscandia consists of several blocks with fabrics differently oriented in 3-D (Vecsey et al., Tectonophysics 2007). Geographic variations of seismic-wave anisotropy delimit individual domains of the mantle lithosphere, each having a consistent fabric. The domains are sharply bounded both in the Proterozoic and Archean provinces and can be modelled in 3-D by peridotite aggregates with dipping lineation a or foliation (a,c). These findings allow us to interpret the domains as micro-plate fragments retaining fossil fabrics in the mantle lithosphere, reflecting thus an olivine lattice-preferred orientation created before the micro-plates assembled, and formed in dynamic conditions far from simple cooling processes which would result in horizontally layered structures. A boundary between regions with positive and negative velocity perturbations in teleseismic P-wave tomography shifts westward with depth. The shift can indicate an inclination of the Baltic-Bothnia Megashear Zone and reflect a wedge like structure of the Proterozoic-Archean transition similarly to that in the south-central Finland (Plomerová et al., 2006). Studies of fossil anisotropy preserved in the mantle lithosphere contribute both to mapping the lithosphere-asthenosphere boundary and deciphering the boundaries of individual blocks building the continental lithosphere.