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Domains of Archean mantle lithosphere deciphered by seismic anisotropy – inferences from the LAPNET array in northern Fennoscandia

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We show spatial variations of relative P-wave travel-time deviations evaluated for ∼90 teleseismic events recorded by about 60 broad-band stations of the LAPNET array (2007-2009, http://www.oulu.fi/sgo-oty/lapnet), as well as lateral variations of shear-wave splitting (Plomerova et al., Solid Earth 2011), to demonstrate variability of fabrics of the Archean mantle lithosphere in northern Fennoscandia. The results clearly demonstrate the Archean mantle lithosphere consists of domains with different fabrics reflecting fossil anisotropic structures (Babuska and Plomerova, PEPI 2006). We detected anisotropic signal both in the P-wave travel-time deviations and shear-wave splitting. Both types of anisotropic parameters change across the array in the same way and stations with similar characteristics form groups. The geographical 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 3D by peridotite aggregates with dipping lineation a or foliation (a,c). We infer the convergently dipping high-velocity directions in domains in the northern part of the array. Boundary between the domains can be associated with the northern half of the Baltic-Bothnia Megashear Zone. In the central part of the array, no pattern dominates in the east, while the high velocities dipping to the NE characterize stations in the west. Anisotropic signals at stations in the south-eastern rim of the LAPNET array are compatible with those evaluated from stations in the north-eastern rim of the SVEKALAPKO array (1998-1999) in southern Finland. The ‘no P-pattern’ at the south-western part of the LAPNET stations has its continuation beneath the central band of the SVEKALAPKO array related to the Proterozoic-Archean transition zone (Plomerova et al., J. Geodynamics 2006; Vecsey et al., Tectonophysics 2007).

These findings allow us to interpret the domains as micro-plate fragments retaining fossil fabrics in the mantle lithosphere, reflecting thus an olivine LPO created before the micro-plates assembled, and formed in dynamic conditions far from simple cooling processes which would result in horizontally layered structures. Studies of fossil anisotropy preserved in the mantle lithosphere contribute both to mapping the lithosphere-asthenosphere boundary and deciphering boundaries of individual blocks building the continental lithosphere (Plomerova and Babuska, Lithos 2010).