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Fennoscandian lithosphere-ashenosphere boundary – electromagnetic constraints

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Knowledge of the present-day structure of the Earth's mantle is essential to our understanding about plate tectonics as well as Earth's thermomechanical evolution over long periods of geological time. Several factors including the temperature, chemical composition, the presence of partial melt or water influence electrical conductivity and seismic velocities in the upper mantle. Anisotropy may also have a profound effect on magnetotelluric and seismic observations.

The first long period electromagnetic soundings in Fennoscandia were completed in early 1980's (e.g. Jones, 1980, Kaikkonen et al., 1983). Since then several additional deep probing studies were carried out (e.g. Pajunpää, 1988; Rasmussen, 1988) before the end of the last century. The recent improvements of magnetotelluric instrumentation have made it possible to obtain reliable and good quality data from magnetotelluric profile and array measurements. This is important, in particular, for upper mantle studies because long recording times are needed for deep probing soundings to obtain long period data and to correct for source field effects. As an example, in the recent EMMA work (Smirnov et al., 2006), simultaneous nine-month recordings at 12 sites were carried out from Aug 2005 to Jun 2006. These recordings provide information for the depths of several hundreds of kilometres. In 1998, a large MT array was employed in Fennoscandia as a part of the SVEKALAPKO/BEAR research (Lahti et al., 2005, Hjelt et al., 2006), which, for the first time, provided data over the entire shield. Since then several extensive data sets have been collected both in the Fennoscandian Shield (Jämtland - Korja et al., 2008; EMMA – Smirnov et al., 2006; MT-FIRE – Vaittinen et al., 2006) as well as on its margins (TOR – Smirnov and Pedersen, 2006; EMTESZ-Pomerania – Brasse et al., 2006).

Results show that in Fennoscandia (and in the East European Craton) electrical asthenosphere is either very deep or is absent (or cannot be detected by magnetotellurics) whereas in Central and Southern Europe electrical asthenosphere is much shallower. Rapid transition from the thick East European Craton to thinner Phanerozoic Europe coincides with the Trans European Suture Zone. Lithosphere is thinning towards the Atlantic Ocean (150 km). Comparison of model resistivities with laboratory data shows that mantle lithosphere is dry. Comparison with the available seismic information show that in the Fennoscandia Shield (and in the Precambrian East European Craton) the "electrical" lithosphere (LAB-E; Korja, 2007) is 50-100 km thicker than "seismic" lithosphere (LAB-S; Jones et al., 2010). This is in contrast to the lithosphere to the south of the Trans-European Suture Zone, where seismically defined LAB is deeper than electrically defined LAB (Jones et al., 2010).

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