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Structure of the upper mantle boundaries in North Eurasia and their origin

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The seismic profiling with Peace Nuclear Explosions (PNE) shows unusual velocity stratification of the North Eurasia upper mantle. The asthenosphere is not traced as a low velocity layer, on the contrary, the 10-20 km thick velocity inversion zones are revealed at depth around 100 km. Several seismic boundaries are traced along the profiles. The most regular boundaries are at depths of 80-120 km (N boundary or 80 boundary) and 200-250 km (L boundary). The reflections from these boundaries are complicate many phase groups which may be formed by the reflective zones with alternating of the high- and low-velocity layers. These boundaries and the low velocity layers were unexpected results of the seismic profiling because it appeared unrealistic to find the regular and strong velocity contrasts in the upper mantle whose velocities are insensitive to the material composition, and no phase transitions were revealed at the boundary depths. The interpretation of the low velocity layers at depth around 100 km as zones of partial melting is invalid in the old platform areas where the melting ("thermal asthenosphere") was supposed at the depths of 250-300 km.

The revealed boundaries might appear as the physical boundaries marked by the sharp changes in the different physical or mechanical properties of the material (porosity, permeability, fissuring and others). The increase or decrease in porosity is invariably followed by the change in the fluid content, which can initiate the different physicochemical transformations of the material, such as the new degrees of metamorphism, and initiate partial melting and mobility of the material at relatively low temperature. The laboratory study of the fluids transportation through the mantle rocks at the high pressure and temperature confirm such transformation. The matter flow along these weak zones may assist the formation of the anisotropic high velocity intermediate layers. Comparison of the seismic data with other geophysical data confirms such origin of the lower velocity layers and seismic boundaries: in many regions they are characterized by higher electrical conductivity. In the Siberian craton the most xenoliths come from the depths of these boundaries. That characterizes these boundaries as high strain zones. These xenoliths have often indications of film melting.

At the boundaries N and L the clear changes are observed in the lithosphere mechanical properties. In many regions above the N boundary the lithosphere has complex block structure, which disappears at the larger depth. That indicates the lithosphere to be more plastic at the depth over 100 km and cannot preserve its own inhomogeneity. The change of the rheology, which may be interpreted as the lithosphere bottom, is visible beneath the L boundary where the Q factor and the velocity-depth gradient decrease.