STRUCTURE OF LITHOSPHERE VELOCITY HETEROGENEITIES IN KAMCHTAKA AND THEIR RELATION WITH SUBDUCTION PROCESSES

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As a result of past years developments, the method of tomographic reconstruction of subsurface velocity structure based on earthquake data became the most efficient and widely used approach for deep Earth’s crust and mantle structure investigation. High volcanic and seismic activity of Kamchatka region provides both research targets and information for seismic tomography and all the necessary seismic information can be found in catalogues of Kamchatka EMSD GS RAS. Limitation of previous tomographic studies primarily resulted from data quality and, in particular, from problems in data consistency.

Here we first present results of a Minimum 1D lithosphere-asthenosphere velocity model (up to about 200 km depth) that serves for uniform high precision earthquake location and as initial reference model for 3D tomography. The model is calculated with program VELEST that has a number of advantages, in particular, the program iteratively solves the coupled hypocenter-velocity model problem for P and S waves to derive 1D velocity models with station delays and hypocenter locations including detailed information about each observation and its contribution to overall solution error estimates. During this 1D joint inversion process, average root mean square residuals decrease from 1.2 s² to 0.26 s².

For three-dimensional velocity structure calculation we used P arrival times from 2386 local earthquakes from the period 1986-2001 that were relocated with the Minimum 1D model. Results of 3D tomographic inversions are presented in the form of horizontal depth sections of crust and upper mantle and vertical profiles along seismic focal zone (SFZ) in the area of maximum seismicity and along volcanic belts – East-Kamchatka and Central Kamchatka Depression (CKD), as well as vertical profiles across transition zone at the latitudes of the volcanoes Mutnovskyi, Avachinskyi, Karymskyi, Kronotskyi, Kizimen, and Northern Volcanoes Group (Klyuchevskoi, Shiveluch). All the profiles show relative velocity change in percents. In comparison with earlier studies, our results provide a more detailed image of the deep structure of Kamchatka by illuminating upper and lower crustal layers, upper mantle and asthenosphere-lithosphere boundary, 3D geometry and internal structural features of high velocity layer corresponding to subducting Pacific plate in the Kurilo-Kamchatkan and Aleutian arc junction area. We may further infer geometries of the boundaries beneath different tectonic elements in Kamchatka transition zone, correlation of volcanic belt position with deep crustal velocity anomalies, and existence of ‘asthenospheric wedge’. The thickness of this wedge varies from south to north along Kamchatka islands arc and in the region of Kronotskyi peninsula this ‘wedge’ practically disappears. In addition we note an abrupt change in the dip of the high-velocity slab (from about 50 degrees in the south to less than 25 degrees north of SFZ in the area of transform junction of Kamchatka and Aleutian arcs) that seems to correspond with the shear zone – Kronotsk-Krutogorovsk fault (Suprunenko et al), which roots are placed in deep lithosphere.

Finally, new tomographic results document significant differences in lithosphere velocity structure beneath two volcanic belts – East Kamchatka and Northern Group in the CKD area. Our images suggest a magma source of the former volcanoes possibly related to asthenospheric wedge while for the latter a mechanism of lithospheric plates interconnection in the island arcs junction area seems more plausible.