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Regional variations in seismic boundaries

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Dividing of the Earth into zones in the frame one-dimensional velocity model was proposed Jeffreys and Gutenberg is the first half of XX century. They recovered the following zones: A – the crust; B – zone in the depth interval 33-413 km, C – zone 413-984 km, D – zone 984-2898 km, E – 2898-4982 km, F – 4982-5121 km, G – 5121-6371 km (centre of the Earth). These zones differ in their seismic properties. Later, zone D was divided to the areas D' (984-2700 km) and D" (2700-2900 km). At present, this scheme is significantly modified and only the layer D" is in wide use. The more seismological studies are carried out, the more seismic boundaries appear. Boundaries at 410, 520, 670, and 2900 km, at which increase in the velocity of the seismic waves is particularly noticeable are considered as having global significance. Moreover, there are indications of the existence of geophysical boundaries at 800, 1200-1300, 1700, 1900-2000 km.

Using 3D P-velocity model of the mantle based on Taylor approximation method for solving of the inverse kinematics multi-dimensional seismic task we have obtained seismic boundaries for the area covering 20-55° E × 40-55° N.

Data on the time of first arrivals of P waves from earthquakes and nuclear explosions recorded at ISC stations during 1964-2002 were used as input to construct a 3-D model. The model has two a priori limits: 1) the velocity is a continuous function of spatial coordinates, 2) the function v(r)/r where r is a radius in the spherical coordinate system r, , decreases with depth. The first limitation is forced since velocity leaps can not be sustainably restored from the times of first arrival; the second one follows from the nature of the observed data. Results presented as horizontal sections of the actual velocity every 25 km in the depth interval 850-2850 km, and as the longitudinal and latitudinal sections of the discrepancy on the 1-D reference model, obtained as a result of solving of the inversion task at 1° in the same depth interval [1, 2].

A general approach to the solving of the seismic tomography task by the method of Taylor's approximation is as follows: construction of a generalized field of mid-point of arrival times of waves at the observation station; construction of mid-points travel-time curves, i.e. cross-sections of the generalized field of mid-point of the arrival times of waves; inversion of travel time of the mid-point curve into speed curve.

Due to the imposed limitations there are no abrupt velocity leaps in the model in use. First derivatives of the velocity for each curve were calculated points of local extreme were identified in order to determine the seismic boundaries. Maps of depths of occurrences of seismic boundaries at about 410 km, 670 km, 1700 km, and 2800 km were constructed. In general there is a deviation from generally accepted values beneath regions with different geodynamic regimes. There is a correlation of the 410 km and 670 km boundaries behaviour with the observed heat flow anomalies and gravitational field.

[1] V.Geyko, T. Tsvetkova, L. Shymlanskaya, I. Bugaienko, L. Zaets Regional 3-D velocity model of the mantle of Sarmatia (south-west of the East European Platform). Geophysical Journal, 2005, iss. 6, P. 927-939. (In Russian)

[2] V. Geyko, L. Shymlanskaya, T. Tsvetkova, I.Bugaenko, L.Zaets Three-dimensional model of the upper mantle of Ukraine constructed from the times of P waves arrival. Geophysical Journal, 2006, iss. 1, P. 3-16. (In Russian)