

# Some common features in the picture of distributions of elastic heterogeneities of the crust and upper mantle of the Northern Caucasus accordingly to the earthquake converted-wave method, the deep seismic sounding and seismology

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Analysis is based on generalizations of regional ECWM and DSS works [Belyaevsky et al., 2006; 2007]. We used a model of the velocity of longitudinal waves for the mantle, calculated by the method of Taylor's approximation by Geyko V. S. [Geyko et al., 2005; Bugaienko et al., 2008]. Due to the fact that seismic methods differ by the type and frequency spectrum of the used waves in this work we consider the relative values of the velocity only.

Epicenters of the earthquakes weakly correlates with distributions of velocities of longitudinal ( $V_P$ ) and transverse ( $V_S$ ) waves and  $V_P/V_S$  in the crust and below the M boundary that are constructed accordingly to the ECWM and DSS data. These distributions are evidently dominated by the direction orthogonal to the strike of the folded structure of the North Caucasus and its main regional faults. Some correlation with discontinuous tectonics can be seen along the 45–46° longitude (fragment of the Transcaucasian regional fault), where at the latitude 44° a stepwise shift to the south for a cut of  $V_P/V_S$  is observed. In general, contours of the parameter  $V_P/V_S$  reflect more clearly the distribution of velocity heterogeneities in the crust compared with  $V_P$  and  $V_S$  slices. Clearly visible is the flexural bend of the contours along the longitude 46° coinciding with a high absorption zone [Shempelev et al., 2010]; more contrast appear the maximum of decreased  $V_P/V_S$  values beneath the Stavropol uplift (45–44° latitude, 41–43° longitude) and prevailed in central parts of plots south-western strike of  $V_P/V_S$  isolines. The highest values of  $V_P$ ,  $V_S$  and  $V_P/V_S$  are in better agreement with the regions of recent volcanic activity compared to the discontinuous tectonics of the Northern Caucasus folded structures. Comparison

with the contemporaneous geokinematic tectonic map of the region [Kopp, 2005] allows us to interpret the distribution pattern of  $V_P$ ,  $V_S$  and  $V_P/V_S$  in the crust of the North Caucasus as a reflection of its horizontal compression by the Arabian plate.

If we turn now to the results of processing and interpreting of seismological data, on the section corresponding to the 50 km depth a correlation between the earthquakes foci with the gradient zone of low values of the longitudinal wave velocities becomes evident. In the next section ( $H=100$  km) a picture of  $V_P/V_S$  distribution similar to the lower part of the crust attracts one's attention. Lower values of  $V_P/V_S$  for the Stavropol uplift correlate with a projection of low  $V_P$  values. This area coincides with area of the recent volcanic activity (Elbrus, Kazbek, etc.). Taking into account presence of gas fields within the Stavropol uplift and its frame the region of low  $V_P/V_S$  values in the lower crust may be explained by high gas content. In the middle crust the area of the relatively low  $V_P/V_S$  values expands that agrees with such interpretation. On sections at 150 and 200 km the  $V_P$  distribution pattern changes dramatically. From the depths of 150 to 200 km the low-velocity area beneath the Stavropol uplift is replaced by the high-velocity one, while the prevailed direction of the velocity contours changes to the south-west and south-east.

At depths of 250 and 300 km of the mantle beneath the North Caucasus is represented by the high-velocity area. In the depth interval of 350–400 km a pattern of the velocity distribution changes again — the sublatitudinal strikes of the low velocity isolines become apparent in the northern and southern parts of the region. In the 450–500 km depth interval the  $V_P$  in the northern part becomes

more slow, we assume that underthrusting of the Scythian plate beneath the East European platform may occur at this depth interval.

From the above analysis we assume that from depths interval of approximately 70—120 km inversion of the velocity distribution and correspondingly of the distribution of mantle heterogeneities starts. [Krasnopevtseva, Kuzin, 2009] on the seismic profile Volgograd — Nakhichevan have shown that the relatively high-velocity folded structure of the Greater Caucasus has a tendency to dive under the Scythian plate, this interval corresponds to the immersion of M ( $H=50$  km). At about the same interval a consistent series of mantle earthquakes with depths of foci 74, 97, 100, 115, 123, 150 km was recorded along the profile. Obviously, such a coincidence of focal depths of earthquakes and the beginning of the interval of inversion of elastic inhomogeneities distribution in the upper mantle is not accidental.

Vertical sections provide an opportunity to analyze the distribution of longitudinal velocities along 45, 43 and 41° N to a depth of 2500 km. Beneath the Stavropol uplift a picture of the velocity distribution differs significantly. To the east of 41—42° E the upper mantle represented by alternating layers: a low-velocity layer at a depth interval 50—150 km

replaced by high-velocity layer at 150—250 km interval and again turn into low-velocity layer that cross the 670 km border of the upper mantle and extend down to 1300 km. In the lower mantle velocity changes do not exceed  $\pm 0.025$  km/s from the reference zero velocity. In the western part of the area both the depth of the layers and velocity values change with the tendency to increase. The depth of the upper low-velocity layer increases to 300 km, of the underlying high-velocity layer — down to 500 km, while the low velocity layer appear at depths of 500—700 km. Anomalies of the velocity in the lower mantle are noteworthy. In contrast to the eastern part, here the alternation of high and low-velocity anomalies with deviations of  $\pm 0.10$  km/s from a depth of 1300 km to 2500 km are observed. Stavropol uplift and Volcano Elbrus with their specific set of anomalies of geophysical fields such as positive anomalies of the thermal field and electrical conductivity are confined to the area of gradient change in the distribution of longitudinal velocities which can be traced throughout the section to a depth of 2500 km.

In general, there is a good correlation between different surface structures of the crust of the North Caucasus and the distributions of velocity of longitudinal waves at all sections.

## References

- Belyaevsky V. V., Egorkin A. V., Solodilov L. N., Rakitov V. A., Yakovlev A. G. Some results of applying methods of natural electromagnetic and seismic fields in the North Caucasus // *Phys. Earth*. — 2007. — № 4. — P. 4—14 (in Russian).
- Belyaevsky V. V., Egorkin A. V., Zolotov E. E., Rakitov V. A., Avenisyan V. I., Konovalov Y. F., Nedyadko V. V. In-depth geological and geophysical studies by seismic prospecting (ECWM) and resistivity (MTS, GMTS, AMTS) methods in the regional profiles Eisk — Stavropol — Neftekumsk — Caspian Sea (850 km) and Corfe-Top Penzhina (500 km). Analysis and compilation of deep geophysical studies conducted in the North Caucasus, Kamchatka, and southern Siberia (report). — Moscow, 2006 (in Russian).
- Bugaienko I. V., Shumlyanskaya L. A., Zaiets L. N., Tsvetkova T. A. Three-dimensional *P*-velocity model of the mantle of the Black Sea and the adjacent territory // *Geophys. J.* — 2008. — 30, № 5. — P. 145—160 (in Russian).
- Geyko V. S., Tsvetkova T. A., Shumlyanskaya L. A., Bugaienko I. V., Zaiets L. N. Regional 3-D *P*-velocity model of the mantle of Sarmatia (south-west of the East European Platform) // *Geophys. J.* — 2005. — 27, № 6. — P. 927—939 (in Russian).
- Kopp M. L. Mobilistic neotectonics of platforms in South-Eastern Europe. — Moscow: Nauka, 2005. — 340 p. (in Russian).
- Krasnopevtseva G. V., Kuzin A. M. The mapping of tectonic activity of the junction zone of the Caucasus and the Scythian plate according to the interpretation of seismic profile of the DSS “Volgograd — Nakhichevan”. *Geologic hazards // Mater. XV All-Russian Conf. with int. participation.* — Arkhangelsk: Institute of Ecological Problems of the North ASC UB RAS, 2009. — P. 250—253 (in Russian).
- Shempelev A. G., Feldman I. S., Belyavsky V. V., Kuhmazov S. U. Results of deep geophysical investigations of the eastern part of the Terek-Kuma Depression // *Mater. XLIII tectonic meeting. 2.* — Moscow: GEOS, 2010. — P. 450—455 (in Russian).