Lithosphere structure of the Black Sea basin from seismic tomography and 3D gravity analysis

© T. Yegorova[1], T. Yanovskaya[2] , V. Gobarenko[1], E. Baranova[1], 2010

[1]Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine
egorova@igph.kiev.ua
valja-gobar@mail.ru
[2]St. Petersburg State University, St. Petersburg, Russia
yanovs@yandex.ru

Black Sea Basin is a back-arc basin formed in the Latest Cretaceous (or at the Cretaceous-Palaeogene boundary) at the hinterland of the Pontide magmatic arc. At present the Black Sea Basin is a flat abyssal plain with the sea floor at a depth of 2 km, which overlaps two large sedimentary basins in the western and eastern parts of the sea (the West (WBS) and East Black Sea (EBS) Basins), filled with thick (up to 12—14 km) Cenozoic sediments. These two basins are separated by the Mid Black Sea Ridge — a NW-trended linear structure of the basement uplift. Thick sedimentary cover masks poorly investigated basement and heterogeneous crystalline crust that is most likely represented by a collage of different microplates and terranes of different affinities, welded together by accretion during the closure of Neotethys. Recent reinterpretation of some existed in the Black Sea profiles of deep seismic refraction study [Baranova etal., 2008; Yegorova et al., 2010] and new seismic experiment in the East Black Sea Basin [Shillington et al., 2009] have shown that the WBS and the EBS basins are underlain by high-velocity (6.6—7.0 km/s) thin oceanic and semi-oceanic crust of 5—7 km thickness confined by the Moho boundary placed at nearly 20 km depth.

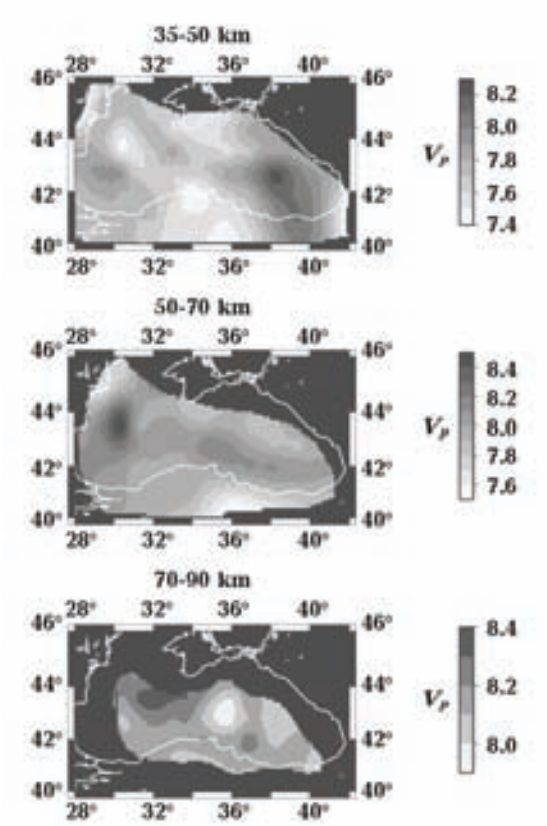
Despite active geological and geophysical explo-ration of the study region, little is known about the structure of lithospheric mantle below the Black Sea Basin. This information, together with distribution of recent seismicity, is of crucial importance for under-standing the geodynamic situation and governed tec-tonic processes in the region [Gobarenko, Yegorova, 2010; Yegorova, Gobarenko, 2010]. The present con-tribution deals with investigation of the velocity struc-ture of the Black Sea lithosphere by seismic tomog-raphy using the data from earthquakes occurred in-side the study region and recorded by seismic stations located along the coastline of the Black Sea. This velocity model was converted into density model in order to calculate the gravity signal from the lithospheric mantle, which was compared with mantle gravity anomalies derived from 3D gravity analysis using the back-stripping method.

Velocity distribution in the upper mantle was calculated using the seismic tomography method, which encompasses partitioning the medium on cells and defining in them velocity corrections. Ini-tial data were corrected for the crust impact, allo-wing us to derive precise information on velocity structure of the upper mantle. Resulting lateral varia-tions of P-wave velocities in the mantle lithosphere of the Black Sea are shown in Figure by horizontal slices of average velocities for the depth of 35—50, 50—70 and 70—90 km.

Derived velocity distribution represents the Black Sea Basin not as a single velocity domain, but rather heterogeneous one, where one can see two dis-tinct areas of increased velocities within the wes-tern and eastern parts of the Black Sea, which are separated by lower velocities in the central part of the sea. Gravity signal from the lithospheric mantle, calculated from density equivalent of this velocity model in Figure, outlines two areas of positive gravity (up to 80 mGal) in western and eastern parts of the Black Sea. They are separated by non-anomalous zone within the central part of the sea.

From the other side, mantle gravity anomalies were derived by back-stripping gravity analysis whereby gravity effect of constrained layers (seawater, sediments, crystalline crust) are removed from initial gravity field. The crust structure here is con-strained by new results from active seismic experi-ments [Baranova et al., 2008; Shillington et al., 2009; Yegorova et al., 2010] Gravity calculations were performed on 10 kma10 km grid.

Final residual anomalies of supposed mantle origin distinguish small positive values (to 40 mGal) in the western part of the Blacks Sea, whereas no significant anomalies were revealed in the eastern part — pre-vailing anomalies here range from zero to 20 mGal. These slight positive mantle anomalies might be indicative of isostatic equilibrium of the Black Sea deep structure, namely that negative gravity effect of sediments is substantially compensated by strong positive gravity impact of the Moho swallo-wing. In general these mantle anomalies agree with mantle gravity signal, derived from seismic tomo-graphy model (despite amplitude of the latter a bit higher of the former), and both are indicative of lack of the asthenosphere or mantle diapir at the depth less 100 km below the Black Sea. This corresponds also with very low surface heat flow density with pre-vailing values in the Black Sea of 30—40 mW/m2 and low deep temperatures estimated to be 500—600 at the depth of 30 km [Kutas et al., 1997].



Distribution of the *P*-wave velocities in the Black Sea lithosphere.

References

Baranova E. P., Egorova T. P., Omelchenko V. D. Re-interpretation of seismic materials of DSS and gravity modeling along the profiles 25,28 and 29 in the Black Sea and the Sea of Azov // Geophys. J. — 2008. — **30**, № 5. — P. 124—144 (in Russian).

Shillington D. J., Scott C. L., Minshull T. A., Edwards R. A., Brown P. J., White N. Abrupt transform from magma-starved to magma-rich rifting in the eastern Black Sea // Geology.— 2009. — **37**, № 1. — P. 7—10.

Yegorova T., Gobarenko V. Structure of the Earth′s crust and upper mantle of West- and East-Black Sea Basins revealed from geophysical data and its tectonic implications / Eds. R. A. Stephenson, N. Kaymakci, M. Sosson, V. Starostenko, F. Bergerat // Sedimentary basin Tectonics from the Black Sea and Caucasus to the Arabien Platform, Geolog. Soc. — London: Spec. Publ., 2010. — **340**. — P. 23—41.

*Gobarenko V. S., Yegorova T. P.*The lithosphere structure and geodynamics of the West and East Black Sea basins // Izvestiya, Phys. Sol. Earth. — 2010. — **46**, № 6. — P. 507—523.

Kutas R. I., Kobolev V. P., Tcvyashchenko V. A., Bevzuyk M. I., Kravchuk O. P. Geothermal model of the Black Sea Basin // Geophys. J. — 1997 — **19**, № 6. — P. 70—83 (in Russian).

Yegorova T., Baranova E., Omelchenko V. The crustal structure of the Black Sea from the reinterpretation of deep seismic sounding data acquired in the 1960s / Eds. R. A. Stephenson, N. Kaymakci, M. Sosson, V. Starostenko, F. Bergerat // Sedimentary basin Tectonics from the Black Sea and Caucasus to the Arabien Platform, Geolog. Soc. — London: Spec. Publ., 2010. — **340**. — P. 43—56.