Hydrodynamic-type model of relaxing media

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We consider a mathematical model of geophysical medium, taking into account effects of temporal nonlocality. This model was derived by G. M. Lyakhov on pure machanical ground in late 70th of the XX century, and had been substantiated by V. A. Danylenko and co-workers a decade later within the framework of phenomenological thermodynamics of irreversible processes.

The set of travelling wave (self-similar) solutions of the modeling system is shown to possess a compacton-like solution, if an external force of specific form is present. In contrast to the classical compactons appearing in the Rosenau-Hyman equation, the compacton appearing in the model under consideration is manifested at specific values of the parematers. In spite of such restriction, the compactly-supported travelling wave solution seems to be of interest, since it is shown to attract the near-by, not necessarily self-similar solutions. Using the numerical experiments, we show that solutions to Cauchy problems are attracted to the compacton if some energy criterion is fulfilled, regardless of the shape of initial data.

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

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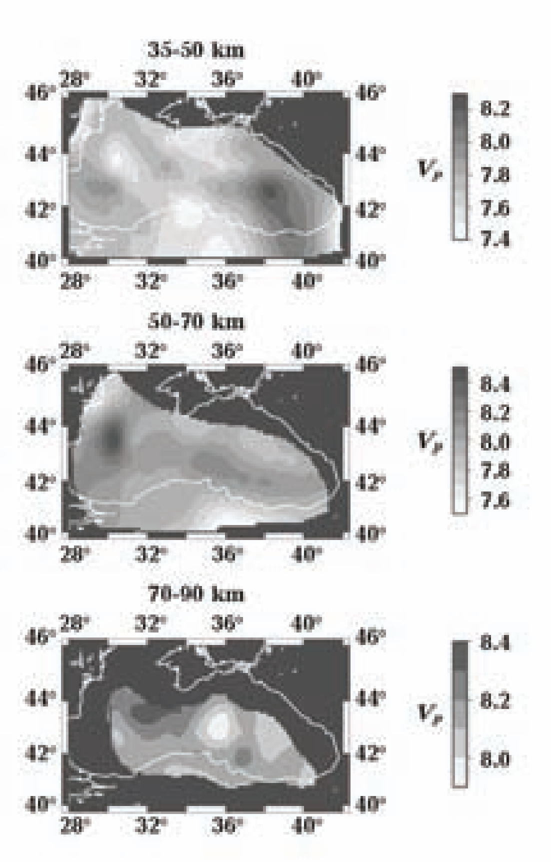
Black Sea Basin is a back-arc basin formed in the Latest Cretaceous (or at the Cretaceous-Palaeogene boundary) at the hinterland of the Pontide magmatic arc. At present the Black Sea Basin is a flat abyssal plain with the sea floor at a depth of 2 km, which overlaps two large sedimentary basins in the 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 et al., 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 exploration 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 understanding the geodynamic situation and governed tectonic processes in the region [Gobarenko, Yegorova, 2010; Yegorova, Gobarenko, 2010]. The present contribution deals with investigation of the velocity structure of the Black Sea lithosphere by seismic tomography using the data from earthquakes occurred inside 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. Initial data were corrected for the crust impact, allowing us to derive precise information on velocity structure of the upper mantle. Resulting lateral variations 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 distinct areas of increased velocities within the western 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.



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

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 constrained by new results from active seismic experiments [Baranova et al., 2008; Shillington et al., 2009; Yegorova et al., 2010] Gravity calculations were performed on 10 km×10 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 — prevailing 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 swallowing. In general these mantle anomalies agree with mantle gravity signal, derived from seismic tomography 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 prevailing values in the Black Sea of 30—40 mW/m^2 and low deep temperatures estimated to be 500—600° at the depth of 30 km [Kutas et al., 1997].

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Important influences of depth-dependent lower-mantle properties on the formation of a plume-fed asthenosphere in the upper mantle

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Asthenosphere is an old geological concept based on uncanny intuition of Reginald Daly in the 1920's. to explain surface geological observations with underlying mobility in mind.

The idea of a plume-fed asthenosphere has been around for a few years due to the ideas of Phipps-Morgan and his father Jason Morgan. Basiclly this calls for a dynamically induced mechanism instead of partial melting or a mineralogical phase change. Using a two-dimensional Cartesian code based on finite-volume method, we have investigated the influences of lower mantle physical properties on the formation of a low viscosity zone in the upper mantle in regions close to a large mantle upwelling. The rheological law is Newtonian and has both temperature- and pressure-dependences. An extended Boussinesq model is assumed for the energetics and both the spinel to perovskite and perovskite to post-perovskite phase transitions are considered. We have compared the differences in the behavior of hot upwellings passing through the transition zone in the mid-mantle for a variety of models, starting with constant physical properties in the lower-mantle and culminating with complex models which have the post-perovskite phase transitions and depth-dependent properties of both the thermal expansion coefficient and the thermal conductivity.

We found that the formation of the asthenosphere in the upper mantle in the vicinity of large upwellings is only possible in models where both depth-dependent thermal expansivity and thermal conductivity are included. The constant thermal expansivity and costant thermal conductivity models fail to deliver a hot low viscous zone, resembling the asthenosphere. Our findings argue for the potentially important role played by lower-mantle material properties on the development of plume-fed asthenosphere in the oceanic upper-mantle.