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Geophysical Models of the Earth s Crust Structure of the Northern Urals

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SUMMARY

The construction process of Earth crust geophysical model using observed geophysical field leads to solution of the inverse problem, which is classical example of ill-posed problem as its solution is unstable and not unique. It is possible to choose specific variant of density or magnetization distribution if additional information is presented. The purpose of this article is to show the results gained from the study of the structure of the Earth crust in Northern Urals using geophysical methods (seismics, gravics and magnetics).

Introduction

The geophysical methods are used for studying of the Earth crust structure. Using observed data we can calculate parameter distribution within the crust correlated for each geophysical field.
Such as we can calculate density distribution for gravitational field and magnetization for magnetic field. But it is possible to choose specific variant of parameter distribution if additional information is presented. So a problem of constructing complex Earth crust model using data of several geophysical methods is rather interesting. Along the Krasnoleninsk profile a seismic velocity cross-section is built, density and magnetization distributions are calculated, the main features of structure of the lithosphere top part of are revealed. For these profiles anew in uniform model representation interpretation of data deep seismic sounding (DSS), gravitational and magnetic is spent.

Seismic, magnetic and gravitational joint interpretation

In this part of paper we describe new results of construction of geophysical models lithosphere Northern Ural Mountains along the Krasnoleninsk profile. The profile is 700 km length. Deep seismic sounding have been made in 1987-1989 by Bazhenovsky geophysical expedition (Druzhinin at al,1990). According to seismic data the model of velocity of elastic longitudinal waves to depths of 40-50 km is constructed. We have applied interpretation method developed for differential sounding and based on apparatus of special fields of times and algorithm of the solution of the inverse kinematic problem. Error of calculated velocity values can be estimated by their comparison with velocity constructed by other methods (for example, using the head and reflected waves, and also values along another profiles). Three profiles DSS are crossed with the Krasnoleninsk profile: Vizhay-Tura, Sosva-Jalutorovsk and Rubin-2 (Figure 1).

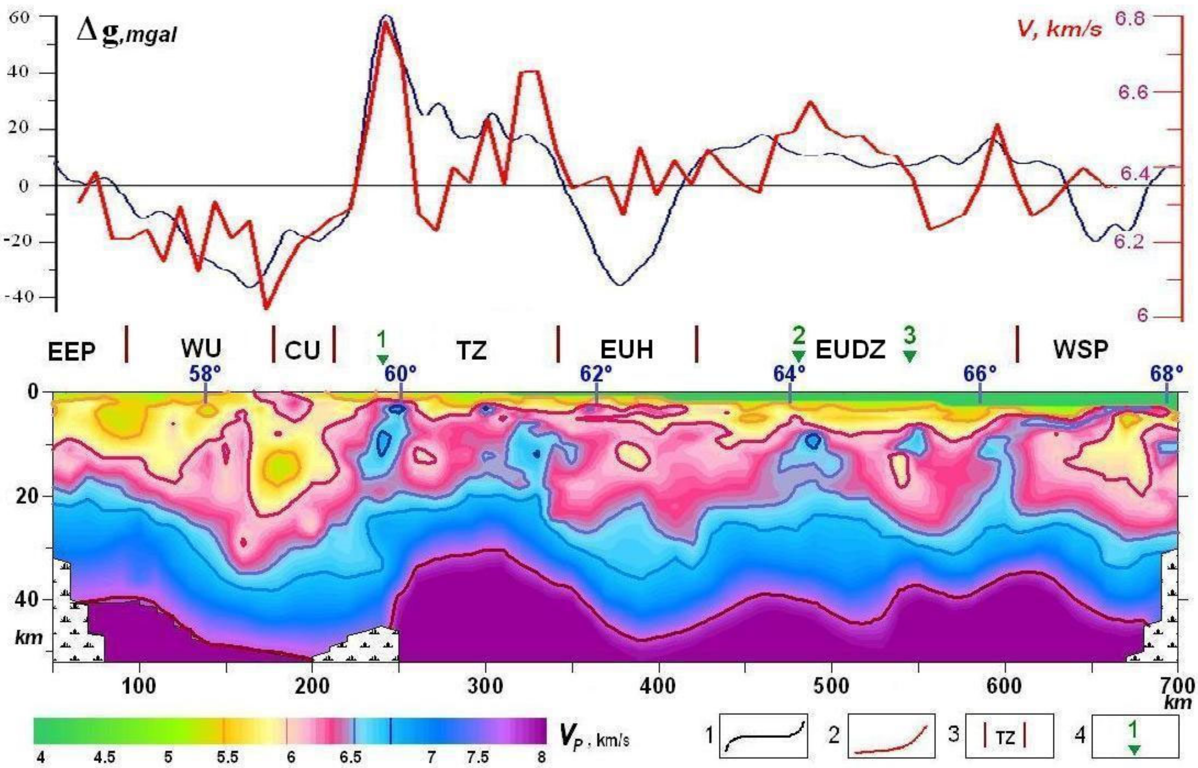

Figure 1 *Seismic transaction along Krasnoleninsk profile (Vp isolines): 1 – average velocity Vp graphic; 2 – gravitational field Δg; 3 – tectonic structures: EEP-East-Europe platform, WU – West Ural, CU – Central Ural, TZ – Tagil zone, EUH – East-Ural high, EUDZ – East-Ural deep zone, WSP –West Siberian plate; 4 – intersection points with DSS profiles: **1** – Vizhay-Orsk, **2** – Sosva-Yalutorovsk, **3** – Rubin-2.*

For these profiles we have constructed anew velocity cuts of Earth crust in uniform model representation. Comparison has shown that the error in definition of velocity corresponds 0,15-0,20 km/s, i.e. 2-3 %, and an error in definition of depths - about 5 %.

The main feature of elastic model of Earth crust of Northern Ural Mountains consists that against separate abnormal objects with high and lowered values velocity longitudinal waves Vp there are two areas with different elastic properties: West Ural and East Ural. The most contrast is the zone of a joint of a crust lowered values velocity the West Ural area and high values velocity Tagilsky, boundary between two named areas and closer on high values velocity to the East Ural structures. On a cut in this zone sharp increasing of all high values velocity levels with amplitude more than 10 km, including for an isoline of speed Vp=8,0 km/s are observed. In the top part of a crust of the Tagilsky and East Ural zones high values velocity blocks are allocated.

If we know seismic velocity values we can calculate density of layers of the lithosphere top part. In crystal earth crust are allocated 9 layers correlated to Vp average values from 4,75 to 8,0 km/s, with step ΔV_P =0,25-0,5 km/s. The Vp=8 km/s isoline was accepted to the bottom border of crust density model. We have considered of 12 layers model with horizontal bottom border on 80 km depth. As a result of the linear inverse gravitational problem solution coefficients of linear dependence of density σ and velocity Vp are defined: σ=0,2Vp+1,6; also density of layers are calculated.

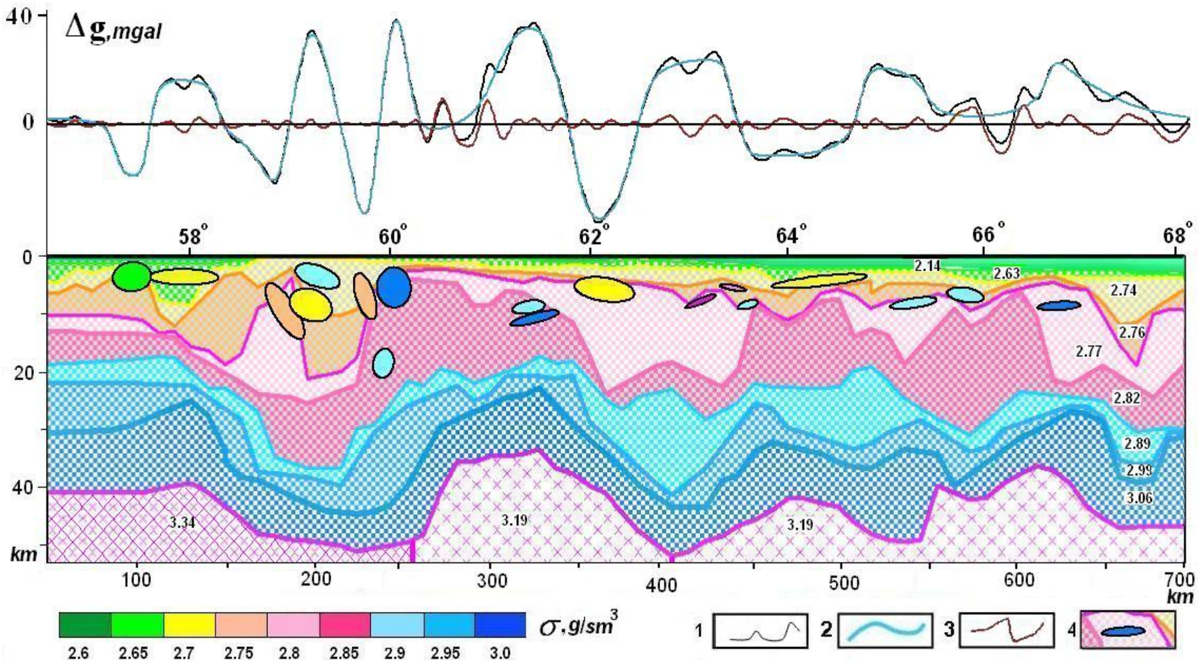

***Figure 2** Residual gravitational anomalies and density of Earth crust along Krasnoleninsk profile: 1 – residual gravitational anomalies; 2 – local sources gravitational field; 3 – model and anomalous field discrepancy; 4 – local anomalies sources.*

The divergence between an initial abnormal gravitational field and a field of layered model is a field of residual anomalies. For these anomalies a nonlinear inverse gravitational problem was solved by Tsirulsky method (Tsirulsky at al, 1980). We make gravitational field inversion using two steps:

1) approximate observed data by the field of singular sources ,
2) solve inverse problem for this field – find local source with definite density values for each singular one. Density values are correlated seismic wave velocities.

As an approximation result of residual anomalies local sources are found and density distribution in the top part of a crust is specified.

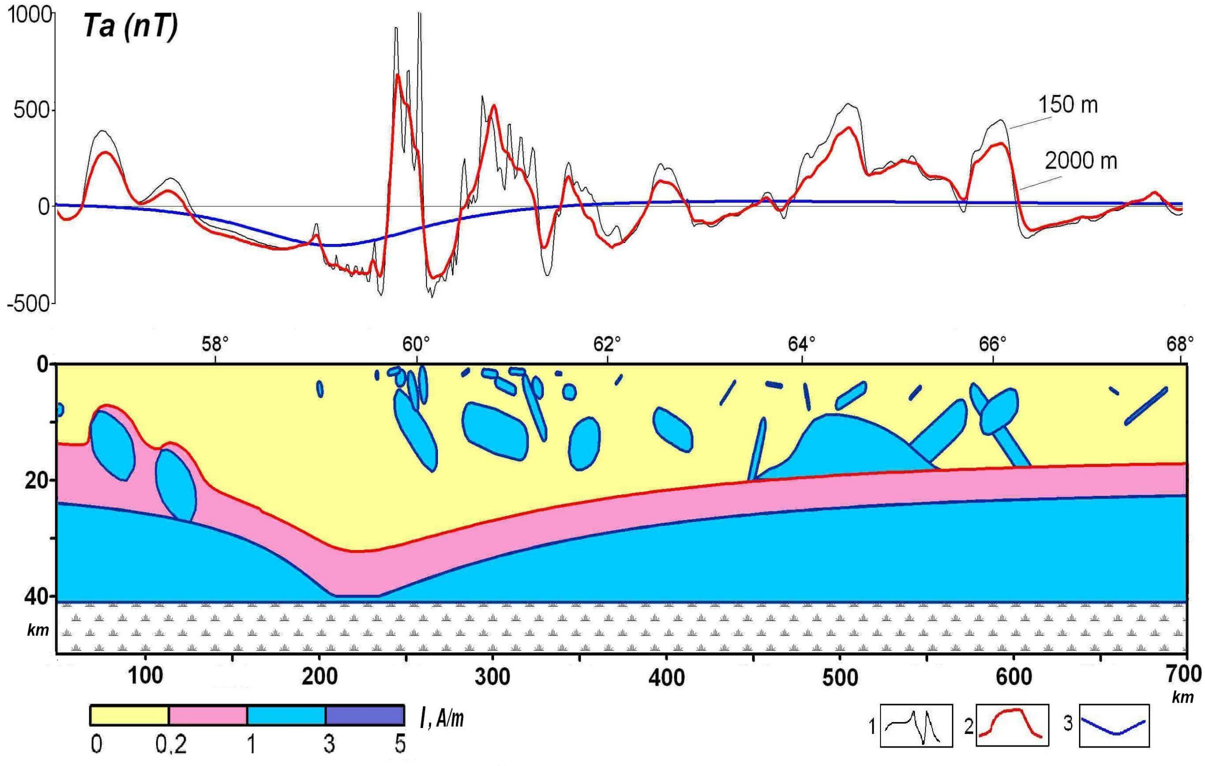

Figure 3 *Earth crust magnetization (I) along Krasnoleninsk profile.*
1 – anomalous magnetic field on 150 m; 2 – magnetic field on 2000 m; 3 – region field.

Magnetic airborne along Krasnoleninsk profile DSS is executed at heights 150 and 2000 meters (Chursin, Fedorova, Shapiro, 1998). Approximation of values of an abnormal magnetic field is executed for height of observation of 150 m, distribution singular sources is found. For the sources located in the top part of a cut, the geometry of contours is calculated for magnetization 3 A/м. In the Ural structures magnetic bodies are located in the crust top part mainly and are connected with basic and ultra basic structure.

Negative anomaly corresponded singular source located considerably below a sole of earth crust is allocated as a result of approximation of an abnormal magnetic field. Intensity of anomaly reaches ~-200 нТл, extent of ~200 km. Doing this regional anomaly inversion we have founded equivalent borders with depths 15 and 22 km and magnetizations 1-3 A/м.

As we can see from figures 1, 3 magnetic anomalous sources are located in regions where Vp>6 km/s and magnetic sources almost always are contained in the top layer of a crust blocks (if Vp>6.5 km/s); in the western part of a profile the isoline Vp=6 km/s plunges from depth of 8 km almost to 30 km. There are low velocity block and a magnetic field the regional minimum is observed. As a result of interpretation negative regional magnetic anomaly in a cut it is possible to allocate almost not magnetic block near the Western Ural Mountains and to track depth of immersing of ancient magnetized breeds of the base of the East European platform under the Ural structures.

Conclusions

Along Krasnoleninsky profile DSS the velocity cut of crust is constructed, density and magnetization values in earth crust is calculated. An original algorithms were used for geophysical data inversion. The computer technologies were developed at Institute of geophysics of UB of the Russian Academy of Sciences.

Joint inversion based on various geophysical data allows to determinate main structure features, to calculate rock physical parameters. As a result we can stable construct crust models. From geodynamical point of view such models are very interesting objects as well for geophysical exploration.

Acknowledgements

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