SIMPLE 2D GRAVITY-DENSITY INVERSION FOR THE MODELING OF THE SEDIMENTARY BASIN BASEMENT

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Introduction

Lateral density variations in the sedimentary basin basement can be calculated using gravity anomaly, depth-to-basement data and density data for the sediments (density-depth distribution, usually). Gravity effect of density variations in the basement is extracted from the total gravity anomaly by removing the joint effect of the sediments with vertical density variations and homogeneous basement of average density contrast. Bouguer slab formula was used in order to calculate the coefficient for the inversion of gravity effect of the basement into lateral density distribution. The procedure was tested using 2D models.

Method

Infinite horizontal slab is the simplest way to create the model of the basin basement. Bouguer slab formula is applied in order to invert gravity effect of the basement into lateral density distribution:

$$\Delta g_b = 2\pi K \Delta\sigma_b h_b ,$$

where K is gravitational constant, Δg_b is gravity effect of density variations in the basement at the observed point and h_b is height of the basement (difference between total depth of the model and depth of the basement, below the observed point). Density variation of the basement ($\Delta\sigma_b$) in each point (with gravity and depth-to-basement data) can be calculated as:

$$\Delta\sigma_b = \frac{1}{2\pi K} \cdot \frac{\Delta g_b}{h_b} = 23.85 \frac{\Delta g_b}{h_b}$$

where $\Delta\sigma_b$ is in [10^3 kg/m], Δg_b is in [10^{-5} m/s^2] and h_b is in [m].

Results and discussion

An example for the 2D gravity-density inversion is presented using the profile from Banat area in Pannonian Basin, Serbia (Fig. 1). Gravity anomalies were calculated using density value of $2.30 \cdot 10^3$ kg/m^3. Density-depth function ($\sigma_s = f(d)$) in the Cenozoic sediments was defined as quartic polynomial, using data from density logging in the boreholes located in different parts of the Pannonian Basin in Hungary (Szabo and Pancsics, 1999). Discretization of the density-depth function in sediments was conducted for the intervals of 200 m and density contrasts were calculated by subtracting the value of $2.30 \cdot 10^3$ kg/m^3 from the data. Average density of the basement is set to be $2.68 \cdot 10^3$ kg/m^3 (density contrast of $0.38 \cdot 10^3$ kg/m^3). Gravity effect of the Cenozoic sediments and homogenous basement was calculated using 2D modeling and then removed from the total gravity anomaly. Depth-to-basement data (Pigott and Radivojević, 2010) were used to model the lateral extension of deeper layers of sediments and the shape of the basement. The total depth of the model is set to be 5 km.

Density variations of the basement were calculated for each point along the profile (81 point, 500 m apart). In order to check the results of inversion, basement was separated into 2 km wide vertical blocks (Fig. 1a) and each block was assigned a median density contrast value ($\Delta\sigma_{b1}$) of 5 points along the block (Fig. 1c). Gravity effect of the first model (Δg_{m1}) was calculated (Fig. 1b) and compared to the gravity effect of density variations within the basement (Δg_b). Although the differences were not high, further iterations were needed. For the next iteration, the value of Δg_b was corrected for the gravity effect of the first model (Δg_{m1}) and corrected value ($\Delta g_b - \Delta g_{m1}$) was applied in the formula for density variation of the basement. Results of the new inversion were added to the previously obtained value of density contrast and the next model was created.

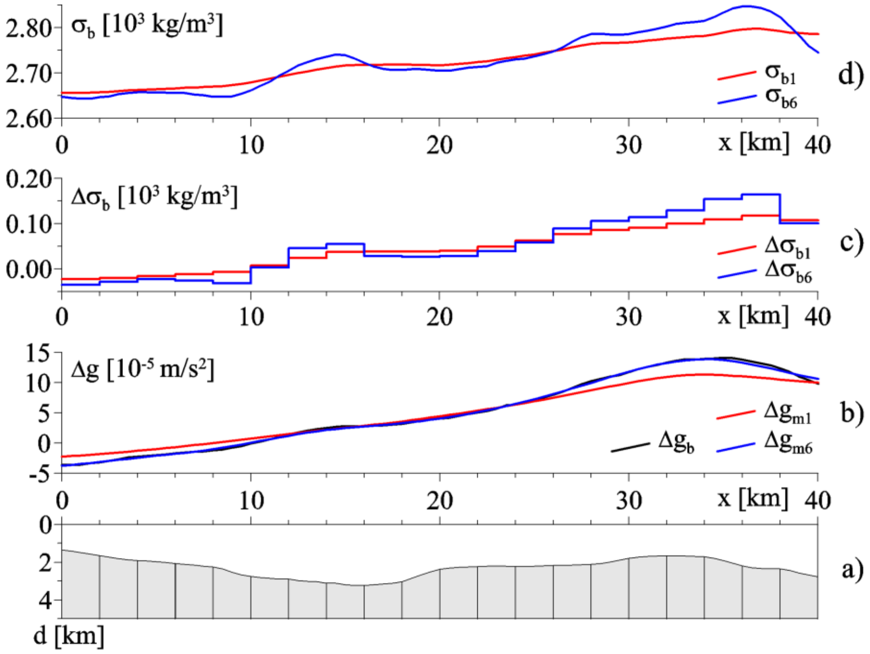

Figure 1. *Results of 2D gravity-density inversion: a) basement model, b) gravity influence of density variations in the basement (Δg_b) and of the first (Δg_{m1}) and sixth (Δg_{m6}) model, c) density contrast of the basement blocks for the first ($\Delta\sigma_{b1}$) and sixth ($\Delta\sigma_{b6}$) model and d) lateral density distribution of the basement along the profile after first (σ_{b1}) and sixth iteration (σ_{b6}).*

Procedure can be repeated as many times as necessary. In this case, satisfactory results were obtained after six iterations (Δg_{m6}). Lateral density distribution of the basement (σ_b) at each point was calculated by adding density contrast obtained by inversion ($\Delta\sigma_b$) to an average value of $2.68 \cdot 10^3$ kg/m^3 (Fig. 1d).

Conclusions

A procedure used for 2D gravity-density inversion for modeling of the sedimentary basin basement is not complicated, but it requires information about vertical density distribution in sediments, as well as depth-to-basement data. The result is presented as a curve of lateral density variations within the basement that can be used for further modeling. All available basement data can be used in order to compile more complex density distribution models, which can be transformed into geological models. The next step in the presented example is to incorporate data for the Mesozoic rock distribution and densities into a model and to unify the blocks with similar densities in order to define possible geological changes in Paleozoic formations.

Acknowledgements

This study was supported by the Serbian Ministry of Education, Science and Technological Development (Projects no. 33003 and 176016).

References

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