The interpretation of new geophysical measurements in the area of northern Slovakia

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Abstract: During the last four years some new geophysical results were obtained within the frame of the international project "Structural – geological conditions of Western Carpathians in border areas of northern Slovakia and their interpretation by means of geophysical measurements". The project was funded and supported by the Ministry of Environment of the Slovak Republic. The aim of this project was the interpretation of deep and subsurface geological structures in the territory of northern Slovakia along detailed measured transects.

The following geophysical measurements were performed: gravimetry, magnetometry and vertical electrical sounding (AB = 4000 m).

The main task of gravity processing was unification of all gravity data (from the territory of Slovakia and Poland). The quantitative interpretation along six gravity profiles has been realized using GM.sys software, too.

The interpretation of geoelectric data consisted of reinterpretation of older geoelectric measurements and new measurements realized in the frame of this project. The results from this interpretation helped us to define structural-tectonic and lithological units to depth of about 1 km.

Geomagnetic measurements were realized by means of PM-2 proton magnetometer along measured gravity profiles.

For reinterpretation of deep geological structures a new reprocessing of deep reflex

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seismic profiles (2T/83, 84; 2AT/84; 512/86 1T/80 a 513/87) has been done (12 sec.). These profiles have been used to define the most important tectonic boundary-lines and to creation of final geological - geophysical cross-section.

Key words: Western Carpathians, gravity, geophysical measurements, geological-geophysical interpretation

1. Introduction

The territory of northern Slovakia, especially between Poland and Ukraine, belongs to the least explored areas in Slovakia. In the frame of the international project mentioned above an investigation area with a width of about 50 km from the border of Czech Republic, Poland and Ukraine has been selected.

On the basis of this project the following tasks have been done:

- collection of geophysical and geological information from the area of interest and a background research has been performed.

- compilation of geological map in the scale of 1 : 500 000 containing main tectonic lines and geologic units

- realization of a new field geophysical measurements, data processing and it's interpretation

- exchange of gravity data between Slovakia and Poland, unification of data and compilation of joint Bouguer anomaly map, calculation of transformed gravity maps and maps of the most significant anomaly sources of gravity and magnetic field

- re-processing of reflex seismic profiles (2T/83, 84, 2AT/84, 512/86, 1T/80, 513/87), interpretation of these profiles

- quantitative interpretation of new-measured gravity, magnetic and geoelectric data

2. Bouguer anomaly map

The territory of Slovakia and southern part of Poland is covered by relatively homogeneous grid of gravity points (2–4 points/km^2) – besides the Tatra Mts. area where the measurements due to the extreme height conditions have been realized only sporadically.

By agreement of Ministry of Environment of Slovak Republic gravity data were exchanged between companies Geocomplex, a.s. and Przedsiebiorstwo Badań Geofizycznych Warszawa in trans-border areas and a joint map of Bouguer anomalies with density 2.67 g.cm^{-3} has been calculated according to *Švancara* formula *(1996)* (Fig. 1). Before that there was a requirement to uniform all data according to agreed standards:

- transformation of all gravity station co-ordinates to S-42 system
- introduction of IGSN 71 system
- applying new gravity latitude formula for WGS84 ellipsoid
- calculation of terrain corrections within 166.7 km radius
- consideration of the Earth's curvature (Bullard)

More than 270 000 original gravity stations have been used to calculation of this map using Oasis Montaj software (grid size: 500×500 m; isoline step: 0.5 mGal).

The compiled Bouguer anomaly map (Fig. 1) reflects the summary gravity effect of all inhomogeneities in the lithosphere. As we can see the gravity sources of this map can be divided into sources generating regional anomalies of a larger extent and sources generating local anomalies. The Bouguer anomaly map in Slovak part is more complicated than in Poland part because of relatively more complicated geological setting in the territory of Slovakia. Structures of gravity field can be divided into three parts:

A) Northern peri-Pannonian positive gravimetric area.
This area spreads from the territory of Central and Inner Carpathians to the Pannonian basin. This whole area is divided to the Danube-Váh (A1), South Slovakian (A2) and East Slovakian subareas (A3).

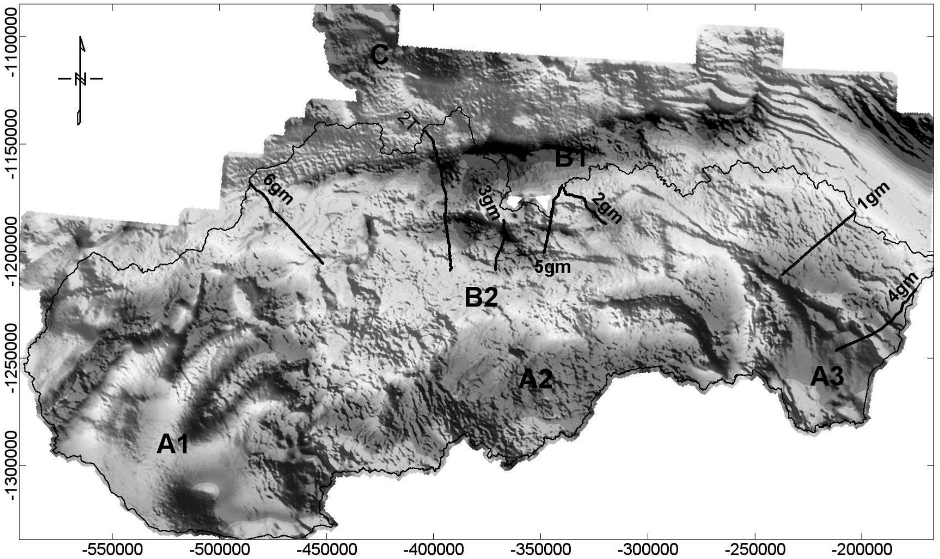

Fig. 1. Compiled Bouguer anomaly map (grid size: 500×500 m; isoline step: 0.5 mGal). Compiled by *Katona (2004)*.

B) The zone of Carpathian gravity minimum.
This zone is divided into two parts: the outer gravity minimum (B1) and the inner Carpathians minimum (B2).

C) Southern slopes of Sliezska positive gravimetric area.

The main task of applied geophysical measurements was the study and quantitative interpretation of deep structures along 6 measured gravity profiles (1 gm – 6 gm and profile 2T, too). Detailed gravity measurements realized on these profiles by means of CG-3 gravity meter (total length of about 206.6 km) were oriented perpendicularly to gravity gradients and main geological structures. The situation of profiles is presented in Bouguer anomaly map (Fig. 1). After standard data processing and calculation of Bouguer anomalies geological-geophysical initial models were prepared using GM.sys (NGA) software. For the 2.75D density modeling we used the geological map of Western Carpathians, interpretation of deep reflection seismic profiles in Western Carpathians (*Biely et al., 1995*) and the newest information resulting from Celebration (2000) project *(Vozár et al., 2002)* were used, too. Some dependencies could be applied from magnetoteluric measurements *(Stefaniuk et al., 2002, 2003).* Before the interpretation a geological cross-section along every profile was constructed by M. Potfaj (GSSR of SR) on the basis of known geological and petrologic data. For the area of Poland we used especially depth data related to European platform *(Źytko, 1997, 1999)*, the extent of Miocen cover *(Oszczypko and Slaczka, 1989)* or the base of Carpathian nappes *(Roure et al., 1993).* In this paper only one gravity profile is presented.

3. Profile 6 gm

The orientation of gravity profile 6 gm is NW–SE and it crosses almost the main geologic units of Western Carpathians – Malá Magura crystalline complex and its Mesozoic cover and nappes (Kľačno village), the Inner Carpathian Paleogene of Domaniža depression (Pružina village), Manín zone and neogene sediments of Váh river (Púchov), complicated structure of Klippen belt and it ends in the Flysch belt (state boundary with Czech Republic).

Our model (Fig. 2) was prepared in two ways: first the known geological situation from the surface was extrapolated to the depth along the profile line, and second the approximate large-scale physical properties of the lithosphere were plotted to this profile. Geological cross-section along this profile was compiled by M. Potfaj. The definition of deep structures was adopted from deep seismic profile 5HR/87 *(Vozár et al., 1999).* In this model we have accepted and adopted known data about deep density interfaces (MOHO, astenosphere-lithosphere boundary) resulting from the newest works published by *Bielik (1998)* and *Bielik and Šefara (2002), Makarenko et al. (2002), Bielik et al. (1999), Dérerová and Bielik (2003).*

The beginning of profile 6 gm is situated in the area of Magura flysch nappes – Rača and Bystrica nappes made mainly of Paleogene flysch formations. In the western parts the nappes are diagonally truncated against the Pieniny Klippen belt. The occurrence of these flysch rocks ($\rho = -0.04$ to -0.01 g.cm^{-3}) is well correlated with negative gravity anomaly.

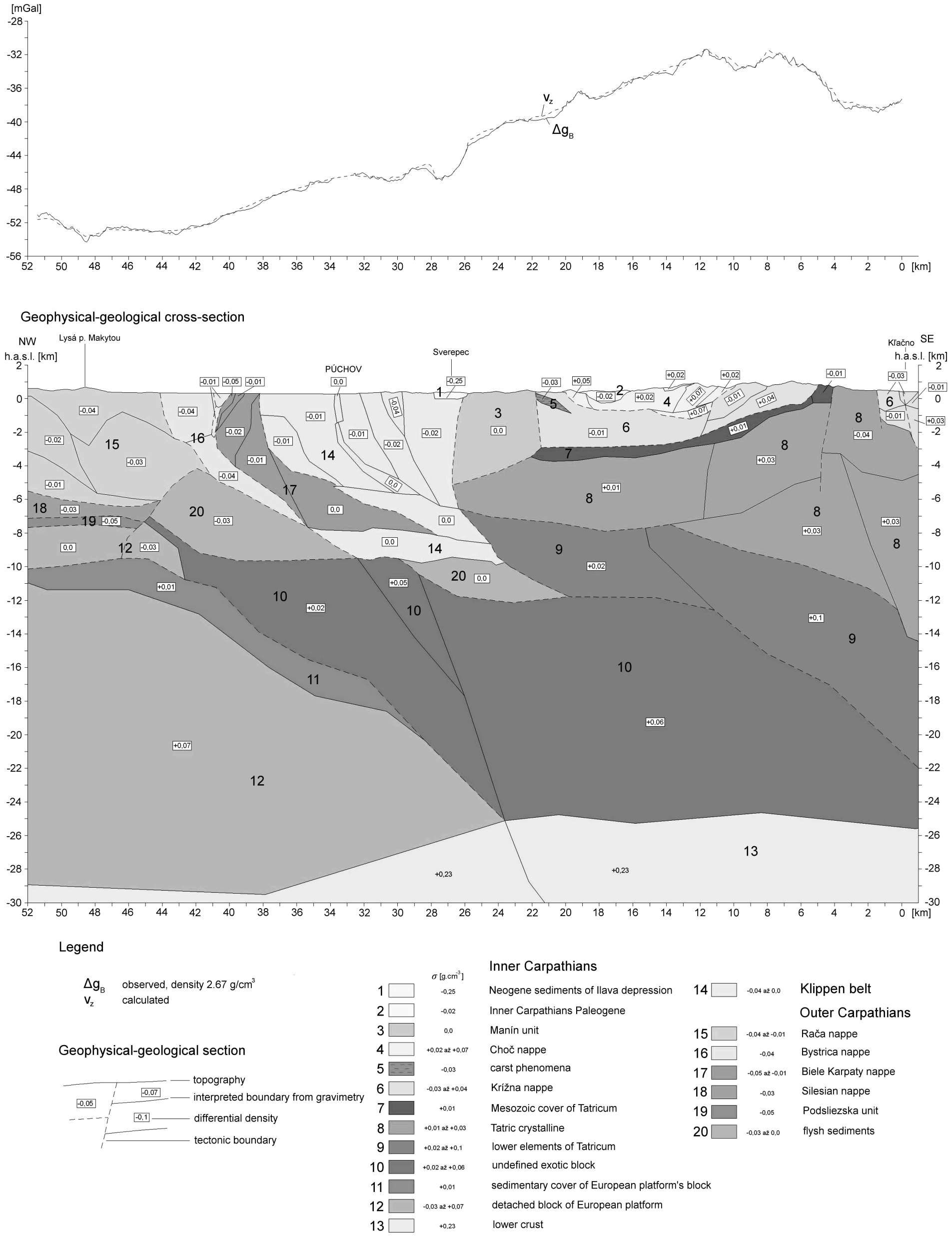

Fig. 2. Results of gravity modeling along profile 6 gm. Compiled by *Katona and Potfaj (2004)*.

Under these complexes we interpret Silesian nappe ($\rho = -0.03$ g.cm^{-3}) and Undersilesian nappe ($\rho = -0.05$ g.cm^{-3}) that have tectonic contact with underthrusting European platform ($\rho = +0.07$ g.cm^{-3}). The flysch rocks of Biele Karpaty nappes we divide into three blocks differ by density ($\rho = -0.02$ to 0 g.cm^{-3}). Lower boundary we interpret in the depth of about 8.5 km and the deepest block passes under the Klippen belt.

The zone of Klippen belt we interpret to the depth of about 10 km as several steeply bedded blocks that differ by densities ($\rho = -0.04$ to 0 g.cm^{-3}).

Further tectonic segments belonging to Inner Carpathians are formed of Tatricum blocks composed of the crystalline basement and overlain by Mesozoic cover. The presence of leucocrate granite to granodiorites in the frame of Malá Magura crystalline complex ($\rho = -0.04$ g.cm^{-3}) induce a negative zone in gravity field. Downwards the density of these complexes increases to +0.03 g.cm^{-3}. The Mesozoic cover units of Tatricum ($\rho = -0.01$ to +0.01 g.cm^{-3}) contact with Krížna nappe, which is represented on the surface by Cretaceous and Triassic rocks – dolomites, limestones, marlstones ($\rho = -0.01$ to 0.04 g.cm^{-3}). Choč nappe is represented by dolomites ($\rho = +0.07$ g.cm^{-3}).

4. Conclusion

The paper brings brief overview of the results in the frame of the task of the international project "Structural – geological conditions of Western Carpathians in border areas of northern Slovakia and their interpretation by means of geophysical measurements". Some of examples and results for the purpose of subsurface studies were limited to the research in which newest technologies were used: gravimetry, magnetometry and vertical electrical sounding (AB = 4000 m). The study of some special selected geological-geophysical and tectonic phenomena is based on quantitative interpretation of different geophysical fields.

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