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Gravimetric map of the western part of Slovakia and its possible interpretations

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Abstract. The aim of our contribution is to characterise briefly the most important gravity anomalies in the northwestern protrusion of the Pannonian Basin, or the anomaly of the Vienna and Danube Basins. The contribution contains also quantitative interpretations of two profiles. We also discuss the problems of the Kolárovo anomaly, which is, from the viewpoint of the intensity of gravity field manifestations in the area under study, the most marked structural phenomenon. The general gravity field image is documented by a map of total Bouguer anomalies and a map of residual anomalies with indication of horizontal gravity gradients.

Key words: gravimetric measurements, gravity anomalies, Bouguer anomalies, gradient, geophysical and geological interpretation, Danube basin.

Introduction

The area under study was the subject of a large number of geophysical measurements. From gravimetric measurements and interpretations we should erhaps mention the works concerning regional gravimetric mapping on the scale 1:200 000 (IBRMAJER 1963) and 1:25 000 (team of authors). In the last time, profile measurements have been carried out in the Vienna Basin, aimed at direct carbohydrate survey (MIKUŠKA et al. 1992-1995). These works have been realised on behalf of the company Nafta Gbely a.s. and they are not accessible in the Geofond files. From more recent works dealing with the region under study there were carried out investigations within the project MGII (Maps of geophysical indications and interpretations): MGII Danube Basin - Northwest (PANÁČEK 1987), MGII Chvojnícka pahorkatina Hills (SZALAIOVÁ et al. 1994), MGII Tríbeč (LANC et al. 1995). An interpretation of the Danube Basin in the southern part of the area has been carried out within the project DANREG, which is still continuing. In 1996, a part of the project Geodynamic Model of the Western Carpathians - A synthesis of the deep structure of the Western Carpathians - Western Slovakia was realised by SZALAIOVÁ & ŠANTAVÝ. In the last mentioned study there are summarised the results of gravimetric works carried out for different purposes. From other works we shall mention the project Bratislava - Environment (HRICKO et al. 1993), where, besides detailed gravimetric measurements, other geophysical measurements were realised as well.

Qualitative interpretation

For the purpose of a qualitative interpretation of the gravity field, we calculated from data of regional gravimetric mapping 1 : 25 000 a map of total Bouguer anomalies (TBA), for the reduction density 2.67 kg.dm^{-3} (Fig. 1). These measurements were evaluated in several technical reports, in which there are described the methods of field work, there is calculated the precision of the measurements and the gravity anomalies are briefly evaluated. A list of regional gravimetric mapping on the scale 1 : 25 000 has been presented in SZALAIOVÁ & ŠANTAVÝ (1996). Besides the TBA map derived maps were calculated too for the purpose of qualitative interpretation (Fig. 2): the map of residual gravity anomalies r = 4000 m, map of regional anomalies and the map of horizontal gravity gradients calculated for r = 4000 according to Blakely.

The first look on the TBA map allows to distinguish intensive regional anomalies. Positive anomalies are regularly alternating with negative ones, and it is important to note the almost parallel positions of the principal axes of the anomalies, both positive and negative ones.

Positive anomalies are caused by the Tatric rock complexes of the "core" mountain ranges. They are the anomalies of the Malé Karpaty, Považský Inovec, Tríbeč Mts. The hidden elevation of the pre-Tertiary underlier in the area of Kolárovo, the so-called "Kolárovo anomaly", is caused by heavier rocks (approx. 2.9 - 3.00 kg.dm^{-3}), probably ultrabasic, ultramafic rocks, amphibolites etc. (BIELIK et al. 1994). Quantitative interpretation - modelling of the Kolárovo anomaly - was carried out by BIELIK et al. (1994). In the TBA map for the reduction density of 2.67 kg.dm^{-3}, it attains an amplitude of +28 mGal, and in the uncovered gravity map, after removing the effects of Tertiary complexes, the amplitude increases to +74 mGal.

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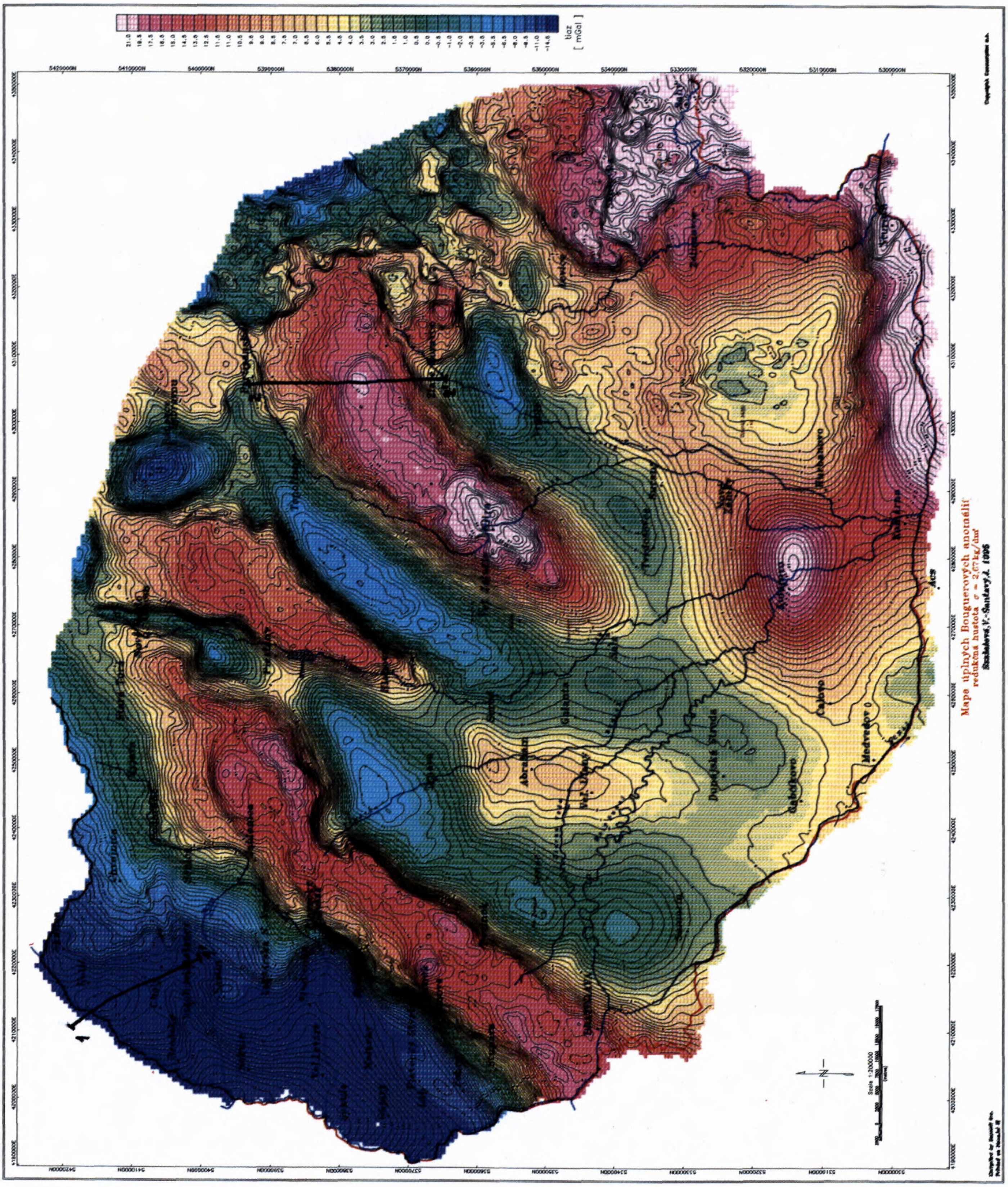
A relatively good correlation between gravity field amplitudes and depths of the underlier ascertained by boreholes may be observed here. It is interrupted only in the area of Kolárovo, Komárno and Čalovo, due to the presence of a basic body in depth, and the C and MOHO discontinuities being nearer to the surface plays a role too. Another positive anomaly is the anomaly situated approximately on the axis Medveďov - Šahy. It is caused by the protruding outlier of the Hungarian Mid-mountains, and it is often referred to as the Pelsso Unit, separated by the Ráb-Hurbanovo line from the Tertiary filling of the Danube Basin. It is built predominantly of Mesozoic rock complexes. The positive anomaly occurring approximately to the east of the Štúrovo-Želiezovce-Levice line is caused by the effects of the pre-Tertiary underlier, which is lying here near to the surface. An interesting positive anomaly occurs in the area Abrahám - Veľké Úľany. It is caused by pre-Tertiary rocks of the Považský Inovec Mts. In TBA as well as derived maps, in the northern part of the anomaly, we may follow a sharp linear gradient of E-W direction, indicating strike-slip tectonics between Abrahám and Trnava.

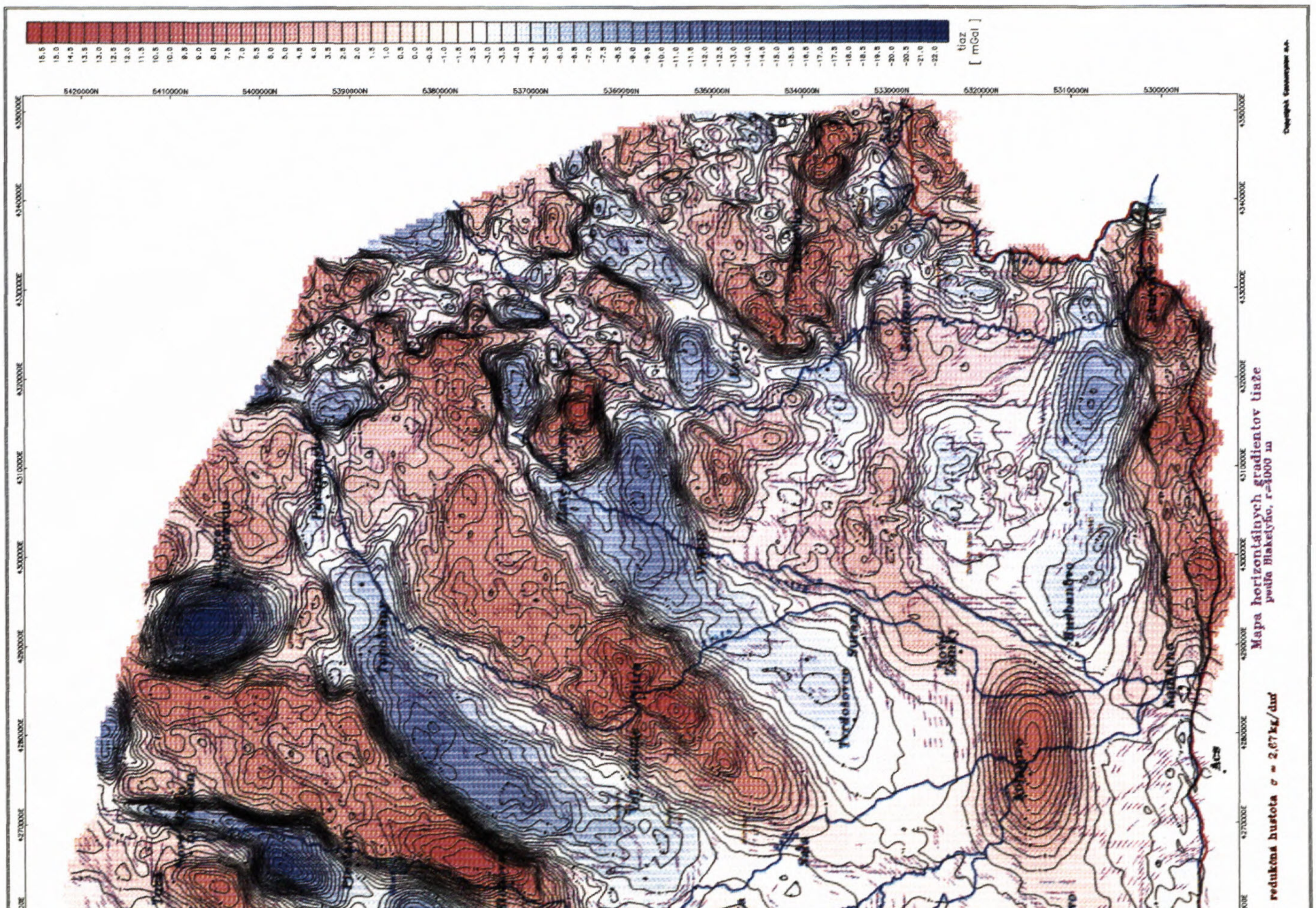
Negative anomalies correspond to light rock complexes of the Tertiary sedimentary filling of the Danube Basin, built predominantly of gravel-sand and clayei rocks. According to the intensity and geometry of isolines, we may estimate the thickness of the sedimentary complexes and their distribution in space. This is however not a rule. We shall present it on the example of the Gabčíkovo anomaly. In its area, as it is evident from the TBA map, there is a relatively positive gravity anomaly, even though according to borehole investigations and seismic interpretations, the pre-Tertiary underlier occurs in great depth. This phenomenon could be explained by the presence of neo-volcanic complexes in the Tertiary filling of the basin, which is confirmed by magnetometric measurements (GNOJEK & PUTNA in DŽUPPA 1993). The most marked negative anomalies correspond to depressions: the Blatná, Rišnov (frequently called the "Topoľčany Bay"), Bánovce, Komjatice and Dubník Depressions. The gravity anomaly in the area of Trnava, which is a part of the Blatná Depression, has, according to PLANČÁR and IBRMAJER (in FUSÁN et al., 1971) regional character and its source, judging from regional gravity anomaly maps for r = 12 and 20 km, is lying very deep. Neogene depression between the core mountain ranges and the depression on the eastern side of the Tríbeč Mts. display an amplitude of -10 to -20 mGal, while in other parts of the Danube Basin, in their southward continuation, it is only -2 to -6 mGal.

The gravity field is influenced by the presence of heavier masses in the underlier (the crust) and the MOHO- discontinuity is in the whole area under study approximately in the same depth. We may state that morphologic elements of the relief of the pre-Tertiary basement are very well reflected in the image of gravity field anomalies. Faults in the substratum show in the gravity field as a marked gravity gradient, in the sigmoidal bending of the isoanomalies at greater distances. In the residual anomaly and horizontal gradient map (Fig. 2) (SZALAIOVÁ & ŠANTAVÝ 1996) we may see a marked manifestation of density boundaries in NE-SW direction, which mostly correlate well with the known tectonic lines. The density difference between the Komárno uplifted block and the Dubník plateau is well visible too. This effect is partly obliterated by the effects of the Kolárovo anomaly. A more complex image occurs in the area of Levice. It is caused by neo-volcanites, and especially by the decreased thickness of the Tertiary filling, which enhances the effects of the pre-Tertiary structure of the area.

The Vienna Basin area (Fig. 3) is from the viewpoint of geophysical studies, especially seismic measurements, one of the most thoroughly studied areas in Slovakia. We shall briefly discuss the principal gravity anomalies of this area.

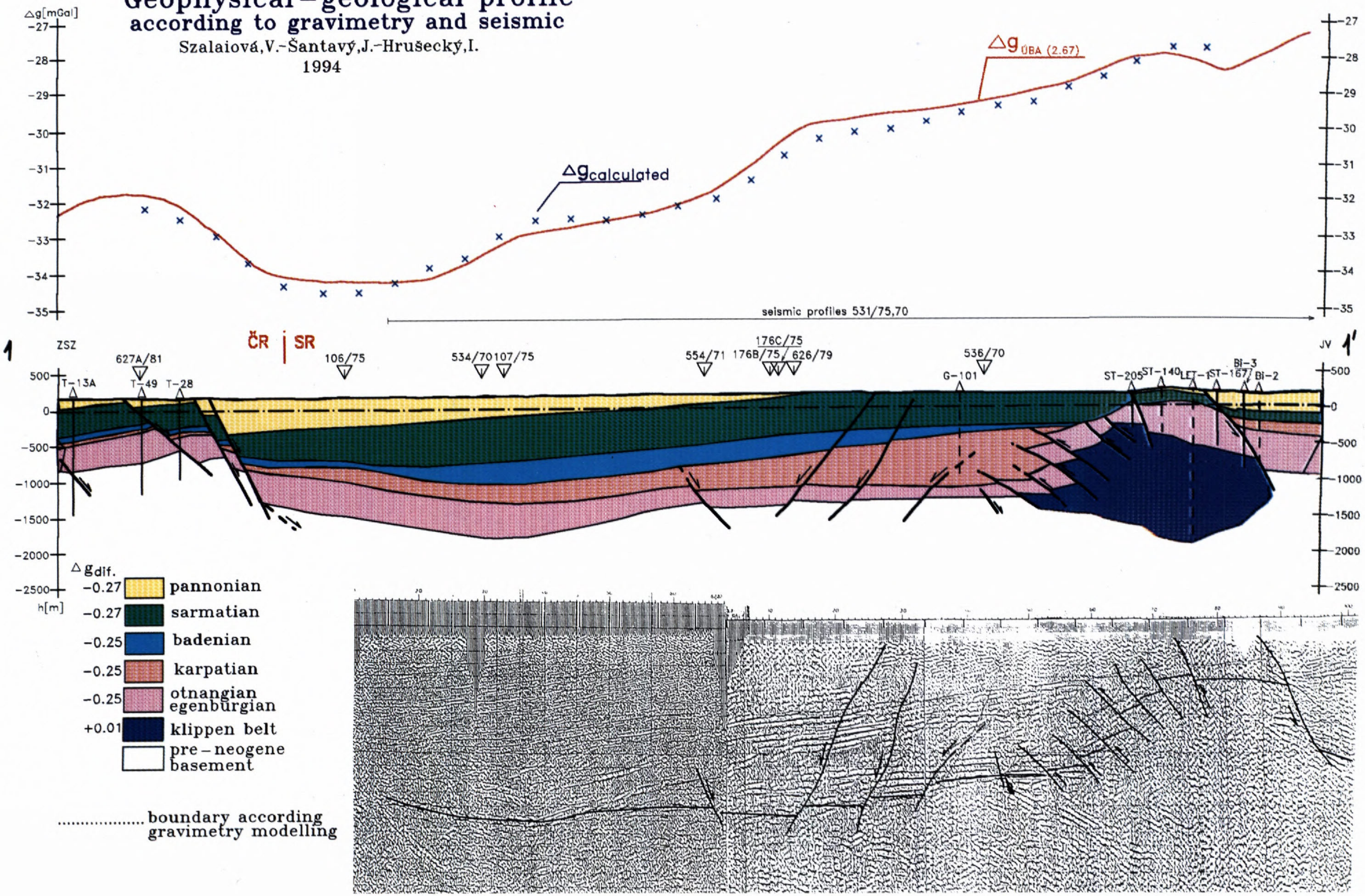
The most prominent gravity anomaly occurs in the area of the Kúty Depression (as much as -40.5 mGal). Its centre is situated in the surroundings of Kúty and the depression is tectonically restricted. In north it is restricted by the Hodonín-Gbely fault, forming, together with the Lužice-Brod fault, the Hodonín-Gbely horst. The depression is defined by the Svätý Ján fault. Another marked negative anomaly (-34.5 mGal) - the Kopčany Depression - is found at the village Kopčany. We assume it has tectonic boundaries, as on its southern side there is a marked gravity gradient. In the south-west of the area, in the surroundings of the town Šaštín-Stráže, there is a relatively positive anomaly (-24 mGal). Its northern boundary is from the TBA map not clear. This anomaly is caused by the presence of rocks of the Choč unit, having higher natural density, which is confirmed by the boreholes Ša 9, 10 and 11. The Štefanov elevation is overlapping with the Šaštín gravity field anomaly, which is deep-seated and affects the structural image of this area. Between Štefanov and Šaštín there is a tectonic contact of the Flysch Belt, the Klippen Belt and the belt of Mesozoic nappes, forming the southern part of the Vienna Basin. Among areally extensive anomalies there are also two anomalies east and west of the village Smrdáky. According to their interpretation (TOMEK 1975) and boreholes, the basement of this area is the Klippen Belt. As derived from the TBA map, several tectonic lines are cross-cutting here. This location should be interpreted in a greater detail, i.e. field measurements should be carried out here. The area west of the village Osuské up to Šaštín-Stráže is characterised by a gravity gradient, representing the downthrow of the basement of the Neogene along tectonic N-S lines into the Brezová Depression. Downthrows along these faults are synsedimentary (ĎURICA et al. 1986) and thus the thickness of sediments on equally old blocks may be different.

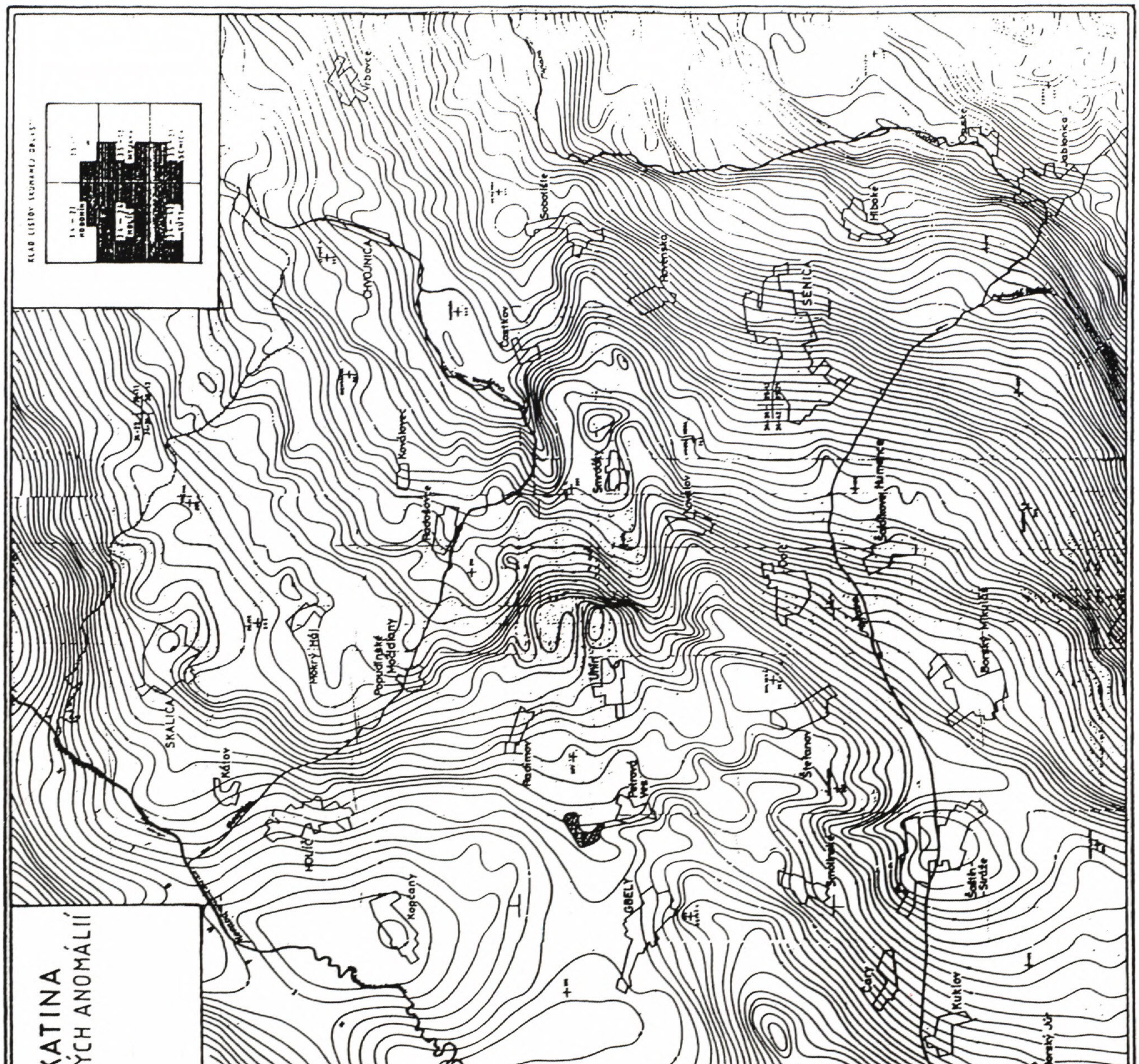


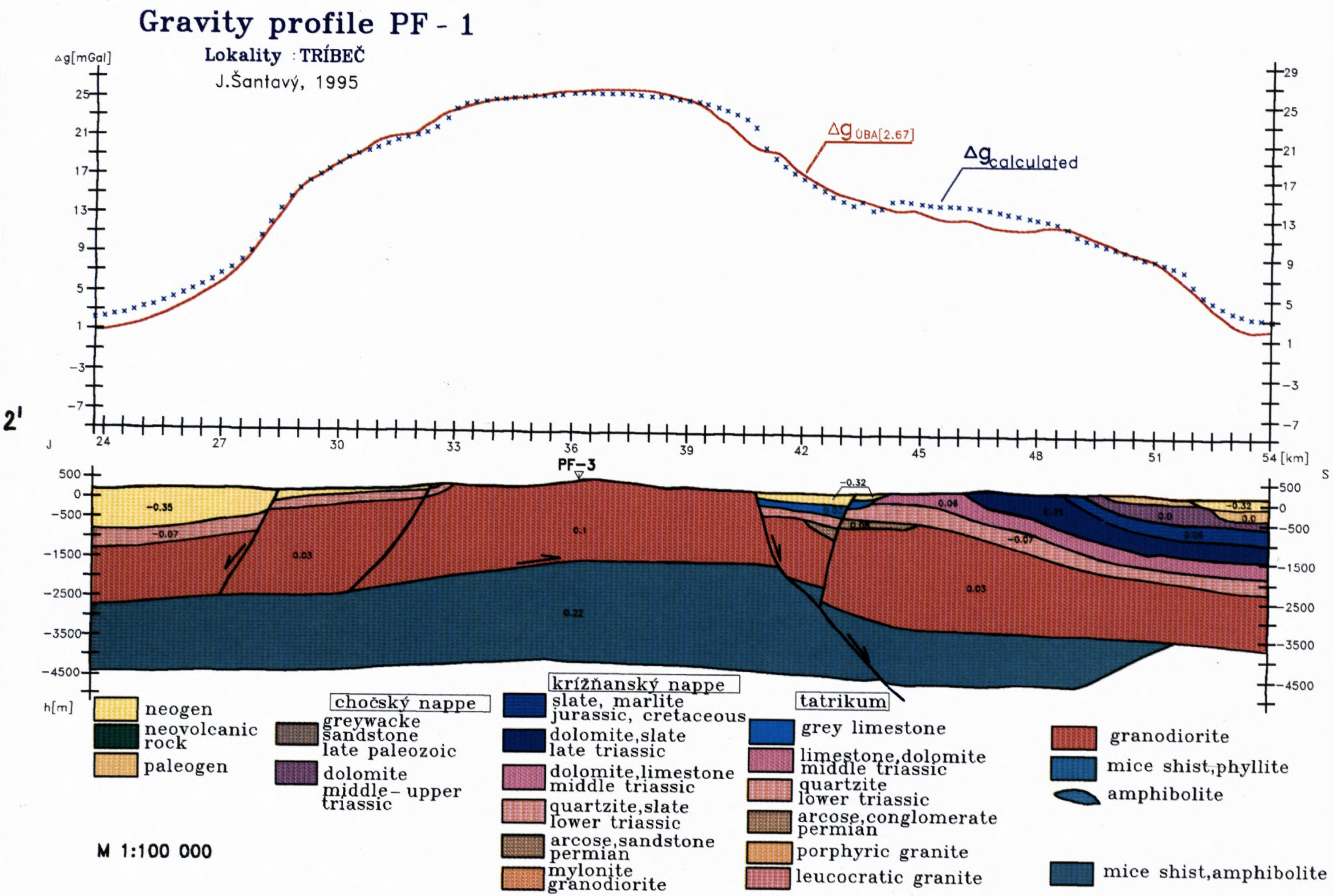

tiaž
[mGal]
Mapa tiažových reziduálnych anomálií
Mapa horizontálnych gradientov tiaže
indikácie hustotných rozhraní

Geophysical – geological profile according to gravimetry and seismic

Szalaiová,V.–Šantavý,J.–Hrušecký,I.
1994




CHVOJNICKÁ PAHORKATINA
MAPA ÚPLNÝCH BOUGUEROVÝCH ANOMÁLIÍ
G = 2,67 kg.dm-3
M = 1: 200.000
SENICA
SKALICA
CHVOJNICA
GBELY


Gravity profile PF - 1
Lokality : TRÍBEČ
J.Šantavý, 1995
Δg[mGal]
Δg ÚBA[2.67]
Δg calculated
2'
2
J
S
[km]
h[m]
PF–3
neogen
neovolcanic rock
paleogen
chočský nappe
greywacke sandstone late paleozoic
dolomite middle– upper triassic
krížňanský nappe
slate, marlite jurassic, cretaceous
dolomite,slate late triassic
dolomite,limestone middle triassic
quartzite,slate lower triassic
arcose,sandstone permian
mylonite granodiorite
tatrikum
grey limestone
limestone,dolomite middle triassic
quartzite lower triassic
arcose,conglomerate permian
porphyric granite
leucocratic granite
granodiorite
mice shist,phyllite
amphibolite
mice shist,amphibolite
M 1:100 000

Quantitative interpretation

As examples of a quantitative interpretation, we present the profile interpreted in the Vienna Basin - the part of Chvojnícka pahorkatina Hills (Fig. 4) and the profile situated across the core mountain range Tríbeč (Fig. 5).

The profile on Fig. 4 is crossing, from WNW, the Gbely-Hodonín Horst, the Kopčany Depression and it continues in SE direction towards the Klippen Belt. It is practically the seismic profile 531/70, 75, prolonged in WNW to the borehole T-13A. The profile displays gradual sinking of the structural elements of the Gbely-Hodonín Horst towards the Kopčany Depression. The profile 531/75 is located on the axis of the Kopčany Depression and it characterises its deeper part. In the area of Radimov it joins the profile 531/70, which continues to the Štefanov elevation and across the elevation to the Kovälov Depression. The surface of flysch is gradually rising towards the above elevation, from the depth of 1250 m on the normal Jánsky fault block, to approx. 600 m in the borehole Št-205. In the cross-section there is interpreted the crossing of the Farská and Jánske faults on the peak of the elevation (Bílek & Hrušecký 1988).

The profile on Fig. 5 is situated in N-S direction, approximately from Partizánske to V. Klíž to Lovce. Regional gravity measurement revealed a marked positive anomaly (TBA for the reduction density 2.67 $kg.dm^{-3}$), with a marked gradient on the southern margin of the Tríbeč Mts. It is possible to interpret quantitatively this anomaly only in the case of the presence of granitoid rocks with a great thickness, or of a heavy body below the granitoid rocks. As we do not have exact data on the thickness of granitoids in this area - there are no data available from a deep borehole - we interpret the thickness of the granitoid body in the model as approx. 2000 m, with a differential density of +0.03 $kg.dm^{-3}$, which, lithologically, may correspond to quartz diorites. Below the diorites, we modelled a body with a differential density of +0.22 $kg.dm^{-3}$ (Šantavý in Lanc et al. 1995). Its origin and composition is unknown, but it could be a micaschists-amphibolite block with a thickness of approx. 2500 m. We assume the above-mentioned heavy body to occur below the whole Tríbeč massif, and to continue and thin out towards the Komjatice Depression in the south. In west it is thinning out towards the Topoľčany bay, and northwards its thickness decreases to about 1500 m. The boundary at approx. 40.5 km corresponds to the Skýcov deep line.

Conclusion and discussion

In the presented paper we attempted to characterise, especially qualitatively, the principal gravity anomalies in the Danube Basin. In the TBA map the greatest effects are caused by core mountains, built of the Tatricum crystalline complex and its cover sequences, as well as the anomaly around Kolárovo, the probable source of which are ultrabasic rocks (Bielik et al. 1994). The interpretation - 3D modelling - yielded results on the probable distribution of the source of the Kolárovo anomaly in space. It has been determined that the anomalous body is asymmetric, elongated in the direction east-west, with its upper boundary in the depth of 5-6 km and lower boundary at 13 km (Bielik et al. 1994). According to Bezák et al. (1995) the Kolárovo anomaly is interpreted as a suture of Meliaticum which, during the disintegration of the orogen (extension), allowed astenospheric matter to ascend. The problems of the interpretation of the Kolárovo anomaly were addressed by a number of specialists and with increasing knowledge and new exact data we shall probably go back to them more frequently.

Besides the Kolárovo anomaly, we should notice the orientation of positive and negative anomalies to NE, which is very clear also in derived maps - the map of horizontal gradients and map of residual anomalies. In the TBA map we can follow also the probable horizontal strike slip of the block of the southern continuation of the Považský Inovec Mts. between Abrahám and Trnava. We think that interesting and new data for the qualitative interpretation could be gained from modelling on seismic profiles measured by the company MAXUS (Dallas, USA), which was carried out for the purpose of carbohydrate survey.

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