GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 34, 4, BRATISLAVA, AUGUST 1983,
Pp. 429—438

VINCENC VYSKOČIL* — MILOSLAV BURDA* — JOZEF PLANČÁR**

ON THE MANIFESTATION OF SHALLOW AND DEEP DENSITY INHOMOGENEITIES IN THE GRAVITY FIELD OF THE CARPATHIANS

(Tabs. 2, Figs. 6)

Abstract: The characteristic features of the anomalous gravity field of the West Carpathians in relation to neighbouring tectonic formations are discussed, as well as the effects of shallow and deep density inhomogeneities. Using more recent initial data, the correlation between Bouguer anomalies, depths of the crust-mantle boundary and elevations above sea level is investigated. It was found that Bouguer anomalies, corrected for the effect of lighter Tertiary sediments, display a closer correlation. Regression coefficients were used to estimate the magnitude of the density jump at the crust-mantle boundary which did not exceed the value of 0.15 g/cm^3.

Резюме: В работе обсуждаются характеристические черты аномального гравитационного поля Западных Карпат относительно соседних тектонических областей и в то же время влияния приповерхностных и глубинных плотностных неоднородностей. При использовании новейших исходных данных исследуется корреляция между аномалиями Буге, глубинами границы раздела кора-мантия и высотами над поверхностью моря. Оказывается, что более тесными корреляционными зависимостями обладают аномалии Буге, исправленные с учетом влияния более легких третичных седиментов. Значение плотностного разрыва на границе раздела кора-мантия, оцененное на основе регрессионных коэффициентов, не превышает 0,15 г/см^3.

Introduction

From what we already know, it follows that there is a quite close correlation in the Carpathians between Bouguer gravity anomalies and depths of the crust-mantle boundary (Vyskočil, 1974, 1977, 1979; Kvitkovič—Plančár—Vyskočil, 1976; Beránek—Ibrmajer, 1977; Vyskočil—Burda, 1980, 1982; Beránek—Zátopek, 1981). However, at the same time a quite pronounced gravitational effect of density inhomogeneities in the upper part of the Earth's crust can be observed (Ibrmajer—Doležal, 1961; Ibrmajer—Mottlová, 1963; Doležal, 1965; Šutor—Čekan, 1965; Buday—Dudek—Ibrmajer, 1969; Plančár, et al., 1977; Fusán—Ibrmajer—Plančár, 1979; Tomek—Švancara—Budík, 1979; Fusán et al., 1981; Ibrmajer, 1981; Tomek—Budík, 1981). In interpreting regional gravity anomalies and in constructing density models of the lithosphere, it is necessary to assess correctly the gravitational manifestations of shallow and deep density inhomogeneities. Some of the questions associated with this problem are discussed in this paper.

* Ing. V. Vyskočil, CSc., RNDr. M. Burda, CSc., Geophysical Institute of the Czechoslovak Academy of Sciences, Boční II, 141 31 Praha 4 — Spořilov.

** Ing. J. Plančár, DrSc., Geophysical Institute of the Slovak Academy of Sciences, Dúbravská cesta 9, 842 28 Bratislava. Died 27th January, 1983.

Characteristic features of the anomalous gravity field of the West Carpathians and of the neighbouring regions

The gravity depression which accompanies the whole range of Alpine orogenesis (Fig. 1) is the most pronounced in the map of Bourguer isanomals of Central Europe (Z o u b e k—V y s k o č i l, 1977). The lowest anomalies with values of —180 to —190 $\times 10^{-5}$ m/s^2 occur in the central part of the Alps. In the West Carpathians they only amount to —60 $\times 10^{-5}$ m/s^2, however, they become more pronounced again in the East Carpathians, where the values of the Bouguer anomalies drop to as low as —100 $\times 10^{-5}$ m/s^2. In the other regions of Central Europe their values fluctuate between —60 and +50 $\times 10^{-5}$ m/s^2.

Apart from its large magnitude, the Alpine gravity depression also differs from the Carpathian in the position of its axis which essentially copies the axis of the main mountain range in the Alps and also the axis of the largest deflection of the crust-upper mantle boundary, although the latter, according to the results of explosive seismology, seems to be displaced slightly to the south. (G i e s e—P r o d e h l, 1976; M i l l e r, 1980). In the Carpathians, the axis of the gravity depression lies roughly along the line Schwechat—Kúty—Uherský Brod—Valašské Klobúky—Bytča—Trstená—Czarny Dunajec—Stary Sacz—Krosno—Staryj Sambor—Drogobych—Dolina—Bytkov, and continues along the outer fringe of the East Carpathians on to Roumanian territory. As opposed to the Alps, in the Carpathians it is permanently located in their outer range. It crosses the Vienna Basin and comes close to the klippen zone in north-west Slovakia. In Poland, north of the High Tatra Mts it deflects from it again and, in the East Carpathians on the territory of the USSR, it runs into the inner zone of the foredeep.

The inner West Carpathians are located on the slope of this gravity depression which gradually adopts positive values (0 — 20 $\times 10^{-5}$ m/s^2) in south Slovakia and Hungary. Similar positive values of Bouguer anomalies also occur at the eastern margin of the Bohemian Massif and along the southern border of the Polish Palaeozoic Platform.

The values of the negative gravity anomalies in the Carpathians are affected by the lower density of Tertiary sediments, particularly in Neogene basins. For example, in the Vienna Basin the correction for the lower density of its sedimentary filling amounts to as much as 50 $\times 10^{-5}$ m/s^2 and, once it has been introduced, negative values of Bouguer anomalies practically vanish (T o m e k—B u d í k, 1981 . By introducing the correction for lighter sediments of the foredeep, the contrast of the regional negative anomaly becomes much less pronounced especially at the outer fringe of the East Carpathians. By introducing the correction for Neogene sediments in the Pannonian Basin and its spurs on the territory of Slovakia, the values of the Bouguer anomalies increase by as much as 40 $\times 10^{-5}$ m/s^2 (S t e g e n a, 1964; P o s g a y, 1980) and in some places perhaps by as much as 50 $\times 10^{-5}$ m/s^2.

It is slightly more difficult to estimate the correction for the lower density of flysch, however according to the results given in (D o l e ž a l, 1965; T o m e k—Š v a n c a r a—B u d í k, 1979) it may come to 20 $\times 10^{-5}$ m/s^2 or more.

By introducing the correction for the lower density of Tertiary sediments, the regional negative anomalies in the region of the outer Carpathians become less pronounced on the whole, while the positive anomalies of the Pannonian

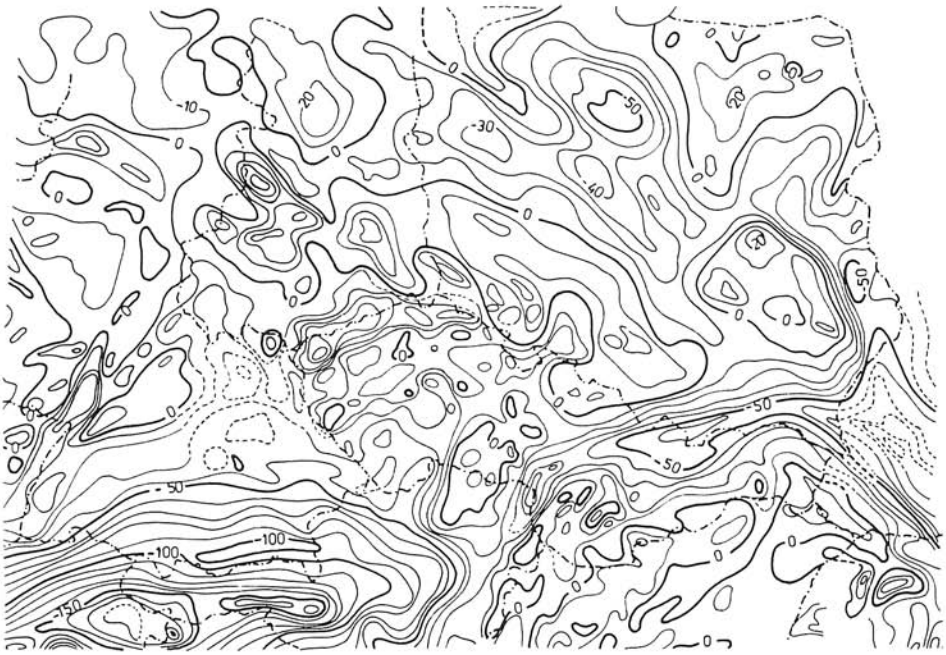

Fig. 1. Map of Bouguer gravity anomalies Δg_B of Central Europe (after [Z o u b e k — V y s k o č i l, 1977]). The values of Δg_B are given in units of $10^{-5} ms^{-2}$.

block become more pronounced. Consequently, the negative Bouguer anomaly (about -50×10^{-5} m/s^2) in the region of the High and Low Tatra Mts. is the more marked. Although the correction for the density inhomogeneities in the upper part of the Earth's crust affects the values of the gravity anomalies considerably, the overall character of the anomalous gravity field in the West Carpathians is preserved to a large extent. One may assume, therefore, that the deep structure has a pronounced gravitational effect here.

In the East Alps, the anomalous gravity field is affected by Tertiary sediments much less. The correction for the lighter sediments of the Alpine foredeep does attain values similar to those observed in the Carpathians (H a r c k e, 1972; K a h l e—W e r n e r, 1980), but introducing it only increases the values of the anomalies on the northern slope of the Alpine gravity depression, which becomes steeper. The overall mightiness of the Alpine negative meganomaly is preserved.

Correlation between gravity anomalies and depths of the crust-mantle boundary

By investigating the correlation between the gravity anomalies and the depths of the crust-mantle boundary, we are able to study the gravitational effects of the deep structure. As a rule, correlation analysis also includes elevations of the Earth's surface and the results are evaluated from the point of view of isostasy. From papers hitherto published (T a n n i, 1942; P o p e l á ř, 1969;

Vyskočil, 1972, 1974, 1977, 1979; Kvitkovič—Plančár—Vyskočil, 1976; Smíšek, 1976; Beránek—Ibrmajer, 1977; Vyskočil—Burda, 1980, 1982) it follows that there is a quite close correlation in the West Carpathians between Bouguer anomalies Δg_B and elevations h, as well as between Δg_B and the depths H of the crust-upper mantle boundary. The correlation between h and H is less pronounced.

At the boundary between the crust and the upper mantle, the classical concept assumes the Mohorovičić discontinuity, at which the velocity of longitudinal seismic waves v_p changes at a jump to 8.0 — 8.2 km/s. In a number of regions (for example, the East Carpathians, south-eastern part of Poland), however, the transition from the Earth's crust to the upper mantle is associated with the occurrence of a transition zone and several seismic boundaries. It is frequently problematic to distinguish the M-discontinuity among them reliably (Podstrigach—Chekunov, 1978; Sollogub—Guterch—Prosen, 1978, 1980) and, as a rule, the lower boundary of this transition zone is considered to be the crust-mantle boundary. The depth H_O of the upper boundary of the transition zone, characterized by v_p-velocities ranging from about 7.4 to 7.8 km/s, are also considered besides the depths H in the correlation analyses in (Vyskočil—Burda, 1982). It has been found that the depths H_O display a closer correlation with Bouguer anomalies and elevations then the depths H.

The values of the correlation coefficients, obtained for the West Carpathians using more recent initial data, are given in Table 1 and in Figures 2—6 some of the correlation fields are depicted. For comparison, Table 1 also contains the values of the correlation coefficients for the East Alps and the Bohemian Massif adopted from (Vyskočil—Burda, 1982). It is evident that the compared correlations are closer in the East Alps than in the West Carpathians. In the Bohemian Massif the correlation between h and H is very weak and between H and Δg_B practically zero. These conclusions are also substantiated by more detailed analyses carried out for the region of Central Europe as a whole using the moving window method, which have also proved a generally larger variability of the values of moving correlation coefficients in geologically older formations to the north of the Alpine—Carpathian zone (Vyskočil—Burda, 1982).

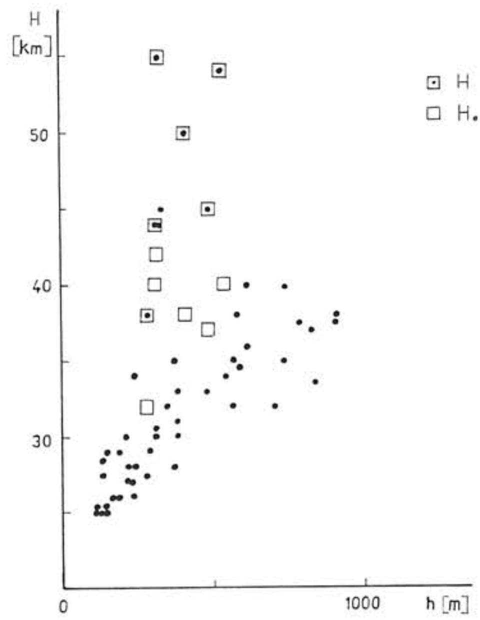

Fig. 2. Correlation between h and H, H_0 in the West Carpathians.

Since the values of Bouguer anomalies Δg_B in the West Carpathians are affected considerably by density inhomogeneities in the upper parts of the Earth's crust, the corrected values of Bouguer anomalies Δg_{BC} were also correlated with the elevations h and depths H, the corrections for the lower density of Tertiary sediments in some regions being only estimated due to the lack

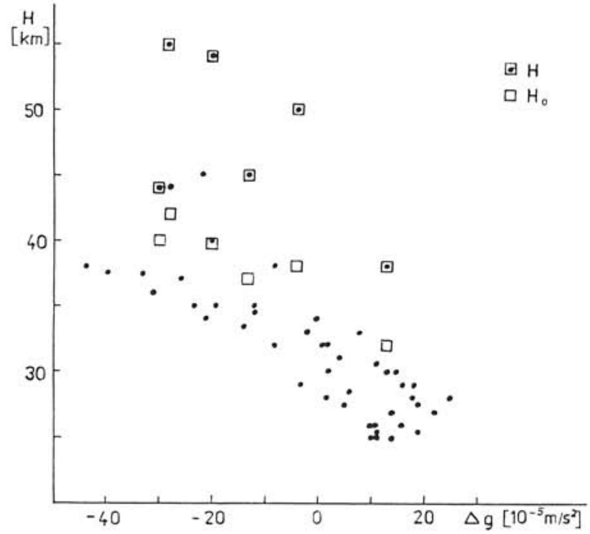

Fig. 3. Correlation between Δg_B and H, H_0 in the West Carpathians.

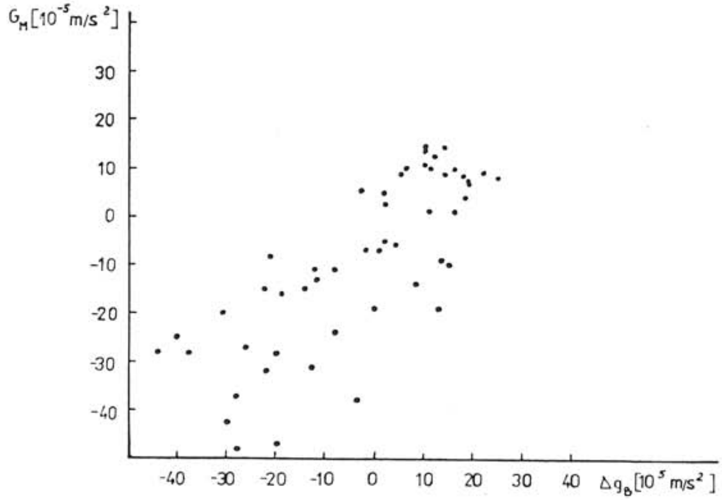

Fig. 4. Correlation between Δg_B and G_M in the West Carpathians. The values of G_M are calculated for the compartments $2° \times 3°$, density jump $\Delta\sigma = 0.1$ g/cm^3 and normal depth of the crust-mantle boundary H = 30 km.

of pertinent data. It was found that the corrected anomalies Δg_{BC} display closer correlation with h, H and H_O than the initial Bouguer anomalies Δg_B. The method described in (B u r d a—V y s k o č i l, 1976; V y s k o č i l—B u r d a, 1976) was then used to calculate the gravitational effect of the anomalous masses bound to the crust-mantle boundary, the adopted differential density being $\Delta\sigma = 0.1$ g/cm³. These gravitational effects G_M were also correlated with the elevations h and anomalies Δg_B and Δg_{BC}. The most pronounced is again the correlation

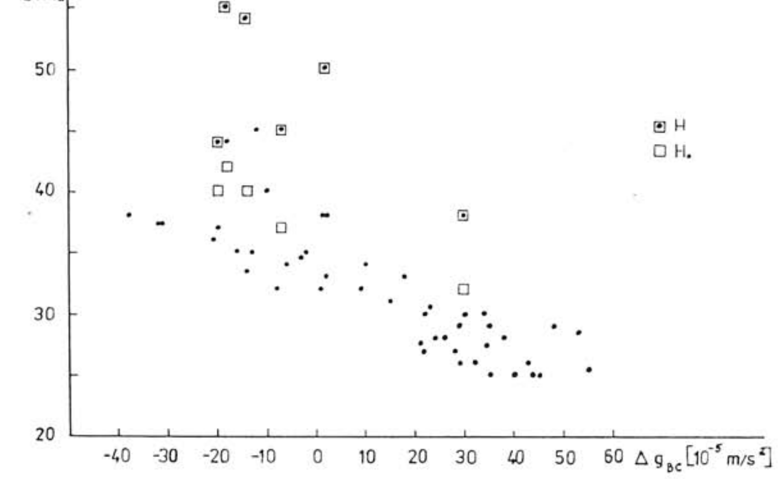

Fig. 5. Correlation between Δg_{BC} and H, H_0 in the West Carpathians.

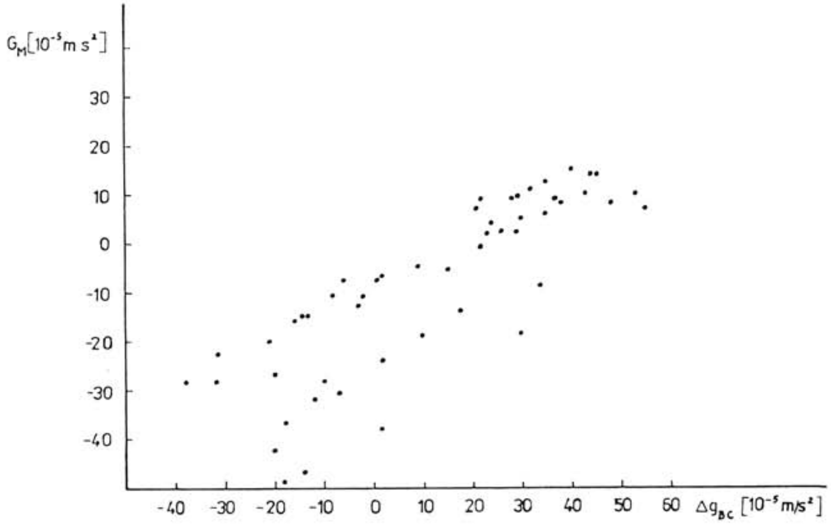

Fig. 6. Correlation between Δg_{BC} and G_M in the West Carpathians. The values of G_M are calculated for the compartments $2° \times 3°$, density jump $\Delta\sigma = 0.1$ g/cm³ and normal depth of the crust-mantle boundary $\bar{H} = 30$ km.

of G_M with the corrected anomalies Δg_{BC} which essentially reflect the effect of deep density inhomogeneities.

Density characteristic of the crust-mantle boundary in the West Carpathians

The lithosphere represents a block-stratified medium with vertical and lateral changes of density and other physical parameters. According to (Krasovski, 1978, 1981; Buryanov—Gordienko—Pavlenkova, 1980) the variation of density is best expressed by a layer-gradient model. In this model, the values of the density jump at the crust-mantle boundary come out relatively small: 0.1—0.15 g/cm^3 (Buryanov et al., 1978; Subbotin et al., 1979; Sollogub—Guterch—Prosen, 1980). In general, however, its magnitude depends on the density conditions in the given lithospheric block. According to (Demenitskaya, 1967, 1975) it may also vary in dependence on the thickness of the Earth's crust.

Assuming quite close correlation between the values of Bouguer anomalies Δg_B, Δg_{BC} and depths H, H_0, the magnitude of the density jump $\Delta\sigma$ at the crust-mantle boundary may be estimated from the values of the appropriate linear regression coefficients, this procedure being essentially based on the formula for the gravitational effect of a Bouguer plate.

The values of $\Delta\sigma$ calculated from these regression functions for the West Carpathians are given in Table 2. The values $\Delta\sigma$, determined from the regression dependences of the corrected anomalies Δg_{BC}, are probably the most accurate. They yield the average value $\Delta\sigma \approx 0.11$—$0.12$ g/cm^3 which is comparable with the values of the density jump at the crust-mantle boundary used in constructing density models of the lithosphere in the East Carpathians (Buryanov et al., 1978; Sollogub — Guterch — Prosen, 1980). It also agrees with the average value $\Delta\sigma \approx 0.13$ g/cm^3 derived from the correlations for the East Alps (Vyskočil — Burda, 1982).

As a result of the effected analyses, it may be said that the density jump at the crust-mantle boundary is about 0.10 to 0.13 g/cm^3 in the West Carpathians. Consequently, on introducing the correction for the lower density of Tertiary sediments, we arrive at approximately the same value of the density jump at the crust-mantle boundary in the West Carpathians as in the East Alps. However, one must bear in mind that the above estimates are only corrected under the assumption that the values of the corrected Bouguer anomalies Δg_{BC} reflect the effect of the anomalous masses bound to the crust-upper mantle boundary in the first place. In reality, these masses need not be the only deep source of the gravity anomalies and various deep density inhomogeneities in the lithosphere may also compensate each other.

Density inhomogeneities may also be caused by lateral changes of temperature in the bottom layers of the Earth's crust and in the upper mantle. If the temperature at a given point is higher by ΔT than the assumed "normal" temperature, a decrease in density may be assumed of $\delta\sigma = -\alpha\,\sigma_0\,\Delta T$, σ_0 being the normal density (for the subcrustal layer $\sigma_0 \approx 3.3$ g/cm^3) at $\Delta T = 0$ and $\alpha = 3 \times 10^{-5}$ °C being the coefficient of thermal volume expansion.

The correction of the gravitational effect for the density decrease due to increased temperature in the Upper Rhine Fault Gap amounts to as much as 80×10^{-5} m/s^2 (Werner — Kahle, 1980; Werner et al., 1981) and in the

Table 1

Values of correlation coefficients

Western Carpathians			
Correlated quantities	Correlation coefficient	Correlated quantities	Correlation coefficient
$h - \Delta g_B$	-0.70	$h - \Delta g_{BC}$	-0.83
$h - H$	0.46		
$h - H, H_0$	0.61		
$\Delta g_B - H$	-0.70		
$\Delta g_B - H, H_0$	-0.83	$\Delta g_{BC} - H$	-0.73
$\Delta g_B - G_M$	0.79	$\Delta g_{BC} - H, H_0$	-0.86
$h - G_M$	-0.63	$\Delta g_{BC} - G_M$	0.84
Eastern Alps		Bohemian massif	
$h - \Delta g_B$	-0.77	$h - \Delta g_B$	-0.68
$h - H$	0.88	$h - H$	0.34
$\Delta g_B - H$	-0.76	$\Delta g_B - H$	-0.15

Table 2

Regression	Regression coefficient (H, H_0 in km, Δg in 10^{-5} m/s^2)	$\Delta\sigma$ (g/cm^3)
$H (\Delta g_B)$	-0.28	0.09
$\Delta g_B(H)$	-1.75	0.04
$H_h (\Delta g_B)$	-0.24	0.10
$\Delta g_B(H_0)$	-2.88	0.07
$H (\Delta g_{BC})$	-0.21	0.11
$\Delta g_{BC}(H)$	-2.47	0.06
$H_0 (\Delta g_{BC})$	-4.02	0.10
$\Delta g_{BC}(H_0)$	-0.18	0.13

Pannonian Basin as much as 180×10^{-5} m/s^2 (Buryanov et al., 1978; Posgay, 1980; Sollogub—Guterch—Prosen, 1980). This effect must be taken into account in constructing density models of the West Carpathians.

Conclusion

In the West Carpathians, the values of Bouguer anomalies are affected considerably by density inhomogeneities, particularly by light sediments in the upper part of the Earth's crust. Consequently, the Bouguer anomalies corrected for the effect of Tertiary sediments display a closer correlation with the depths of the crust-mantle boundary. The estimates that were carried out, yield a relatively small density jump at the crust-mantle boundary which does not exceed 0.15 g/cm^3.

REFERENCES

BERÁNEK, B. — IBRMAJER, J., 1977: Gravimetrie a výsledky hlubinné seizmické sondáže v ČSSR. „Problémy současné gravimetrie" Sborník referátů z celostátního semináře v Liblicích 1976. GFÚ ČSAV a Geofyzika, n. p., Brno, pp. 5—25.

BERÁNEK, B. — ZÁTOPEK, A., 1981: Earth's crust structure in Czechoslovakia and in Central Europe by methods of explosion seismology. In: Geophysical Syntheses in Czechoslovakia (Edit. A. Zátopek), Veda, Bratislava, pp. 243—264.

BERÁNEK, B. — ZÁTOPEK, A., 1981: Preliminary results of Geophysical Syntheses in Czechoslovakia and Central Europe based on explosion seismology until 1980. In: Geophysical Syntheses in Czechoslovakia (Edit. A. Zátopek), Veda, vyd. SAV Bratislava, pp. 469—497.

BURDA, M. — VYSKOČIL, V., 1976: Možnosti praktického použití trojrozměrných hustotních modelů. Sborník 6. celostátní konference geofyziků, Plzeň 1975, III. díl, Geofyzika, n. p. Brno, pp. 187—198.

BUDAY, T. — DUDEK, A. — IBRMAJER, J., 1967: Některé výsledky interpretace gravimetrické mapy ČSSR v měřítku 1:500 000. Sborn. geol. Věd, Ř. UG (Praha), 8, pp. 7—35.

BURYANOV, V. B. et al., 1978: Kompleksnaya geofizicheskaya model litosfery vostochnykh Karpat. Geofiz. Sborn., Naukova dumka (Kiev), 83, pp. 3—16.

BURYANOV, V. B. — GORDIENKO, V. V. — PAVLENKOVA, N. I., 1980: A combined geophysical model of the crust for the south of the European part of the USSR. Stud. geophys. geod. (Praha), 24, pp. 114—123.

BURYANOV, V. B. et al., 1980: Kompleksnaya geofizicheskaya model stroenia i razvitia litosfery Karpat i sredneevropeiskikh gereinid. In: Tektonosfera Ukrainy i drugikh regionov SSSR, Naukova dumka (Kiev), pp. 17—24.

DEMENICKAYA, R. M., 1967: Kora i mantia Zemli. Nedra, Moskva. (Vtoroe izd. 1975), 256 pp.

DOLEŽAL, J., 1965: Kvantitativní interpretace tíhových profilů v západokarpatském flyši. Sborn. geol. Věd Ř. UG (Praha), 4, pp. 59—83.

FUSÁN, O. — IBRMAJER, J. — PLANČÁR, J., 1979: Neotectonics blocks of the West Carpathians. In: Geodynamic Investigations in Czechoslovakia, Veda, vyd. SAV Bratislava, pp. 187—192.

FUSÁN, O. — IBRMAJER, J. — KVITKOVIČ, J. — PLANČÁR, J., 1981: Block dynamics of the West Carpathians. In: Geophysical Syntheses in Czechoslovakia (Edit. A. Zátopek), Veda, vyd. SAV Bratislava, pp. 153—157.

GIESE, P. — PRODEHL, C., 1976: Main features of crustal structure in the Alps. In: Explosion Seismology in Central Europe, Springer Verlag, Berlín, pp. 347—376.

HARCKE, H., 1972: Die Struktur der Erdkruste im nordlichen Alpenvorland — Eine Synthese aus seismischen und gravimetrischen Daten. Beitrag 88, Geophys. Inst. Universität (TH) Karlsruhe, 68 pp.

IBRMAJER, J., 1981: Geological interpretation of gravity maps of Czechoslovakia. In: Geophysical Syntheses in Czechoslovakia (Edit. A. Zátopek) Veda, vyd. SAV Bratislava, pp 135—148.

IBRMAJER, J. — DOLEŽAL, J., 1961: Souborné zpracování a interpretace gravimetrických měření ve flyšové oblasti ČSSR. Užitá geofyzika (Praha), pp. 37—79.

IBRMAJER, J. — MOTTLOVÁ, L., 1963: Zhodnocení tíhových a magnetických měření v Podunajské nížině. Sborn. geol. Věd, Ř. UG, (Praha), 1, pp. 69—96.

KAHLE, H. G. — WERNER, D., 1980: A geophysical study of the Rhinegraben II. Gravity anomalies and geothermal implications. Geophys. J. Roy. astron. Soc. (Oxford), 62, pp. 631—647.

KRASOVSKII, S. S., 1978: Modelirovanie v gravitatsionnom pole struktur zemnoi kory i verkhnei mantli. VIEMC, Ministerstvo geologii SSSR, Moskva, 80 pp.

KRASOVSKII, S. S., 1981: Otrazhenie dinamiki zemnoj kory kontinentalnogo tipa v gravitationnom pole. Naukova dumka (Kiev), pp. 264.

KVITKOVIČ, J. — PLANČAR, J. — VYSKOČIL, V., 1976: The isostatic conditions in relation to the recent vertical movements of the earth's crust in the West Carpathians. Geogr. Čas. Slov. Akad. Vied (Bratislava) 28, pp. 122—131.

MILLER, H., 1980: Struktura zemnoi kory vostochnykh i juzhnykh Alp po dannym litosfernogo eksperimenta ALP — 75. In: Issledovanie litosfery i astenosfery na dlinnykh profilyakh GSZ, Nauka (Moskva), pp. 43—58.

PLANČAR, J. et al., 1977: Geofyzikálna a geologická interpretácia tiažových a mag-

netických anomálií v Slovenskom rudohorí. Záp. Karpaty, Sér. geol. (Bratislava), 2, pp. 7—144.
PODSTRIGACH, Ya. S. — CHEKUNOV, A. V. (Eds), 1978: Karpatskii geodynamichskii poligon. Sovetskoe radio, (Moskva), 127 pp.
POPELÁŘ, J., 1968: Gravity field and isostasy in the area of the Czechoslovak West Carpathians. Sbor. geol. Věd, Ř. UG (Praha), 7, pp. 7—24.
POSGAY, K., 1980: Rezultaty issledovania zemnoi kory i verkhnei mantii na territorii VNR metodom glubinnykh otrazhenii. In: Issledovanie litosfery i atmosfery na dlinnykh profilyakh GSZ, Nauka, Moskva, pp. 79—91.
SMÍŠEK, M., 1976: Příspěvek gravimetrie k hlubinné stavbě Západních Karpat. In: Problémy současné gravimetrie, GFÚ ČSAV a Geofyzika, n. p., pp. 43—50.
SOLLOGUB, V. G. — GUTERCH, A. — PROSEN, D. (Eds), 1978: Stroenie zemnoi kory i verkhnei mantii centralnoi i vostochnoi Evropy. Naukova dumka, (Kiev), 272 pp.
SOLLOGUB, V. B. — GUTERCH, A. — PROSEN, D. (Eds), 1980: Struktura zemnoi kory centralnoi i vostochnoi Evropy po dannym geofizicheskikh issledovanii. Naukova dumka, (Kiev), 208 pp.
STEGENA, L., 1964: The structure of the earth's crust in Hungary. Acta geol. Acad. Sci. hung. (Budapest), 8, pp. 413—431.
SUBBOTIN, S. I., 1979: Gravitatsionnaya model kory i verkhnei mantii. Naukova dumka (Kiev), 248 pp.
ŠUTOR, A. — ČEKAN, V., 1965: Regionální gravimetrický a geomagnetický průzkum v oblasti východního Slovenska. Sborn. geol. Věd. R. UG (Praha), 4, pp. 35—57.
TANNI, L., 1942: On the isostatic structure of the earth's crust in the Carpathian countries and related phenomena. Publ. Isost. Inst. (Helsinki), 11, 100 pp.
TOMEK, Č. — BUDÍK, L., 1981: Konstrukce a interpretace odkryté tíhové mapy Vídeňské pánve. Sborn. geol. Věd. Ř. UG (Praha), 17, pp. 173—186.
TOMEK, Č. — ŠVANCARA, J. — BUDÍK, L., 1979: The depth and the origin of the West Carpathian gravity low. Earth planet. Sci. Lett. (Amsterdam), 44, pp. 39—42.
VYSKOČIL, V., 1972: Correlation between Bouguer anomalies, heights of the terrain and depths of the crust-mantle boundary in Central Europe. Studia geophys. geod. (Praha), 16, pp. 329—338.
VYSKOČIL, V., 1974: Comments on the manifestation of deep structure of Czechoslovakia in the anomalous gravity field. Traveaux Inst. Geophys. Acad. Tchécosl. Sci., Geofyz. Sbor., 1972 (Praha), 365, pp. 127—139.
VYSKOČIL, V., 1977: Isostatic properties of the territory of Czechoslovakia and their association with the motions of the earth's crust. Travaux Inst. Geofyz. Sborn., 1975 (Praha), 432, pp. 57—63.
VYSKOČIL, V., 1979: Correlation analysis of geophysical fields on the territory of Czechoslovakia. In: Geodynamic Investigations in Czechoslovakia, Veda, vyd. SAV (Bratislava), pp. 133—137.
VYSKOČIL, V. — BURDA, M., 1976: On the computation of the gravitational effects of three-dimensional density models of the earth's crust. Stud. geophys. geod. (Praha), 20, pp. 213—218.
VYSKOČIL, V. — BURDA, M., 1980: Some results of the correlation analysis of geophysical fields on the territory of the ČSSR. Travaux Inst., Geofyz. Sborn., 1978 (Praha), 503, pp. 87—101.
VYSKOČIL, V. — BURDA, M., 1982: Projev rozhraní mezi kurou a pláštěm v tíhové mapě střední Evropy. In: Výzkum hlubinné geologické stavby Československa. Loučná 1982, Geofyzika (Brno), pp. 161—168.
WERNER, D. — KAHLE, H.-G., 1980: A geophysical study of the Rhinegraben — In: Kinematics and Geothermics. Geophys. J. Roy. astron. Soc. (Oxford), 62, pp. 617—630.
WERNER, D. — KAHLE, H.-G. — ANSORGE, J. — MUELLER, ST., 1981: Mass displacement and geothermics within the upper mantle the Rhinegraben rift system: A model to interpreted data from gravimetry and seismology. Contribution, Institute of Geophysics, ETH-Honggerberg (Zurich), 232, 16 pp.
ZOUBEK, V. — VYSKOČIL, V., 1971: Anomální tíhové pole ve vztahu ke geologickým strukturám v oblasti střední Evropy. In: Výzkum hlubinné geologické stavby Československa, Loučná 1971, Ústav užité geofyziky, Brno, pp. 97—133.
ZOUBEK, V. — VYSKOČIL, V., 1977: Le champ gravimetrique anomal en relation aux structure geologiques de l'Europe Centrale. Coll. intern. CNSR (Rennes), 243, pp. 359—369.

Review by J. ŠEFARA Manuscript received November 2, 1982