B. GEOPHYSICS IN THE REGION OF THE PROJECT

B.1. GRAVIMETRY

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Two subareas, E of Karlovy Vary and S of Klatovy (Fig.3), not covered by the previous survey, have been recently measured in the framework of the project "Geological model of western Bohemia in relation to the deep borehole KTB 1 in the FRG". A detailed gravimetry survey of the area of the Czech Republic, at the scale 1 : 25 000, commenced in 1970. It included measurements of 4 to 6 stations per km^2. The field measurements and data processing into Bouguer anomaly maps were conducted by the company Geofyzika, Inc., Brno, Czech Republic.This resulted in the complete detailed gravimetry coverage for the W part of the Czech Republic. A Bouguer anomaly map has been compiled at the scale 1 : 200 000, based almost exclusively on detailed data (1 : 25 000) over an area of 50 km along both sides of the seismic profile 9HR, covering about 17 000 km^2 (Fig. 3).

The set of detailed gravimetry maps of this region at the scale 1 : 200 000 is presented in Šrámek (1994b) and a set including more important maps is presented here on a reduced scale (Pls. 1 to 7).

The Bouguer anomaly map contains gravity signals as a function of the density structure of the crust to a depth of approximately 5 to 10 km, exceptionally up to 15 km. The derived gravity maps (Pls. 3 to 6) show the gravity effect calculated for a certain depth level. The gravity maps are important in providing indications of three-dimensional geological structures. The interpretation of gravity data thus provides information on the depth continuation of geological bodies having a sufficient density contrast compared to neighbouring units.

B.1.1. Gravity field – its features and geological interpretation

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The gravity field of the region (Pl. 1) shows remarkable variation and attains a maxima of +20 mGal in area of the Kdyně gabbro complex and a minimum of –57 mGal in the Karlovy Vary granite pluton which is the lowest gravity value in the Czech Republic. Geological interpretations of the gravity field of the region were presented by Polanský et al. (1973, 1983, 1990), Doležal et al. (1981), Pokorný et al. (1985), Blížkovský et al. (1988), Pokorný (1975), Röhlich-Šťovíčková (1968), Mrlina et al. (1993) a.o. A detailed review of existing geophysical gravity interpretations was compiled by Pokorný (1993). In the following interpretation of gravity anomalies and structural features (gradients and indications of tectonic discontinuities), results obtained by the quoted authors are used.

B.1.1.1. Division of the gravity field using horizontal gradients of gravity in areas with a regionally stable gravity field

The gravity field of the region is divided by regional horizontal gradients which indicate a vertical density contrast on the order of several kilometres among crustal blocks with a distinct geological structure (Pls. 1, 7). The gravity gradients are used to define domains with a regionally stable gravity field, showing either dominantly positive or negative gravity values (Blížkovský et al. 1988). The density gradient corresponding to the Litoměřice thrust-fault represents the boundary between the Krušné hory negative gravity area and the Teplá-Barrandian Unit (TBU) positive gravity area. The deep-seated character of this boundary diminishes in the proximity of Mariánské Lázně and here it splits in two branches. The more prominent branch coincides further with the Mariánské Lázně fault and, following a shift of 4 km to the west, it corresponds approximately to the West Bohemian shear zone (= the Bohemian quartz lode). This relatively shallow gravity gradient, running from Mariánské Lázně up to the CR-FRG international boundary, represents a divide between the positive gravity area of the TBU and the negative subarea of the Bohemian Forest. The gravity gradient of the Central Bohemian Suture corresponds to the boundary between the positive gravity area of the TBU and the negative gravity area of the Moldanubian Zone. In the region studied the Central Bohemian Suture is intersected and partially displaced by the Klatovy and Benešov faults, and some transversal faults.

A comparison of gravity areas shows notable qualitative differences in the homogeneity of the gravity field. The TBU positive area is characterized by a strongly defined internal structure owing to large gravity gradients along the borders of partial anomalous bodies. The main structural trend of this area is NNE-SSW to NE-SW. In the Krušné hory area the negative gravity subarea of the Karlovy Vary pluton is dominant. Its northern part has a NNW-SSE elongation, and the southern part trends NE-SW. The gravity field in the area of this pluton also indicates the influence of a WSW-ENE trend (gradient of the Krušné hory marginal fault) and a NW-SE trend. Geological units bordering on the Mariánské Lázně fault exhibit notable discordance in their internal gravity structure: the Bohemian Forest (Moldanubian Zone), with structures trending N-S, and the TBU with structures trending NNE-SSW to NE-SW. The main region of the Moldanubian Zone is characterized by subdued gravity field variation, free of a distinct linear orientation of gravity isolines. This situation is caused by the limited variation in density of the prevalent rock types.

B.1.1.2. Geological interpretation of the main anomalies of the gravity field

The sources of gravity anomalies in the region have been characterized by Šrámek-Mrlina (1993 and 1994). The anomalies listed are shown in Pl. 2. A Bouguer anomaly map (Pl. 1) and a published geological map of the Czech Republic are useful in studying the description of the main anomalies. The structural scheme of the gravity field is shown in Pl. 7.

The Krušné hory negative gravity area and the Bohemian Forest subarea

The Krušné hory area is dominated by the negative anomaly of the Karlovy Vary pluton (anomaly 3 in Pl. 2, only anomaly number from here on). The gravity anomaly of this pluton, indicating its lower limit, has its central part coinciding with the Krušné hory fault and overlaps along with the Sokolov brown coal basin. In the area of the Horní Slavkov gneiss block the isolines of the Karlovy Vary pluton show a bulging to the SW towards a smaller negative anomaly corresponding to the Žandov granite intrusion (anomaly 3a).

In the remaining parts of the Krušné hory area, the gravity field is influenced by the subsurface Krušné hory pluton, located below metamorphic rocks of the Krušné hory and Jáchymov Groups (anomaly 3b). Mica schists of the Svatava subarea, phyllites of the Vogtland-Saxony Palaeozoic (anomaly 2), and phyllites of the Cheb subarea (anomaly 5) belong to a positive gravity area. Neogene sediments of the Cheb basin (anomaly 1) and granites of the Smrčiny-Fichtelgebirge pluton (anomaly 4) produce a negative gravity field. The gravity effect of the Smrčiny pluton is much weaker compared to the Karlovy Vary pluton, indicating a significantly shallower extension of the former.

In the negative gravity subarea of the Bohemian Forest, (Blížkovský et al. 1988), the southern part of the Bor pluton, elongated N-S, represents the most notable negative anomaly which indicates a particularly deep continuation of this part of the pluton. Besides this part, only the northernmost part of the pluton has distinct negative features, while the central and much of northern part coincide with a positive anomaly. This indicates a rather limited thickness of the granitoid body and also the presence of mantle roof pendants, including amphibolites (anomaly 7e, 20). A negative field is also associated with the Tachov orthogneiss (anomaly 21), which possibly extends eastwards below the Bor pluton, and the Rozvadov pluton (anomaly 22).

The Teplá-Barrandian Unit positive gravity area

Positive anomalies elongated SSW-NNE to SW-NE are typical of this area. The positive anomalies are caused by volcanic and plutonic basic rocks. Particularly strong anomalies are associated with the Kdyně pluton, the Poběžovice pluton and the amphibolite massif of Černá hora (anomalies 35, 36, and 37). The positive gravity area contains surface bodies with an increased density, such as basic intrusions, basaltic metavolcanites (anomalies 38, 40, 44, and positive anomalies inside structure 35) and subsurface sources in the upper part of crust. The latter include basic intrusions and volcanic accumulations approximately 3 to 5 km below the Earth's surface (anomalies 35, 36, and 37). Smaller negative domains in the general positive gravity area comprise lower-density metasediments free of basic magmatic rocks (anomaly 45) and small granitoid intrusions (anomalies 41a, 41b, and 80).

In the eastern part of this positive gravity area, around the Kdyně, Stod, and Poběžovice plutons, there is an oblong-shaped background positive area consisting of smaller local anomalies (anomaly 35). These local positive anomalies correlate with the Kdyně pluton and with the Domažlice-Kralupy volcanic belt continuing NNE. Southwest of the Štěnovice pluton the anomalous belt becomes narrower and the positive values somewhat decrease (compare the width of anomalies 35 and 37). This narrowing is caused by transversal faulting (Stod fault) and also by probable absence of subsurface intrusive basic rocks further NNE. The continuation of the Domažlice-Kralupy belt is indicated by anomalies 28 (accumulation of volcanites near Radnice), 16, and 33.

Besides the central volcanic belt (Domažlice-Kralupy) the following volcanic belts are also indicated: Nepomuk-Příbram (anomalies 49, 52), Stříbro-Plasy (anomaly 15) and Svojšín (anomalies 15c and 15d).

The Brdy anomaly, No.32, largely coinciding with the Nepomuk-Příbram belt, probably indicates a subsurface basic intrusion.

Another remarkable positive anomaly is a doublet, Nos. 7 and 8. Anomaly 7 corresponds to the Mariánské Lázně Complex (MLC) and comprises several smaller anomalies (7a through 7e). The whole composite anomaly has a complicated shape with indications of horizontal gravity gradients which probably correspond to contacts between basic rocks and lower-density metasedimentary rocks, i.e., gneisses and migmatites of the Teplá Crystalline Unit and Moldanubian paragneisses and migmatitic cordierite gneisses of the Bohemian Forest. Metamorphosed basic rocks of the MLC continue in the subsurface structure towards the SE below the Teplá Crystalline Unit up to a distinct gravity gradient (anomaly 7a), coinciding with the biotite isograd on the surface. Local positive gravity anomalies occur in the subareas of the central and northern Bor pluton and in amphibolite accumulations W of Tachov (anomalies 7e and possibly 7f). Although these anomalies appear as a possible continuation of the MLC, the respective basic rocks should belong to tectonic units other than the MLC.

The second remarkable positive anomaly in the NW (anomaly 8) is probably associated with metabasic rocks equivalent to the MLC, hidden in the crystalline complex below platform (Žatec area) and Permian-Carboniferous sediments of the Kladno-Rakovník basin. The Tertiary

Doupov stratovolcano overlaps the subsurface accumulation of MLC rocks and increases the total gravity effect (anomaly 8a).

The Kladruby and Čistá-Jesenice granitoid plutons and the Štěnovice stock occur in the TBU positive gravity area. The Kladruby pluton (anomaly 24) reaches its deepest subsurface extension in its NW part, showing the NE-SW trend of the gravity minimum axis. The Sedmihoří plug coincides with an independent, nearly circular gravity anomaly (No. 47). A similar symmetric negative gravity effect is caused by the Štěnovice stock (anomaly 48). The Čistá-Jesenice composite pluton is seen in the gravity field as an intrusion with variable density corresponding to variations in petrography. The part near Petrohrad is characterized by positive gravity anomalies (Nos. 13 and 13a). The Padrť granite intrusion, probably an apophysis of the Central Bohemian Pluton, is associated with a negative gravity anomaly (53). The hypothetical subsurface Přovany intrusion, interpreted from the negative gravity field No. 26, remains somewhat uncertain. The Stod massif is associated with a positive gravity anomaly (43). This probably indicates a small thickness of this granitoid body and the possible presence of basic rocks in the deeper structure. The part of the Central Bohemian Pluton (CBP) NW of the gravity gradient of the Central Bohemian Suture and NE of the "Rožmitál axial ramp" (= flexure) also has a positive gravity field. This indicates a rather limited thickness of granitoids and the presence of higher-density (basic) rocks below these granitoids. The tectonic affiliation of these basic subsurface rocks is somewhat uncertain, but according to some interpretations they should represent basic igneous rocks belonging to the TBU.

An extensive negative gravity anomaly is seen between the positive anomaly of the MLC in the NW and the positive gravity area of the Kdyně, Poběžovice, and Stod plutons, and the Stříbro-Plasy volcanic belt in the SE. This lower-density Kladruby-Manětín zone (anomaly 23) probably corresponds to a part of the TBU free of basic igneous rocks. Cambrian volcanites of the Křivoklát-Rokycany belt (anomaly 29) and the Permian-Carboniferous sedimentary fill, i.e., the Plzeň basin (anomaly 25), the Kladno-Rakovník basin (anomaly 9), and the Manětín basin (anomaly 10, 10a), are associated with negative gravity anomalies.

The Moldanubian negative gravity area

In the studied part of the Moldanubian Zone the composite negative gravity effect is caused mainly by the presence of granitoids, migmatites, felsic granulites, and orthogneisses. Positive gravity areas correspond to durbachitic melagranitoids, paragneiss units free of granitoids, and, to some extent, to thick accumulations of the Varied Group.

A dominant gravity feature of the main Moldanubian area is the extensive negative anomaly 64, designated as the Putim anomaly. Its northern part coincides with surface outcrops of the CBP, and its central and W parts correspond to strongly migmatized areas of the Moldanubian Zone and the Podolsko complex, comprised of leucocratic migmatites, orthogneisses, and minor felsic granulites which attain a structural thickness of at least several km.

The Prachatice and Křišťanov granulite massifs are characterized by steep gradients in the regional gravity field and by prominent negative anomalies (72, 89). The Blanský les granulite massif is associated with a lower gravity contrast, owing to the presence of abundant ultramafic rocks, mainly metaperidotites (anomalies 75, 76), and to a smaller structural thickness of the massif. The positive gravity anomalies associate with durbachites of the Velký Mehelník intrusion (69), the Želnava massif (77) and the Netolice intrusion (anomaly 73).

The Central Bohemian Pluton (CBP) shows a negative anomaly associated with the Blatná granodiorite (anomaly 60) and the Klatovy apophysis (anomalies 58, 59a). The domain of the "Rožmitál axial ramp" (= flexure) coincides with the negative gravity anomaly 55.

Local negative gravity anomalies coincide with individual granitoid intrusions of the Moldanubian Plutonic Complex (MPC): the Prášily pluton (anomaly 79), the Vydra massif (84), the Strážný pluton (88), the Plechý pluton (87), and a subsurface intrusion near the Prášily pluton (anomaly 78). The Ševětín pluton further E is also associated with a negative gravity anomaly (No. 71).

Rather extensive subareas of the Moldanubian Zone devoid of granitoid rocks are indicated by regional positive anomalies (Nos. 68 and 83).

B.1.1.3. Geological interpretation of "derived" gravity maps

Maps of residual and regional gravity fields

The derived gravity maps (Pls. 3–6) show accentuated anomalies of certain wave lengths in the Bouguer anomaly map, corresponding to the respective depth level. Pl. 3 shows a map of the residual gravity anomaly, retaining the gravity effect of a layer from the Earth's surface to a depth of approximately 3 to 5 km. The residual signal of the gravity field is contained in the regional gravity map representing the gravity effect from the level of approximately 3 to 5 km below the Earth's surface to greater depths (Pl. 6).

The map of the residual gravity anomaly shows a splitting of some gravity anomalies, a narrowing of gravity gradients, and shifts in the position of centres of anomalies. Pl. 3 shows increased gradient contrast along the southern margin of the Karlovy Vary pluton, reflecting a narrowing of the Litoměřice thrust-fault gradient. Also notable is the shift to NW of the positive gravity anomaly below the Doupov stratovolcano (Pl. 6, anomaly a). This probably reflects the effect of a subsurface basic body in the crystalline complex.

In the area of the regional positive anomaly between the Kdyně, Poběžovice, and Stod plutons, the map of the residual gravity anomaly shows a subarea with a closed negative gravity anomaly. This indicates a domain in which higher-density rocks are absent from near surface parts of the crust (anomaly b). Higher-density rocks can be expected in a deeper crustal structure, which lie under subareas with positive surface gravity anomalies as well as the subarea with the negative anomaly b (compare Pl. 6).

In the Moldanubian Zone, the map of the residual gravity anomaly shows a splitting of the extensive Putim negative gravity anomaly. The northern part in the split pattern coincides with granitoids of the CBP (anomaly e_1) and joins the negative gravity anomaly of the Blatná granodiorite (anomaly e_2) and the "Rožmitál axial ramp" (anomaly e_3). These three anomalies thus indicate lower-density rocks in the CBP. The S part of the Putim anomaly splits into several subdued, both positive and negative anomalies, which do not support the existence of a large low-density unit in the upper part of the crust. Rather, the existence of such a low-density body is indicated in Pl. 6, characterizing a structure below the level of the map of the residual gravity anomaly, i.e., in the interval between 5 and 15 km below Earth's surface. This information suggests that the Podolsko complex is a major unit in the Moldanubian Zone.

Granitoids of the Klatovy apophysis are accompanied in the map of the residual gravity anomaly by anomalies f_1 and f_2, the former showing a deeper-level continuation. In the Moldanubian Zone, subareas free of granitoids and intense migmatization are indicated by the anomalies g_1, g_2, and g_3.

Maps of density boundaries

Maps of density boundaries (Linsser's indications) localize steep to vertical interfaces of adjacent domains with contrasting densities. Such boundaries correspond to lithological boundaries, faults, or to a combination of both. They also express horizontal and vertical structural features in zones of broad gravity gradients, including the trends of axes in such gradient zones.

Maps of Linsser's indications are shown in Pl. 5 for the level 500 m below the Earth's surface, corresponding to gravity discontinuities of a shallow geological structure, and for the level of –5000 m (Fig. 6), characterizing the deeper tectonic structure.

B.1.1.4. Quantitative interpretation of selected gravity anomalies and estimates of depth positions of respective rock units

Table 1 summarizes data on depth extension of the most important geological units and igneous bodies. It is noted that a quantitative interpretation of gravity anomalies frequently has a large number of possible solutions. In view of this, an average value is given or a certain range of a given parameter, primarily the vertical position of the base of respective body. This parameter is adversely influenced by the complicated structure of the gravity field and by interference from neighbouring bodies of variable density. Even so, the data on depth position provide important information on the structure of the upper part of the crust and on the geometry of individual bodies with anomalous density. Most of the data contained in Tab. 1 have been drawn from unpublished reports by Dobeš, Doležal, Mrlina, Polanský, and Švancara. Various types of calculators and computers were used with programs for direct and inverse gravimetric task. Most often, Talwani's method of 2-D and 2.5-D modelling has been used. Recently, advanced systems for the interactive interpretation of profile data have been used.

Table 1. Summary of data on depth of the main geological bodies based on quantitative interpretation of gravimetric data

Anomaly No. (see Pl. 2)	Geological source	Depth of the margin (in km)	
		top	base
1	Cheb basin	0	0.05–0.1 locally up to 0.35
3	Karlovy Vary pluton	0	10–15
4	Smrčiny pluton	0	6–8
7	Mariánské Lázně Metabasite Complex		
	western part	0	2–3
	eastern part	1–2	5–8
11	Čistá-Jesenice pluton	0	6–8
15	metabasites (Stříbro-Plasy belt)	0	0.5–1
16	metabasites (Domažlice-Kralupy belt)	0	0.5–1.5
19	Bor pluton, S. part	0	6–8
22	Rozvadov pluton	0–0.5	6–7
24	Kladruby pluton	0	2–4
25	Plzeň basin	0	0.8
26	Přovany pluton	0.5	1.5–3
29	Křivoklát-Rokycany belt	0	3
35	basic rocks of the Kdyně pluton	0–1	3–5
38	Černá hora amphibolite massif	0	2–3
39	Drahotín stock	0	0.5
40	Poběžovice pluton	0	2
42	Babylon stock	0	3
43	basic rocks of the Stod pluton	0.3	3–4
45	phyllites without basic rocks	0	1–1.5
46	Vidice amphibolite belt	0	0.5–1
47	Sedmihoří stock	0	8–10
48	Štěnovice stock	0	6–8
58, 59a	Klatovy apophysis	0	3
60	Central Bohemian Pluton: western part	0	3–5
64	Podolsko complex (Putim anomaly)	2–3	10–15
78	hidden granite pluton	0.3	5
79	Prášily pluton	0	5

Table 2. Sources of anomalies shown in the structural scheme of the gravity field (Pl. 2)

Anomaly No.	Geological source	References
1	Cheb basin	Polanský, Šťovíčková, Racková (1973), Polanský (1975)
2	Vogtland-Saxony Palaeozoic Svatava crystalline unit	
3	Karlovy Vary pluton	Polanský (1970, 1971, 1973, 1978) Polanský, Petrák (1974), Polanský, Škvor (1976), Conrad et al. (1983)
3a	Žandov pluton	Polanský, Šťovíčková, Racková (1973), Polanský, Škvor (1976), Polanský (1978), Mrlina (1993)
3b	elevation of the Krušné hory pluton	Polanský (1970, 1971, 1973), Polanský, Škvor (1976)
4	Smrčiny pluton	Polanský (1970), (1971), Polanský, Šťovíčková, Racková (1973)
5	Cheb crystalline unit	
6	Sokolov basin	Polanský (1975), Polanský, Šťovíčková, Racková (1973)
7	Mariánské Lázně Metabasite Complex	Petrák, Polanský (1969), Polanský (1975, 1978), Polanský, Škvor (1976), Mrlina (1993)
7a	basic intrusive rocks amphibolites	Petrák, Polanský (1969), Polanský (1975, 1978), Polanský, Škvor (1976), Mrlina (1993)
7c	diorite to gabbro intrusion near Brod nad Tichou	Mrlina (1993)
7d	amphibolite body	Mrlina (1993)
7f	amphibolites of the Moldanubian Zone Bohemian Forest	Pokorný et al. (1987), Mrlina (1993)
8	basic and ultrabasic rocks of the crystalline basement of the North Bohemian basin and the Kladno-Rakovník basin	Buday et al. (1969), Polanský (1971), Polanský, Škvor (1976)
8a	neovolcanites of the Doupov stratovolcano	Buday et al. (1969), Polanský (1971)
9	Permo-Carboniferous of the Kladno-Rakovník basin	Bartošek et al. (1969)
10	Permo-Carboniferous of the Manětín basin	
11	Čistá-Jesenice pluton, eastern margin of anomaly corresponding to the Permo-Carboniferous of the Kladno-Rakovník basin	Buday et al. (1969)
12	Čistá-Jesenice pluton the Tis and Jesenice parts, respectively	Buday et al. (1969)
13	Čistá-Jesenice pluton Petrohrad part	Buday et al. (1969)
13a	a facies of the Petrohrad granite ? (SE of Lubenec)	
15	spilites (Stříbro-Plasy belt)	Mrlina (1993)
16	spilites (Domažlice-Kralupy belt)	Polanský (1988a, 1988b), Polanský, Mrlina, Peška, Pokorný (1990)
17	Permo-Carboniferous of the Žihle basin	
19	Bor pluton, southern part	Pokorný, Polanský (1971), Polanský, Škvor (1976)
20	amphibolites and basic intrusives below granitoids of the Bor pluton	Pokorný, Polanský (1971), Polanský (1975), Polanský, Škvor (1976), Doležal et al. (1981)
21	Tachov orthogneiss	Doležal et al. (1981), Mrlina (1993)
21a	eastern continuation of the Tachov orthogneiss or granitoids of the Bor pluton	
22	Rozvadov pluton	Doležal et al. (1981), Mrlina (1993)
23	Kladruby-Manětín zone	Polanský (1971), Mrlina, Polanský (1986, 1987), Polanský, Mrlina, Peška, Pokorný (1990)
24	Kladruby pluton	Mrlina, Polanský (1986), Polanský, Mrlina, Peška, Pokorný (1990)
25	Plzeň basin the main "light" body	Polanský, Mrlina, Peška, Pokorný (1990), Mrlina, Polanský (1986, 1987)
25a	Permo-Carboniferous of the SW part of the Plzeň basin,	
26	the supposed Přovany granitoid pluton	Mrlina, Polanský (1986, 1987)
27	spilites (Domažlice-Kralupy belt)	Polanský, Mrlina, Peška, Pokorný (1990)
28	spilites (Domažlice-Kralupy belt, Radnice body)	Polanský, Mrlina, Peška, Pokorný (1990)
29	Křivoklát-Rokycany belt	Dobeš, Dolanská (1973), Šrámek et al. (1986)
32	the "Brdy anomaly", basic rocks below the Cambrian	Válek, Jaroš (1972), Jaroš, Válek (1975), Mísař et al. (1984), Tomek et al. (1976)
33	spilites (Domažlice-Kralupy belt)	
35	spilites (Domažlice-Kralupy belt) and basic intrusive rocks of the Kdyně pluton	Buday et al. (1969), Doležal et al. (1981), Vejnar et al. (1984), Polanský, Mrlina, Peška, Pokorný (1990), Kadlec, Motlová, Šustr (1976)
36	regional background of the gravity field, the source see anomaly No. 35	

Table 2 (continuation)

38	Černá hora amphibolite massif	Doležal et al. (1981), Polanský, Mrlina, Peška, Pokorný (1990)
39	Drahotín stock	Polanský, Mrlina, Peška, Pokorný (1990)
40	Poběžovice pluton	Doležal et al. (1981), Vejnar et al. (1984), Polanský, Mrlina, Peška, Pokorný (1990)
41	fine-grained granitoids of the Domažlice Crystalline Unit	
42	Babylon stock	Doležal et al. (1981), Vejnar et al. (1984)
43	Stod pluton-basic body below granitoids of the Stod pluton, its base is in a depth of 3 to 4 km	Polanský et al. (1983), Mrlina, Polanský (1986), Polanský, Mrlina, Peška, Pokorný (1990)
43a	NNE part of the Stod basic body supposed below the Stod pluton	Mrlina, Polanský (1986), Polanský, Mrlina, Peška, Pokorný (1990)
44	spilites between Holýšov and Staňkov	
44a	Carboniferous of the Merklín basin	Polanský, Dobeš, Mrlina (1982)
45	"Úsilov negative anomaly", (metasedimentary unit free of basic rocks)	Doležal et al. (1981), Vejnar et al. (1984)
46	Vidice amphibolite belt	Pokorný et al. (1987)
47	Sedmihoří stock	Mrlina, Polanský (1986)
48	Štěnovice stock	Šlechta, Polanský, Dolanská (1980)
49	spilites of the Klatovy-Dobříš belt and spilites between Borovno and Nové Mitrovice	Polanský et al. (1983)
51, 52	spilites	
53	Padrť granite pluton	
56	granodiorite (marginal type) of the Central Bohemian Pluton	
57	basic rocks of the Central Bohemian Pluton	Šrámek et al. (1986)
58, 59a, 59b	granitoids of the Klatovy apophysis	Polanský et al. (1983)
60	the main negative depression of "light" granites of the Central Bohemian Pluton	Mrlina, Polanský, Dolanská (1984)
61	positive anomaly of the Červená type granodiorite, Central Bohemian Pluton	
62	Mirotice roof pendant in the northern part metabasites of the Jílové belt	

Table 2 (continuation)

64	negative anomaly probably indicating a strong migmatitization in the Moldanubian Zone	Tomek (1974, 1975)
65	basic rocks of the Central Bohemian Pluton	Šrámek et al. (1986)
66	metabasites of the Jílové belt	Šrámek et al. (1986)
68	positive gravity anomaly between the Moldanubian Pluton and the Central Bohemian Pluton (Moldanubian gneisses)	Mottlová, Suk (1970), Mísař et al. (1972), Suk, Weiss (1975)
69	Mehelník durbachite pluton	Tomek (1974), Tomek, Obr (1975)
69a	Bechyně orthogneiss	
71	Ševětín pluton	Kadlec, Odstrčil, Šalanský (1978)
72	Prachatice granulite massif	Mísař et al. (1972), Šrámek (1994)
73	Netolice pluton	Šrámek (1994)
74	ultrabasic rocks and amphibolites in the Blanský les granulite massif	Kadlec, Odstrčil, Šalanský (1978)
77	Želnava durbachite pluton	Mísař et al. (1972)
78	a hidden granite body in the Šumava part of the Moldanubian Pluton	Mrlina, Polanský, Dolanská (1984)
79	Prášily pluton	Mísař et al. (1972)
80	an elongated granite body	
83	positive anomaly indicating the absence of granite bodies in the Moldanubian gneiss complex	
84	Vydra pluton	
87	Plechý pluton	Mísař et al. (1972)
88	Strážný pluton	Mísař et al. (1972)
89	Křišťanovice granulite body	
90	Chomutov basin (western margin)	
91	fictive anomaly resulting from calculation during the separation	
92	anomaly apparent in residual map, Horní Slavkov Crystalline Unit	
93	spilites	

Table 2 (continuation)

Anomaly No.	Geological source	References
94	basic intrusive rocks and amphibolites	Polanský, Mrlina, Peška, Pokorný (1990)
95	Bor pluton (northern part)	Polanský (1975)
96	amphibolites and basic intrusive rocks, Kdyně pluton	Polanský, Mrlina, Peška, Pokorný (1990)
97	spilites	
98	basic intrusive rocks and amphibolites, Kdyně pluton	Polanský, Mrlina, Peška, Pokorný (1990)
99	spilites	
100	positive anomaly indicating higher-density rocks below the Central Bohemian Pluton	Buday et al. (1969)
101	granulites of the Blanský les massif	Kadlec, Odstrčil, Šalanský (1978)
102	absence of basic rocks in the crystalline complex, corresponding to the "Úsilov anomaly"	
103	orthogneisses near Hluboká nad Vltavou	

Table 3. Regional faults in the structural scheme taken from earlier interpretations (Pl. 7)

Symbol of the fault	Name of the fault	References
A	Tachov fault	Polanský et al. (1973)
B	Horní Slavkov fault	Polanský et al. (1973, 1990)
C	Jáchymov fault	Polanský et al. (1973, 1983, 1990)
D	Litoměřice fault	Polanský et al. (1973)
E	Stříbro fault	Polanský et al. (1990)
F	Kladno fault	Polanský et al. (1983, 1990)
G	Klatovy fault	Polanský et al. (1983)
H	Stod fault	Mrlina (1993)

B.1.1.5. Structural scheme of the gravity field

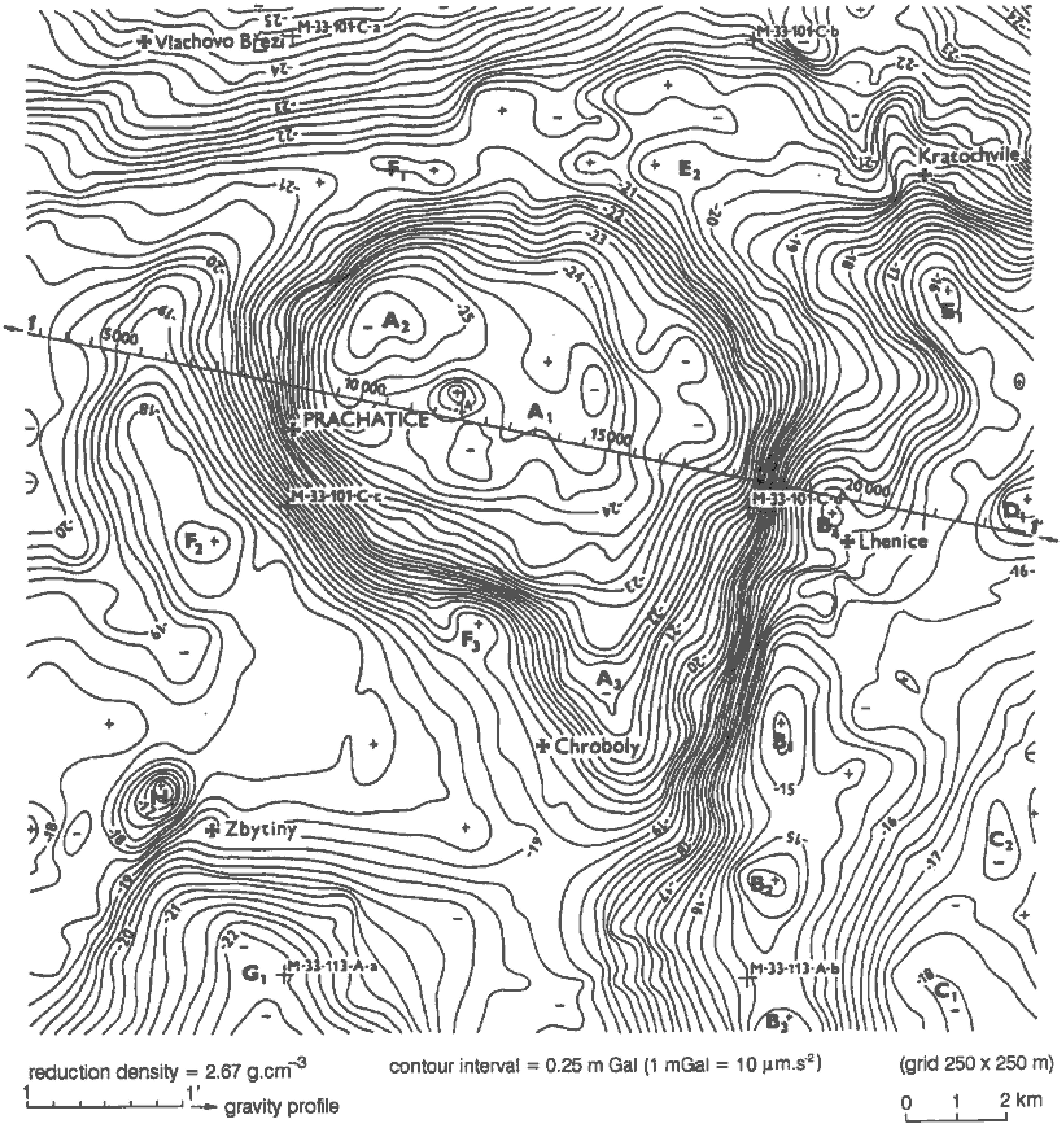
In construction of the structural scheme of the gravity field (Pl. 7) all the gravity maps of western Bohemia listed by Šrámek (1994b) were used. The most important information from these maps and interpretation results are incorporated in the scheme which, by using simplified graphic means, shows structural features of the gravity field. Many of these structures are not as easily noticed in the Bouguer anomaly map and in maps of the residual gravity anomaly. The structural scheme also contains the interpretation of regional fault positions (Tab. 3) given by Polanský et al. (1973, 1983, 1990) and Mrlina (1993).

The axes of gravity gradients are shown according to their continuation in depth, i.e., deep, moderately deep to near-surface, and shallow-near surface gradients. The axes of "deep" gravity gradients represent boundaries of major gravity areas with a relatively limited variation in the gravity field. Also shown are contours of more important gravity anomalies, numbered 1 to 89 in the same way as in the catalogue by Švancara et al. (1993). Since some anomalies given in this catalogue are not included in the structural scheme (Pl. 7) due to the merging or splitting of some anomalies, some numbers in the consecutive sequence are omitted. Newly interpreted anomalies are numbered 90 to 103. Table 2 reviews the sources of gravity anomalies.

The contours of anomalies indicate the maximal extent of the anomalous mass and need not always correspond to the shape of a geological body, as given by a geological map. New interpretations in the structural scheme resulted in changes mainly in the Cheb basin and in the subarea among the Kdyně, Stod, and Poběžovice plutons. Improved accuracy is based on a smaller step (0.5 mGal isolines) and more extensive data used in the interpretation (regional maps, maps of the residual gravity anomaly, and maps of density boundaries). The structural scheme also shows axes of regionally important depressions and elevations. Indications of transverse faults (mainly NW-SE) are based on the abrupt termination of anomalies, shifts of anomalies, deflection of gravity field isolines, or the loss of correlation of the field. These transversal discontinuities frequently represent the youngest faulting.

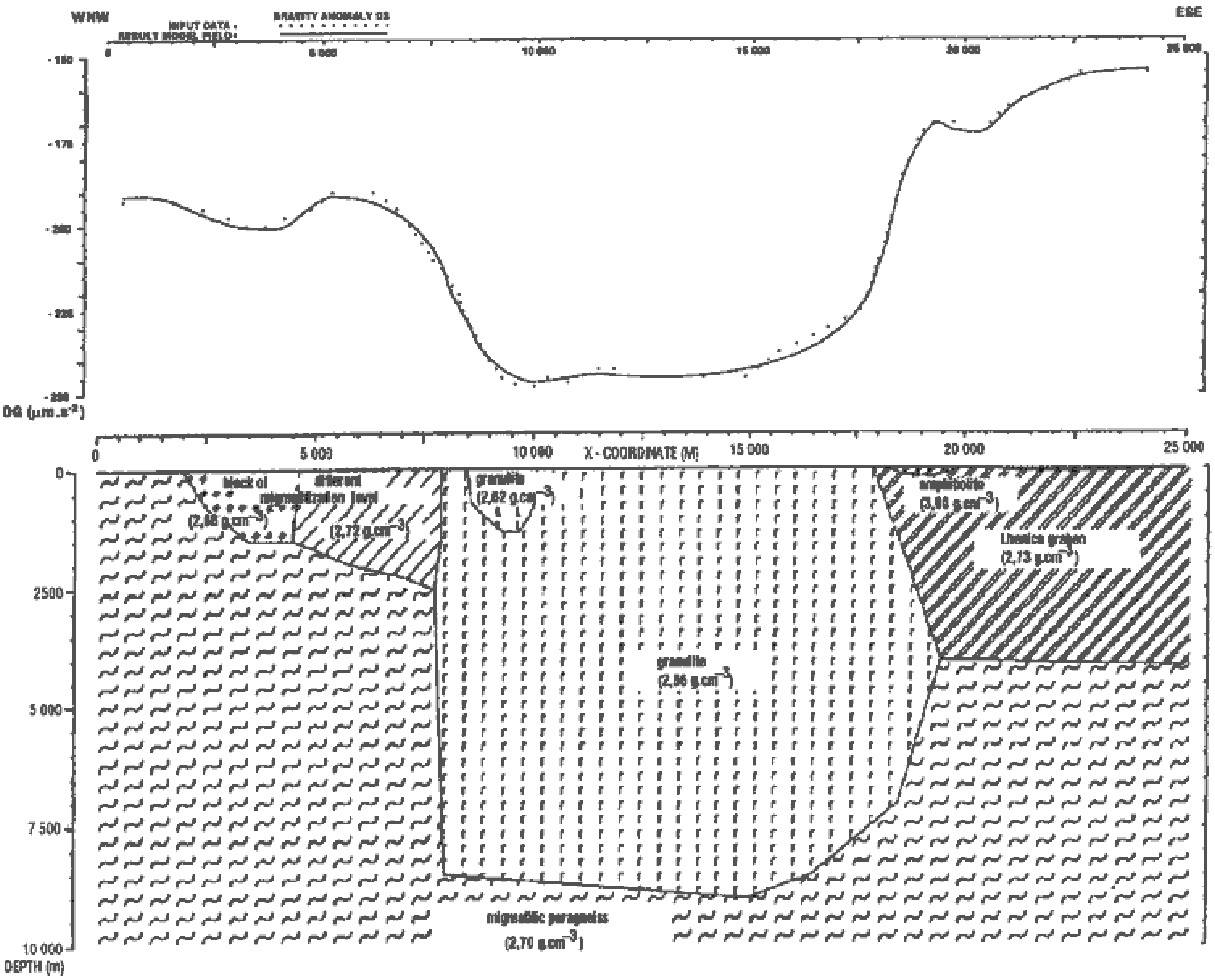
B.1.1.6. The Prachatice granulite massif in the gravity field and its quantitative interpretation

In a late stage of the present project, a gravity map of the Prachatice granulite massif based on detailed measurements was compiled (Fig. 9) as it includes an area transected by the seismic profile 9HR. This new information (Šrámek 1994a) is not included in the area shown in Pl. 1. In the gravity map (Fig. 9), the Prachatice granulite massif corresponds to a strong negative gravity anomaly bound by a sharp marginal gravity gradient. The N part of the anomaly has a nearly circular shape (Fig. 9, anomaly A_1) with an outlier protruding to the S (anomaly A_3). The junction of the granulite massif with the Varied Group zone in the east, i.e., the Lhenice linear zone (= Lhenice graben according to some authors), is accompanied by a steep gravity gradient which may indicate a tectonic boundary along the Lhenice linear zone. The base of the Prachatice granulite massif was calculated using a quantitative 2.5-D model to a depth of 8 to 9 km (Fig. 10). The quantitative interpretation of gravity data for the granulite massif indicates a predominance of subvertical orientation in the N-S trending outer boundaries. The contours of individual geological bodies around the granulite body, used for the calculation of the gravity profile, were taken from a geological map at 1 : 200 000.



9. The Bouguer anomaly map of the Prachatice granulite massif (see Fig. 66 for location).

Among the geological bodies in Fig. 9, those associated with positive anomalies include durbachitic granitoids of the Netolice intrusion (anomaly E_1). A positive anomalous elevation encircles most of the Prachatice granulite massif (anomalies E_2, F_1, F_2). They probably indicate metamorphic rocks free of migmatization, accompanied at lower levels by higher-density rocks such as amphibolites and durbachites. In the Lhenice linear zone, there are distinct positive anomalies B_1, B_2, B_3, and B_4 corresponding to numerous amphibolites, garnet-rich gneisses and possibly durbachites. Anomalies D_1, C_1 and C_2 occur inside the Blanský les granulite massif and correspond to ultrabasic rocks (D_1) and felsic granulites free of ultrabasic lenses (C_1, C_2). The northern part of the Křišťanovice granulite massif is also associated with a negative gravity anomaly. At the NW periphery of the Křišťanovice granulite massif, the Blažejovice gabbroic body occurs, corresponding to the positive anomaly H_1. The northern part of the area in Fig. 9 is influenced by the S margin of the regional Putim negative gravity anomaly, juxtaposed here along the Týn nad Vlta-



10. Gravity section of the Prachatice granulite massif. Location of the section 1–1' is shown in Fig. 9.

vou–Vodňany–Vimperk zone of mylonitic-cataclastic deformation.

The detailed gravimetric study of the Prachatice massif presents an example of the contrast brought about by a low-density felsic granulite body emplaced in a regional gneissic complex with moderate density values and the potential for this situation to characterize some of the major structural discontinuities, such as the Lhenice linear zone. This north-south to NNE-SSW trending zone of tight refolding with a steeply dipping planar structure and deformation-recrystallisation under amphibolite facies (D2/M2) was later modified by brittle faulting with faults oriented parallel to the planar structures. The linear zone cuts-off the older planar structures inside granulite, dipping NNE. This is the first time that a substantial vertical displacement (a minimum of 8 km) along steep S2 structures could be quantitatively evidenced in the Moldanubian Zone of SW and S Bohemia.

B.1.2. Density model of geological structure along the profile 9HR

J. Švancara, M. Chlupáčová

B.1.2.1. Gravity modelling

The completion of the 9HR seismic profile marked the beginning of a new period in the interpretation of the gravity data in western Bohemia. The measurement provided data on the course of acoustic impedance changes for the whole Earth's crust. The gravity modelling itself was carried out along a composite straightened 9HR profile. Bouguer anomalies from the gravity database for a reduction density of 2670 kg/m^{-3} were assigned to the section every 500 m. Pl. 8 depicts the gravity anomalies along the Klingenthal–Oloví–Sokolov–Teplá–Konstantinovy Lázně –Blatnice–Přeštice–Horažďovice–Volyně–Prachatice line. The gravity modelling was performed using the interactive program MaGGE (Halíř 1994).

The initial geometry of the density model was derived from the line-drawing of the essential reflections along the geotraverse 9HR (Dvořáková et al. 1993) obtained through the ray migration of reflections and the wave migration of the 9HR profile. In the process of the modelling, the authors were using the geological interpretation of the 9HR geotraverse proposed by Tomek et al. (this volume).

The analysis of the migrated seismic section was vital for the definition of the density model. The authors used the correlation of both dynamically strong reflections and the areas of equal echogeneity.

Particular attention was paid to the natural rock densities (Hrouda-Chlupáčová 1993). These were used for the preparation of the initial model and subsequently their calculated values were utilized for the geological interpretation of the modelled structures (Švancara-Chlupáčová 1994).

The resultant density model of the crust, which is in full agreement with gravity data measured along the 9HR profile is presented in Pl. 8. The light granite of the Karlovy Vary pluton, as thick as 11–12 km, accounts for the dominant minimum at the beginning of the geotraverse (0–45 km). The density increase towards the north-west is attributed to a dense Ordovician phyllite (density 2800 kg.m^{-3}, thickness 2.5 km) and a mica schist (density 2706 kg.m^{-3}, thickness 4 km). The local gravity minimum between km 5 and 10 is probably caused by an oval-shaped body of light (2600 kg.m^{-3}) granite which is up to 2.5 km thick. An abrupt gravity increase along the south-eastern edge of the Karlovy Vary pluton (km 40–45) coincides with the contact of the massif and dense rocks (2908 kg.m^{-3}) of the Mariánské Lázně Complex (MLC). The complex lower boundary of the MLC is assumed at a depth of about 7.5 km. At this depth, the MLC joins up with a thick crustal suture zone (2826–2966 kg.m^{-3}). The gravity maximum between km 50 and 63 is subdued by the influence of rather low-density rocks of the Teplá Crystalline Unit, approximated by three bodies with densities of 2688 kg.m^{-3}, 2675 kg.m^{-3} and 2698 kg.m^{-3}.

The Barrandian Proterozoic is subdivided into two bodies having densities of 2725 and 2747 kg.m^{-3}. These units are separated by the Stříbro-Plasy volcanic belt, the density of which averages 2870 kg.m^{-3}. Another gravity minimum may be associated with the up to 3 km thick granite pluton. Its density is 2626 kg.m^{-3}. A thick complex with the density 2800 kg.m^{-3} dipping towards the lower crust beneath the Klatovy fault accounts for the low amplitude positive gravity anomaly in the section between km 82 and 97.

Another distinct gravity maximum occurs in the interval 102–123 km. It is linked with dense Proterozoic rocks of the Blovice area, the density of which is assumed to be within the range of 2771–2782 kg.m^{-3}. Local gravity maxima within this area correspond to volcanic belts. Their densities average 2880–2950 kg.m^{-3}.

Based on the interpretation of the time section a distinct antiformal structure has been distinguished beneath the Blovice Proterozoic complex at the lower crust/mantle boundary. The density within this structural element ranges from 2989 to 3009 kg.m^{-3}.

The Klatovy deep fault has been recognized at km 124. It is assumed to be subvertical, slightly dipping to the northeast. The Klatovy apophysis of the Central Bohemian Pluton is represented by a wedge-shaped body with a density of 2725 kg.m^{-3} at a depth of about 6 km. The Klatovy apophysis is separated from the Chanov apophysis by gneiss and migmatite of the Plánice part of the Strážov crystalline unit. The density of these metamorphic rocks averages 2750–2772 kg.m^{-3}. The Blatná and Červená granodiorite of the Chanov apophysis in the interval between km 133–153 is characterized by a density of 2686 kg.m^{-3}. A domal structure has been identified at the depth range 2.5 to 13 km beneath the granodiorite based on the seismic data. The densities amount to 2724–2736 kg.m^{-3}. A body of migmatized gneiss belonging to the Moldanubian Zone has been outlined between km 152 and 173. The density averages 2716 kg.m^{-3}. Orthogneiss with a density of 2689 kg.m^{-3} has been observed further to the south-east. The thickness of this structure is 5 to 6 km. A low-density geological body (2638 kg.m^{-3}) is believed to account for a gravity minimum which coincides with km 165 of the geo-traverse. It represents the south-eastern tip of the Putim structure identified through the gravity survey by Tomek (1974, 1975).

The Prachatice granulite massif occurs at the end of the profile between km 185 and 195. Its density is 2660 kg.m^{-3} and the massif extends to depths up to 8 km. To the north-west the structure is bordered by amphibolite as dense as 2814 kg.m^{-3}, which explains the local gravity maximum at km 185.

The authors are aware that the above interpretation is only one of the alternatives and that several different density models could be created using the measured gravity data. The authors tried to lower the ambiguity of this model by using the a priori – from the point of view of gravity modelling – seismic and petrophysical data. Further details on the presented interpretation and techniques are described in Švancara et al. (1993) and Švancara-Chlupáčová (1994).

B.1.2.2. Rock densities used in the modelling

The presented density model respects the deep seismic profile in the upper crust and is slightly simplified in the lower crust comprising probably the Proterozoic fundament. This approach partially eliminates the ambiguity of possible shapes, mineral compositions and densities of the bodies under consideration, and corresponds to the decreasing power of gravimetry with depth in distinguishing individual geological bodies.

In the development of the density model, the database created during 30 years of activity in the frame of various regional and local projects of gravity and petrophysical surveys (for summary see Hrouda-Chlupáčová 1993) was used. This database provided us with several thousands of high quality data, which enabled us to reliably characterize the geological bodies cropping out in the area studied. The determination of the most probable density distribution in hidden structures and bodies of the model was a rather difficult task, because it was necessary, in addition to the use of the database, to make some assumptions on the depth dependence of porosity, the pressure and temperature influence on densities of individual minerals and, most important, of the plausible petrological character of the geological bodies under consideration. The reliability of the density model may, in principal, increase, if the distribution of longitudinal wave velocity with depth is known, because a good statistical correlation exists between the bulk density and the velocity of propagation of longitudinal waves within the Earth's crust. Unfortunately, the velocities can be calculated only from refraction or wide angle reflection seismic measurements, which is not the case of the 9HR reflection profile. Consequently, we could use, in elaborating our density model, only the velocity sections of the refraction profile VI/70 presented by Beránek et al. (1975), and re-interpreted by Novotný (this volume). The distance between this profile and our density 9HR profile is about 20 km in the Krušné hory Mts. region and about 70 km at the southern margin of the Barrandian region. These profiles are even more distant in the Moldanubian region. In addition, when constructing our model, we also respected the density model along the DECORP MVE 90 profile passing along the German part of the Krušné hory Mts., approximately between the towns of Hof and Bautzen (Conrad et al. 1994).

The mean natural densities of the principal types of magmatic and metamorphic rocks of the Bohemian Massif are as follows (in kg.m^{-3}): granite – 2620, tonalite – 2730, diorite of Variscan age – 2790, diorite of pre-Variscan and unknown age – 2850, basic rocks – 2950, orthogneiss – 2630, quartzite – 2640, granulite – 2680 and 2730, migmatite – 2690, crystalline limestone – 2720, micaschist – 2710, gneiss – 2710, phyllite – 2730 and 2830, amphibolite – 2950 and 3000, pyroxene granulite – 2830 (Uhmann 1989). The above densities characterize the near-surface layer displaying the average porosity of 1.5 %. In the lower layer, often deeper than 500 m and very probably from 3 km to 15 km in deep, the porosity is very low and the natural rock density is about 10 to 20 kg.m^{-3} higher. In the deeper crust, the almost exclusive controlling factor for the natural density is mineral composition and the natural density virtually equals the grain density.

The density of the Karlovy Vary granite pluton, the dominant body of the Saxothuringian Zone from the point of view of gravity, seems to be conspicuously low (Pl. 8). It corresponds approximately to 2 % porosity, because the grain density is very homogeneous in this body, equal to 2650 kg.m^{-3}. In our opinion, the autometamorphic granites, probably representing the dominating facies in the deeper levels of the massif, contain frequent altered zones which display relatively high porosity, about a few percent, and can reach several kilometres in depth. The tectonic zones affected by subsequent hydrothermal alteration also display such high porosities and vertical extension. In addition, the mineral composition of the granites can change with depth, which primarily means the content of potassium feldspar (2570 kg.m^{-3}) can increase and the contents of quartz (2650 kg.m^{-3}) and sodic plagioclase (2630 kg.m^{-3}) can decrease. These changes were observed in the deep boreholes drilled into the tin-bearing granite stocks, in the vicinities of Cínovec (borehole CS-1), the Krušné hory Mts., and Krásno (borehole K-25) near Horní Slavkov. A hidden granitic body, indicated by the gravity survey at the beginning of the profile at the depth of 6-10 km, appears to have a slightly higher density compared to that of the Karlovy Vary pluton or nearby orthogneisses which may be similar, for example, to the Smrčiny orthogneisses.

The Ordovician phyllites of the Krušné hory Mts. represent, on the other hand, a unit with an anomalously high density. The metamorphic rocks underlying the rocks of the Arzberg Group show a relatively high density as well. They are probably represented by more mafic micaschists, similar to those cropping out in the southern part of the Svatava or Dyleň crystalline complexes, or by sillimanite biotite paragneisses known from the margins of the Horní Slavkov crystalline core.

The five kilometres thick, highly reflective zone, interpreted as the lower group of the Saxothuringian nappes by Tomek et al. (this volume), is created in his opinion by strongly tectonized metamorphic equivalents of the oceanic crust, including eclogites and possibly high-pressure granulites. The surface outcrop of this structure is represented by the MLC. For our modelling, we adopted the density which is a compromise between the high densities of garnet and zoisite amphibolites and eclogites (2990, 2970, and 3270 kg.m^{-3}, respectively), and the intermediate densities of gabbrodiorites and diorites (2780 kg.m^{-3}). These basic igneous rocks are probably more frequent in the deeper parts of the complex than at its surface (see Polanský et al. 1990). Serpentinized ultrabasic rocks of the MLC show very low (almost "granitic") densities and belong, together with banded amphibolites and limestones of the Kladská Unit rimming the MLC at the W and SE, to the intermediate density rock units. Consequently, we suppose that the average density of the whole Saxothuringian lower thrust unit does not exceed 2900 kg.m^{-3} in the upper crust. In the lower crust, where the thrust is dipping into the root zone, we also suppose a high content of gabbrodiorite intrusive rocks or a higher content of different granulites resulting in the gradual density increase from 2900 to 3000 kg.m^{-3}.

The units with lower density in the Teplá Crystalline Unit (TCU) probably consist of orthogneisses and pegmatites. Two principal units, only slightly differing in density, can be distinguished in the north-west flank of the Upper Proterozoic of the Teplá-Barrandian Unit (TBU) in the upper part of the crust. The first, located at the boundary with the TCU region, contains predominantly metagreywackes and the second, located farther to the SE, comprises a substantial amount of metapelites. The relatively highest densities in the TBU are displayed by the Blovice Proterozoic unit and both the Kralupy-Domažlice and Dobříš-Klatovy volcanic belts. The presence of relatively frequent basaltic volcanogenic rocks as well as the sulphide mineralization of the volcano-sedimentary origin resulted in the slight increase in density of this south-eastern Proterozoic rock unit. The shallow gravity depression in the NW limb of the TBU is interpreted as an effect of a relatively thin lensoid granite body similar to the low-density Lestkov granodiorite and Tis granite.

A hidden large basic complex extended under the Upper Proterozoic in the TBU in the upper crust and dipping to the root zone at the boundary with the Moldanubian Zone is obviously the source of the positive regional anomaly in the SE part of the TBU. Both the age and composition of this reflecting structure, to which probably the Kdyně gabbro massif belongs, should not be uniform; a variety of metamorphosed basic rocks can be represented. The presence of either older or younger basic rocks in the whole structure cannot be excluded. The existence of thick layers of Cadomian basic rocks rich in plagioclase in various parts of the upper crust should explain the weak Variscan metamorphic overprint of the overlying Upper Proterozoic units, since plagioclase exhibits very low thermal conductivity and hornblendes and pyroxenes show only intermediate values, while highly conductive quartz is absent in these rocks.

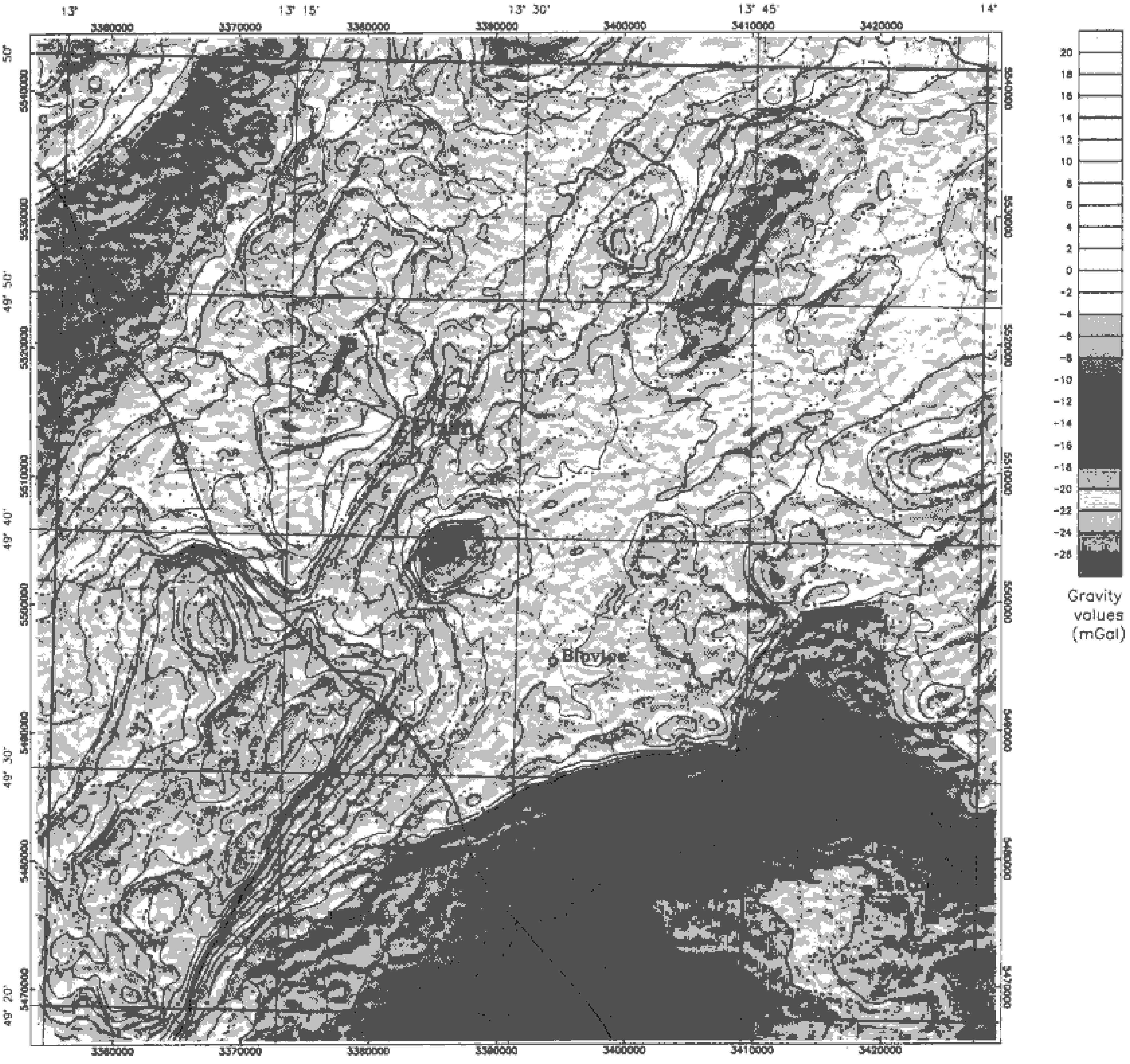
In the Moldanubian Zone, a surprisingly conspicuous reflective antiform exists under the Blatná granodiorite which should be represented by the sequences of metamorphic rocks with highly variable elastic velocities and likely with variable densities as well. Such a sequence can be formed, for example, by layers of quartzites, limestones and/or orthogneisses and fine-grained paragneisses alternating with the high-density layers probably corresponding to sillimanite-biotite gneiss, amphibolites and calc-silicate gneiss. The interpretation of the so-called Putim negative anomaly provides evidence of a hidden structure of low density rocks, elevated in our model to 3 km under the surface. As it follows from the above mentioned density data, the source of this anomaly can be either a granite massif or a large body of orthogneisses or strongly migmatized gneisses corresponding to rocks of the Podolsko complex; felsic granulites are probably present in this body. The geology of the Podolsko complex on the present surface shows that all the enumerated quartzo-feldspathic rocks are represented. The lower crust of the Moldanubian Zone comprises rocks whose densities correspond to biotite gneiss and tonalite.

The basement of the Variscan nappes is created by parautochthonous crustal segments which are, in synthetic works on the geological structure of central Europe, regarded as a Proterozoic complex, intensely re-worked during the Variscan orogeny. Tomek et al. (this volume) point out the pattern of the reflexes in the fundament of the Saxothuringian Zone (CEU), indicating an intense effect of deformation. In our opinion, the parautochthonous rocks are represented by rocks of the type of pearl gneisses and granodiorite gneisses in the upper parts, while the lower parts are represented by mafic granulite gneisses and granulites. Tomek et al. (this volume) hypothesizes the whole Lužice massif could belong to the CEU, while Conrad et al. (1994), in interpreting the MVE-90 profile, consider the positive gravity anomaly of the Lužice massif to be due to a body characterized by conspicuous stratification and a downward density increase because the outcropping granodiorites with a the density of about 2720 kg.m^{-3} cannot cause this anomaly. We adopt this idea and assume a density increase with depth, even though less intensive than that of the Lužice massif. The zonation in density may have taken place as early as in the formation of the protolith or later, during the extension regime, mainly during "magmatic underplating", or through basification due to the melting and ascension of granitoid magmas. Some downward increase of density is probably due to regional metamorphism; the increasing pressure and temperature resulted in mineral assemblages with a higher proportion of garnet and pyroxenes. In particular, during the period of increased heat flow during the Variscan orogeny, HT metamorphic minerals may have crystallized. The lower crust in the Moldanubian Zone, at least in its westernmost areas, seems to be more basic than the CEU. The structures in the lowermost parts of the crust are highly hypothetical, and may represent relics of "stacking" of the root zone of the nappes in the region, and deformed and transformed later. On the other hand, they resemble structures originated through simple shear extension. We hypothesize that these structures show mineral compositions and densities similar to those of the basic lower crust. In the basement of the CEU, at the depth of 30 to 34 km, Tomek et al. (this volume) interpret a flat intrusive body having a chemical composition similar to that of the alkaline basalt and transformed under the PT conditions typical of the crust/upper mantle boundary. The existence of basaltoid intrusions of Tertiary age at the base of the CEU seems to be very likely on the basis of the complex geochemical and petrological evolution of the young basaltoid volcanism in the central Europe (cf. Wilson-Downes 1991). Even though the heat flow in this part of the Ohře (Eger) rift is about 70 to 80 mW.m^{-2} (Čermák 1979), which is partly due to the Variscan granitoids, the estimated temperatures at the base of the crust are about 600 to 700 °C and, therefore, near boundary between amphibolite and granulite facies. Hence, we suppose a mineral association of the pyroxene gabbro, or pyroxene granulite with a density of about 3000 kg.m^{-3}. The density of the upper mantle was considered as comparable to spinel lherzolites, dunites and peridotites, close to 3250 kg.m^{-3}. The grain density of the spinel lherzolites sampled as xenoliths in the Tertiary basalts at Dobkovičky in České středohoří, at Zámeček near Chomutov, Provodín near Česká Lípa and in Smrčí ranges from 3226 to 3296 kg.m^{-3} and inspired the considered value for the upper mantle.

B.1.3. Advanced processing of gravity data

J. Švancara

The good quality of the gravity data combined with the current techniques of the presentation of potential fields made it possible to create colour maps of the gravity field supplemented by a shaded relief of the total horizontal gradient of gravity. These maps depict clear indications of linear structural-tectonic elements, which are included in the high-frequency portion of the gravity field and have not been traceable by standard methods. The following map units have been compiled at the scale of 1 : 200 000: M-33-XII Karlovy Vary, M-33-XIV Teplice, M-33-XIX Mariánské Lázně, M-33-XX Plzeň, M-33-XXVI Strakonice and M-33-XXVII České Budějovice. Fig. 11, as an example, depicts the reflectance image of the horizontal gradient of gravity for the map sheet Plzeň.



11. Colour map of the gravity field of western Bohemia, supplemented by the reflectance image of the horizontal gradient of gravity, depicts the contact zone between the Teplá-Barrandian Unit and Moldanubian Zone. Scale 1 : 500 000, north illuminated, grid size 0.25 km (J. Švancara 1995).

The content of the maps is the following:

- coloured gravity values with the interval of 1 mGal (the scale covers the whole Bohemian Massif),
- reflectance image of the horizontal gradient of gravity for the 0° azimuth and 45° elevation,
- Linsser's indications of density contacts for the depth of –500 m; the intensity of the indication is coded in the size of the symbol,
- generalized drainage pattern including rivers (the digitalized model on the scale 1 : 500 000 provided by O. Man),
- the topographic situation of the 9HR profile, Gauss-Krueger system km grid, geographic grid 10x15',
- state border.

B.2. MAGNETOMETRY AND RADIOMETRY

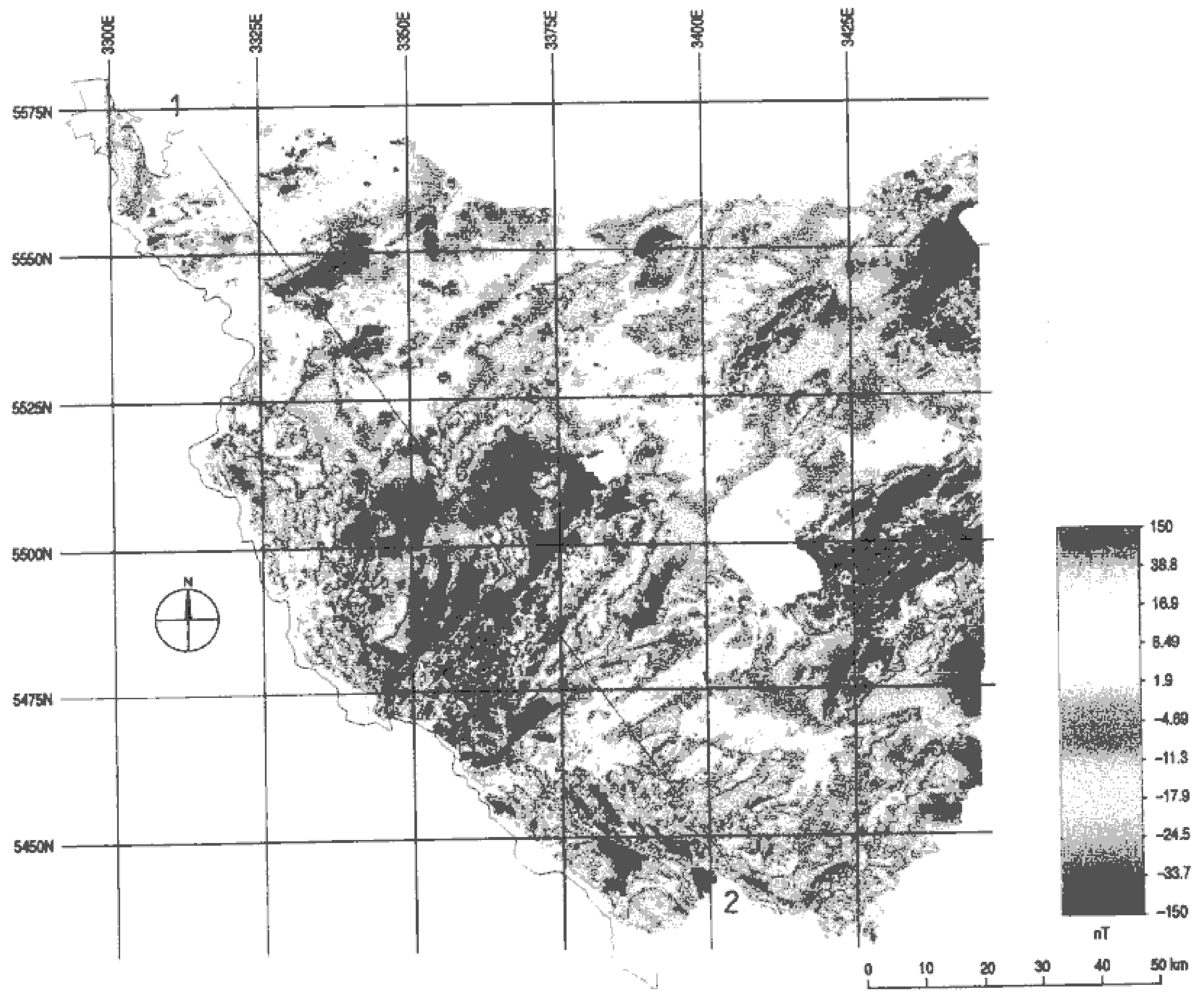
L. Pokorný, M. Manová, L. Beneš

The magnetic field and the radioactivity in the region of the project "Geological model of western Bohemia in relationship to the deep borehole KTB in the FRG" were investigated by means of an airborne survey. Within the framework of the present project, the important border region along the CR-FRG boundary, a belt 140 km long and about 10 to 15 km wide between the town Kraslice in the NW and the village Kvilda in the SE, was investigated during 1991–1992 using the above mentioned aiborne geophysical methods (Fig. 3). The results of these latest measurements have been evaluated and interpreted by Dědáček et al. (1993). This report also includes aeromagnetic and airborne gamma spectrometric maps at a scale of 1 : 100 000 as well as a map of analytical continuation of the magnetic field at a level 1 km above the Earth's surface (Figs. 12, 13).

The majority of older data used was obtained within the framework of several stages of geophysical mapping of the territory of the Czech Republic. The field of geomagnetic total intensity and the field of natural gamma-ray activity were measured simultaneously.

Whereas the results of the aeromagnetic survey at the scale 1 : 200 000, performed as early as during the fifties, are now of historical interest only, the simultaneously produced aeroradiometric map at 1 : 200 000 (Mašín 1965, compiled 1966) became a basis of the study by Matolín (1970). This study, which discusses the radioactivity of rocks of the Bohemian Massif, has been a source of basic information on this geophysical parameter till now. The aeromagnetic and aeroradiometric mapping at a scale of 1 : 25 000, conducted in parts of the area of the present project during the period 1965–1971, was of essential importance for more detailed geological and geophysical studies. These measurements were performed with the Russian apparature ASG-46 and data were presented in maps of isolines of the total geomagnetic intensity and of the total gamma-ray radiation. They have been evaluated in a number of research reports (Pokorný et al. 1972, Pokorný 1976, Šalanský-Manová 1973, 1974, 1976, 1977).

In a later stage of the aerogeophysical survey, 1976–1986, an essential part of the investigated area, with the exception of its SW and NW, part was covered; in particular, the region along the border with the FRG has not been included. These measurements have been performed with a Geometrics-Exploranium device (the proton magnetometer G 801/3 B and the four-channel gamma-spectrometer DiGRS 3001). An essentially higher magnetic measurement accuracy as well as the application of gamma-ray spectrometry (determining, in addition to the total radiation, the concentrations of each of three main radioele-



12. A synoptic view of anomalies in the magnetic field of western Bohemia, plotted on a conventional grid in kilometres. Position of the profile line 1–2 for the magnetic model of crustal structure (Fig. 14) is also shown.

ments, i.e. K, U, Th) is characteristic of this new mapping. The output of these 1 : 25 000 scale measurements includes also the maps of concentrations of radioelements K, U, Th and their ratios on the scale 1 : 50 000 in addition to contour maps of total geomagnetic intensity and total isoradiation on the same scale. The evaluation and geological interpretation of this work has been the subject of several research reports (Gnojek-Obstová 1977, Gnojek-Dědáček 1977, Dědáček et al. 1985, 1986, 1988).

B.2.1. Magnetic field

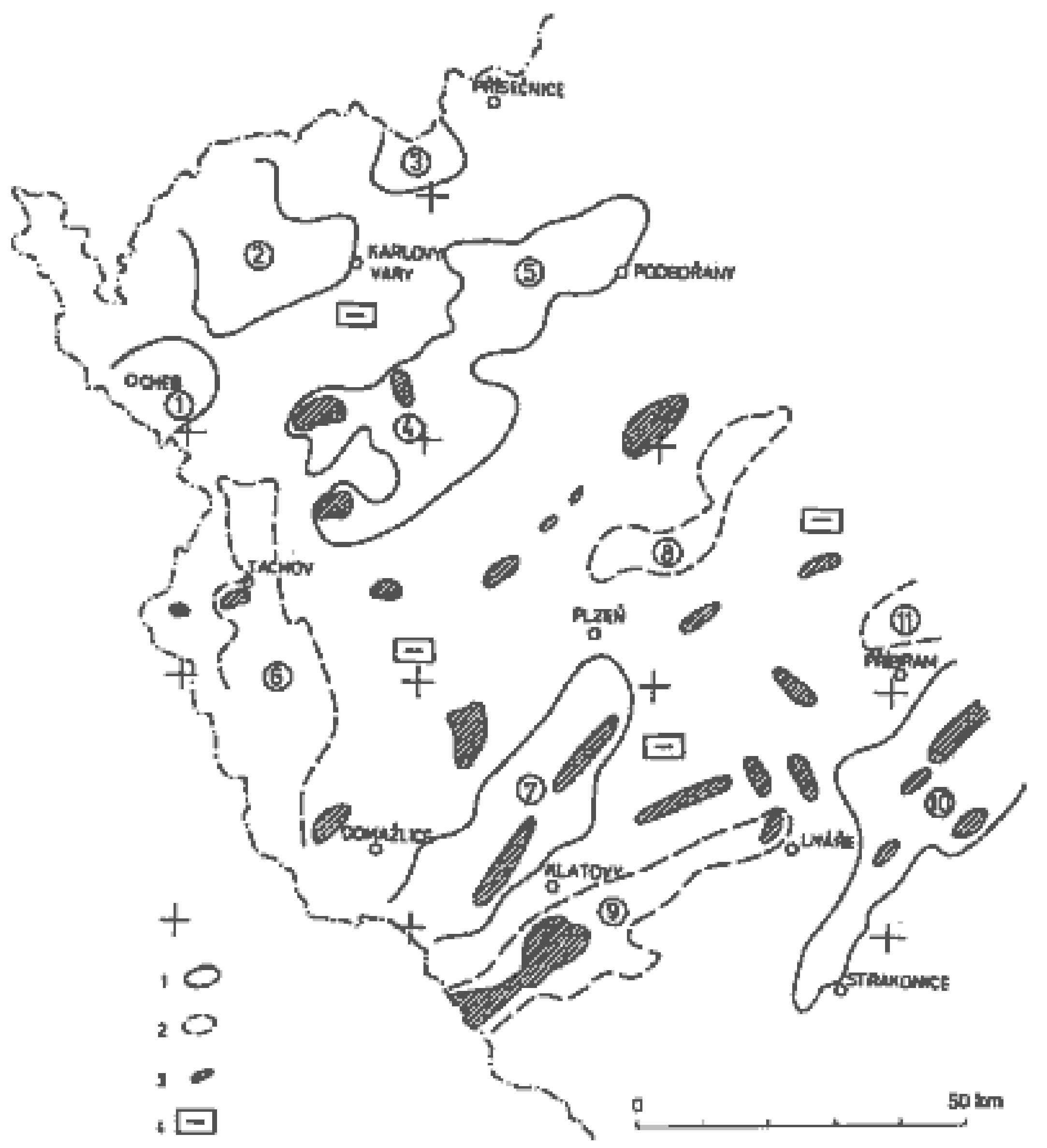
L. Pokorný, L. Beneš

The map of the magnetic field of the area (Fig. 12) has been compiled solely from accurate airborne measurements conducted after 1976; sections not yet covered by new measurements have been omitted. The scheme of regional anomalous magnetic patterns, compiled on the basis of analytical field continuation computing (Fig. 13), has been adjoined; the earlier less accurate measurements have also been used for the completion of this scheme.

B.2.1.1. Characteristics of the anomalous magnetic field of the area

The magnetic field of the area (Fig. 12) is of a highly varying character. The presence of extensive Pre-Variscan as well as Variscan crystalline units and of weakly metamorphosed Upper Proterozoic is the main reason for this situation. These units contain a number of magnetized horizons, in particular those of metavolcanites belonging to several stratigraphic levels. In some cases the formation of ferrimagnetic accessories during metamorphism took place and some parts of high-grade metamorphic units carry polygenetic assemblages of magnetic phases. Even in areas covered by platform sediments, which are usually weakly magnetized or non-magnetized, numerous strongly magnetized Tertiary volcanites occur. The influence of magnetized rocks in the crystalline basement below platform sediments can also be significant. Many sources of magnetic anomalies are situated directly at the surface or at a shallow position. The effects of such local anomalous sources can be explained without difficulty; this is possible because a relatively good regional petromagnetic database about the rocks of the project area was used. Many of these local anomalies are grouped in certain belts important for evaluation of both the regional and local tectonic patterns of individual major units. The important local anomalies and regionally extensive belts will be mentioned in the following section on the geological-geophysical interpretation.

The overall zonal arrangement of the major extensive regional magnetic anomalies, continuous over the region studied, is of particular interest. This zonation is to be analysed as an indication of important structural boundaries of tectonic units; their orientation can be related to tectonic patterns in the area. The zonal arrangement of regional magnetic anomalies was recognized and interpreted in earlier studies (e.g., Pokorný et al. 1985, Blížkovský et al. 1988 etc.) as an indication of deep-seated linear faults bounding individual crustal blocks. However, with respect to phenomena of collisional tectonics and plate tectonic evolution, the internal deformation of units due to thrusting and folding should be considered. Interpretations aimed at reconstruction of pre-orogenic, early regional patterns appear to be beyond the capabilities of methods and data available at present.



13. A scheme of anomalies in the regional magnetic field of western Bohemia.
1 – remarkable regional anomalies with maxima over +50nT, calculated for the level 1 km above the Earth's surface: 1 – ChB anomaly 2 – Olovi-Sokolov anomaly, 3 – Jáchymov anomaly, 4 – Teplá anomaly, 5 – Doupov anomaly, 7 – Kdyně-Štěnovice anomaly, 10 – central Bohemian anomaly; 2 – less remarkable regional anomalies with maxima lesser than +50nT, calculated for the level 1 km above the Earth's surface: 6 – Český les Mts. anomaly, 8 – NE continuation of the Kdyně-Štěnovice anomaly, 9 – Klatovy anomaly, 11 – Brdy anomaly; 3 – local anomalies caused by deeper subsurface bodies; 4 – regional domains with subdued magnetization.

The relationship between the localization of the regional magnetic anomalies and the local ones was also considered. Within the regional positive anomalous zones, the frequency of local anomalies is, as a rule, higher than in areas of a weak magnetization. Some local anomalies, sometimes of high intensity, do occur in areas of weak magnetization.

The azimuthal orientation of regional magnetic (as well as gravity) anomalies is an important feature. All the main magnetic anomalous belts (excluding the subdued N-S trending elevation of the Český les Mts. – Bohemian Forest – area) are characterized by a general NE-SW direction. Nevertheless, the main anomalous zones are not completely parallel to each other. The regional anomalies of the central zone within the TBU Upper Proterozoic closely approximate the "proper" NE-SW trend. This zone is represented in the investigated area by the impressive Kdyně-Štěnovice regional anomaly and by its subdued continuation to the NE. The regional anomalies are associated here with volcanic and plutonic bodies, partly in a subsurface position and of tholeiitic composition (cf. Dědáček et al. 1985, 1986, 1988). It can possibly be considered as a relict member of an original extensional structure (?) in the Proterozoic sedimentary basin (cf. Pokorný et al. 1985, Polanský et al. 1990).

B.2.1.2. Main belts of regional magnetic anomalies and their correlation with the anomalies of gravity

Proceeding from N to S, the following regional magnetic anomalous belts can be recognized:

1. The zone of the Krušné hory Mts. and Smrčiny Mts., consisting (from W to E) of the anomalies of Cheb, Oloví-Sokolov, Jáchymov (or Klínovec) and (outside the investigated area) the anomaly of the eastern Krušné hory Mts. Further continuation of this zone to the E can be seen in the regional magnetic elevation in the area of the Upper Lusatia. All the partial anomalies of this belt have been described several times in the past (Pokorný 1969, 1976, in Saxony Scheibe 1966 a. o.). The regional magnetic elevations are frequently accompanied by local anomalies occurring on this background, and are thus explained as a total of their surfacial influence by some authors (e.g. Scheibe 1966). Nevertheless, some local anomalies also occur outside the regional magnetic elevations and the regional anomalies extend in some cases into regions free of local anomalies, e.g., into the outcrop area of non-magnetic granite in the Nejdek pluton. Regarding also the general characteristics of regional magnetic elevations, it can be supposed that the main anomalous sources occur at depths of a few kilometres under the present surface. The local anomalies occurring on the background of regional elevations within low- to medium-grade metamorphosed rocks in the surroundings of Cheb, Sokolov and Jáchymov are connected with volcanic and metavolcanic rocks and magnetic components of sedimentary-metasedimentary sequences; the sources of the regional component of the anomalies can also be represented by plutonic bodies. In cases showing positive correlation with residual gravity anomalies, e.g., in the western Krušné hory Mts. and Smrčiny Mts., a mafic composition of these rock bodies can be supposed. Where such a correlation does not exist or it is even negative (a positive magnetic field coincides with negative values of the gravity field) some alternative explanation should be considered. Thus, in the case of the magnetic elevation of the eastern Krušné hory Mts., magnetic rocks are interpreted to occur under granite bodies; magnetite-bearing cordierite gneisses are suggested as a probable rock type (Pokorný 1976). The belt of regional magnetic anomalies can be interpreted as an indication of a volcanoplutonic zone in the complex of the Saxothuringian Zone. The azimuthal orientation of the zone, regardless of later cross-cutting faults, corresponds to the main Variscan structural trend of this unit (WSW-ENE to W-E).

2. The belt of Teplá-Doupov, running roughly parallel to the belt mentioned above, is localized along and primarily S of the southern boundary of the Saxothuringian Zone, but the Saxothuringian complex is supposed to extend further SE below the Mariánské Lázně Complex (Tomek et al., this volume). In a way similar to the zone of the Krušné hory Mts., this zone can also be traced far to NE and outside our area, under the Tertiary and Cretaceous platform sediments. The regional magnetic anomalies correlate very well with the gravity anomalies; both can be traced continuously over a great distance (with a number of transversal offsets). The magnetic anomalous zone itself is extended to the W as far as the Schwarzwald Mts. This remarkable zone indicates an approach of magnetic basic rocks to the surface, along the Saxothuringian Zone – Teplá-Barrandian Unit boundary. Most of these strongly magnetized rocks are, of course, inaccessible for direct observation. They are hidden at depths of several kilometres under the present surface; e.g., the depth of the main source of the regional gravity anomaly of Teplá has been calculated to be between 1 and 8 km. These rocks crop out only in areas of limited extent such as the Mariánské Lázně Complex comprised of magnetized amphibolites, metagabbros and serpentinites in this unit and its surroundings. The Teplá-Doupov magnetic and gravity anomalous zone must be considered as a unit of high tectonic importance. According to the present tectogenetic conception, it can be interpreted as a zone of Variscan emplacement and an exhumation of crustal rocks that experienced metamorphism under lower crust conditions (e.g., eclogites, see chapter C.2.) plus upper mantle rocks and their juxtaposition with the upper crust. A number of notable local anomalies partly influencing the regional magnetic field require consideration based on detailed geological and geophysical maps and information, since in a small area the magnetic rocks belong to two distinct units, i.e., the Mariánské Lázně Complex and the Kladská Unit (see chapter C.3.). The latter unit includes low- to medium-grade LP magnetic metabasites and magnetic metacarbonates at Útvina and a sequence of magnetized rocks at Michalovy Hory. The recurrent activity of the closely associated Litoměřice fault zone indicated by the strongly contrasting geology of the juxtaposed Saxothuringian Zone and the TBU, volcanism in the Permian as well as the Tertiary (mantle-derived alkali basalts), geothermal and also partial seismic activity, is notable. The information available is insufficient for the interpretation of changes in the three-dimensional configuration of units along this zone and the changing patterns associated with recurrent activities.

3. The magnetic belt of Kdyně-Štěnovice, traceable continuously in the NE direction into the Bohemian Cretaceous basin area out of the region studied, is of a different type. There are rough positive correlations with the gravity anomalies, with the exception of a small segment of the Štěnovice granodiorite massif where the correlation is negative. However, the continuity of individual patterns of this central anomalous zone of the TBU Precambrian is by

far not as well defined as in the former zone. In the surroundings of Plzeň, both the magnetic regional anomaly and the associated gravity anomaly are disrupted by a system of cross faults trending NW-SE. Further along, their continuation to the NE is less distinct; the anomalies of both physical fields become more expressive again as far as NW of Prague, outside the investigated area. The magnetic elevation of Kdyně-Štěnovice coincides with the outcrops of the south-western segment of the main volcanic Radnice-Kralupy belt. The regional components of the magnetic and gravity anomalies are, with high probability, related to sources deeper than the volcanites exposed on the surface even where these steeply NW dipping volcanic bodies reach a depth of several kilometres. The presence of a covered, extensive and strongly magnetized body of rocks of high density can be presumed here on the basis of measurements. Contact metamorphism around subsurface intrusions contiguous with the Kdyně-Stod pluton may account for part of the total magnetization effects. The magnetization-bearing mineral of the volcanites is generally pyrrhotite, as shown by the petrophysical study. This mineral has been considered by Šťovíčková (in Dědáček et al. 1985, 1986) to be a primary phase crystallized from tholeiite magmas. It's content fluctuates within broad limits; volcanic rocks with very low values of magnetization occur here as well.

Towards the NE, the Upper Proterozoic sedimentary complex is preserved in gradually greater thickness. The increasing preservation of younger members (or tectonically higher units) towards the NE is also indicated by the presence of the Lower Palaeozoic – the Prague Basin. Therefore, the main sources of magnetic as well as gravity anomalies in the Upper Proterozoic occur in a deeper position towards the NE and thus their physical influence on the surface is subdued. Even the local magnetic anomalies connected with the outcrops of volcanites in the main volcanic zone are less frequent here and mostly less intensive. The outcropping volcanic rocks in these parts of the Upper Proterozoic apparently belong to higher, less magnetized volcanic members of the complex.

4. The zone of Central Bohemia occurs in the SE along the boundary between the TBU and the Moldanubian Zone. This zone is very similar to the zone of Teplá-Doupov in the NW, including an extension far to NE along with the coinciding anomalous zone of gravity. The south-western part of this zone occurs in the crystalline complex of the Moldanubian Zone between two peripheral outliers of the Central Bohemian Pluton. The main north-eastern section of this magnetic zone is located in the northern part of the pluton, in the areas of metamorphosed roof pendants ("islets") and in the Jílové volcanic belt, that is in the so-called transitional zone of Central Bohemia after Röhlich-Šťovíčková (1968). Sources of the regional anomalies probably occur at least partly in the deeper subsurface levels and include covered bodies of possible mafic subvolcanic or plutonic rocks (Šalanský-Manová 1973). Such bodies possibly belong in part to the TBU. The surface rocks in this zone are, however, often strongly magnetized. Rock types with a high magnetization include volcanites of the Jílové zone, some granitoid rocks of the pluton such as the marginal granite, Sázava tonalite etc. In the surroundings of Příbram, a weak but obvious magnetic elevation of the Brdy Mts., correlating with a positive gravity anomaly, runs to the W from the trend of the main magnetic anomalous belt; this situation also suggests the presence of a covered basic body underlying the Cambrian sediments. Notable is a weakly anomalous area projecting from the Mirovice roof pendant into the Moldanubian Zone.

In the Moldanubian Zone, zonally arranged regional magnetic anomalies of tectonic significance are relatively rare. Examples include the Královský hvozd Unit, the Kaplice Unit (shear zone) and the Týn nad Vltavou-Vodňany shear zone (Šalanský 1967, Vrána 1979, 1992). The regional magnetic field in the Moldanubian Zone fluctuates within weakly negative values in extensive areas, mostly connected with regional antiformal patterns with outcrops of granitoids. The positive anomalous areas are, as a rule, less extensive and they correspond to synformal(?) structures and coincide with a greater thickness of metamorphic rocks of the Varied Group. A remarkably higher magnetic field is generally characteristic of granulites and ultrabasites of the granulite complex in southern Bohemia. Local anomalies within the area, caused by surface sources often arranged in stripes, are sometimes continuous over distances of many kilometres.

B.2.1.3. Correlation of the regional magnetic field with the results of interpretation of the 9HR seismic profile and with the density model

All interpretations hitherto of the regional magnetic belts in the investigated area either were limited to considerations mostly from the point of view of surface geology or they were referred to supposed (not verified by seismics) undulation or disruption by faulting of the upper surface of the so-called "basaltic layer" in deeper crust. These ideas were often connected with supposed vertical movements along deep faults (Mašín 1966, Pokorný 1976, 1987). However, new data show that supposed vertical movements can not explain the recent inhomogenity of the upper crust, even where faulting and vertical movements have been undoubtedly proved. Therefore, an attempt at correlation of the model of crustal structure in the investigated area based on the reflection seismic results of the 9HR profile (Kraslice-Prachatice, see Tomek et al., this volume) supported by the complementary density model (derived from the detailed regional gravity data) with the regional anomalous magnetic field of the area has been undertaken. The regional magnetic field itself was determined by an analytical computation of the field continuation from the level of measurement to a level of 1 km above the Earth's surface; thus the influence of surfacial and shallow magnetic anomalies was decreased. The simplified density model (Švancara-Chlupáčová, this volume) based on the seismic results as well as on the gravity field in the area were used as a basis for the quantitative evaluation of the magnetic field.

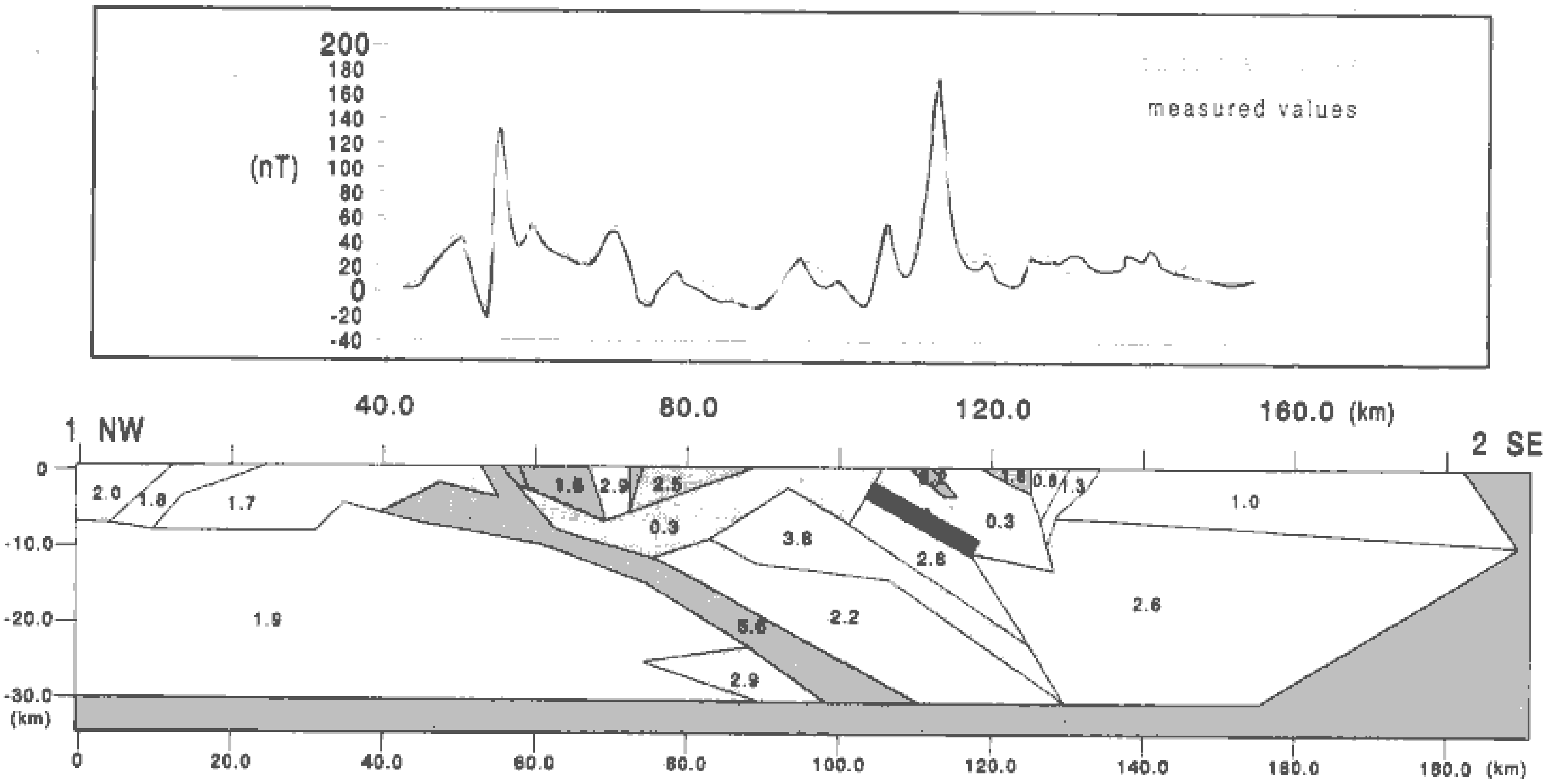
The computation was performed using the results of the most accurate airborne measurements obtained during the recent works. As this measurement is not complete in the north-western part of the area, and data from sufficiently extensive surroundings of the profile necessary for the computation were absent in part, the interpretation could not be performed in the first kilometres of the profile.

The main feature of the magnetic field of the area is a systematical increase of the regional magnetic field values of the higher order from the axis of the TBU as far NW as the border with the Saxothuringian Zone. Such a phenomenon is absent both in the south-eastern flank of the TBU and in the Moldanubian Zone. The regional anomalous magnetic belts mentioned above occur on the general background of this increasing field. This important phenomenon can be explained, as shown by our model (Fig. 14), by presuming a relatively strongly magnetized layer within the interior part of the crust. This layer may be 3–5 km thick and it could be rooted near the axis of the TBU. Further NW it obviously occurs in a shallow position a few kilometres under the surface and dips only flatly to the NW. Besides this deep dome-like structure (culminating under the Krušné hory Mts. antiform), a similar more shallow, less extensive and less magnetized structure is supposed under the magnetic and gravity "plain" NW of Plzeň. No comparable phenomena have been found in the Moldanubian Zone; only an inexpressive subhorizontal magnetic boundary at a depth of about 10 km under the surface can be distinguished there. Naturally, the petrographic type of these magnetized "layers" can be explained in different ways; the presumption of tholeiitic (largely volcanic) rocks is most probable. The sources of the regional anomalies of lower order as well as those of deeper rooted local anomalies can be interpreted either as larger hidden volcanic or plutonic bodies (e.g., under the main Radnice-Kralupy volcanic belt, at km 105 to 118, where the presence of an almost 2 km thick, very strongly magnetized tabular body reaching down to a depth of about 10 km has been derived by the computations), or as the rooting of volcanic bodies exposed on the surface. The magnetic model outlined can be applied to the western part of the area where the whole (supposed) south-eastern flank of the Upper Proterozoic has been reduced. Probably a more complete picture would be obtained if similar magnetic models along profiles located east of the 9HR profile would be drawn up.

B.2.1.4. Magnetic indications of transversal faults

The regional magnetic field of the investigated area is zoned; therefore the changes of the course of the individual anomalous belts (sudden changes of their width, splitting into individual smaller anomalies, horizontal shifts of maxima, general changes of the field characteristics) indicate in a number of cases the presence of regional transversal faults. These indications can often be correlated with similar gravity indications. The type and sense of movements along the indicated faults can be occasionally inferred.

For example, the course of the Mariánské Lázně fault and the West Bohemian shear zone is indicated in the NW of the area. A sinistral strike-slip movement, in addition to the vertical component, took place. Northwards, a possible continuation of this fault is indicated by the sinistral displacement between the regional magnetic elevation of Oloví-Sokolov in the E and the Cheb anomaly in the W. In the S, this fault has a role at the western boundary of an extensive regional magnetic depression, against the rela-



14. Magnetic model of crustal structure along the 9HR seismic profile. Measured values of total intensity are calculated to the level of 1 km above the Earth's surface. Numbers shown in crustal segments represent average values of magnetic susceptibility (10^{-3} SI) introduced to satisfy the model; domains distinct in terms of the magnetic susceptibility are colour-coded (arbitrary). Geometry of the crustal segments is adjusted to crustal structure indicated by the 9HR reflection seismic model.

tively positive regional magnetic field in the area of the Český les Mts. The NW-SE trending faults between Horní Slavkov and Karlovy Vary are conspicuous. The indication of this fault zone is very important at the north-eastern termination of the Kdyně-Štěnovice magnetic and gravity anomalies; a substantial drop in the eastern crustal segment along the sinistral fault here is evident.

Important NW-SE trending faults occur along the NE margin of the area studied. They are most expressive in the NW part, where they correspond to the Jáchymov fault. It displaced the magnetic elevation of Doupov northwards against the elevation of Teplá, and thus a sinistral movement is also indicated here. Further to the SE, some indications of NW-SE trending transversal structures may correspond to flexure-like deformations.

B.2.2. The field of natural radioactivity

M. Manová

Natural radioactivity of rocks in the area under consideration was studied by means of aeroradiometric survey and by laboratory investigation of rock samples, including the determination of abundance of particular radioactive elements. This approach was commonly applied in all parts of the Bohemian Massif since the early period of the aeroradiometric measurements. The most important early study concerning our area is by Chlupáčová (1974), dealing with radioactivity of granitic rocks in western and NW Bohemia. As for the radioactivity of rocks in the whole Bohemian Massif, the almost present state of the art was reviewed by Manová and Chlupáčová (in Šalanský et al. 1989).

In the framework of the present project a 10 km wide belt along the country border (Fig. 3) was surveyed by the airborne measurement for the first time. A new set of 1 : 50 000 radiometric maps was compiled for western Bohemia, in which the new data are integrated with those for areas measured during the previous surveys.

The following text refers to Pl. 9, presenting a scheme of anomalies of the radioactivity field. The scheme was derived from the results of gammaspectrometric survey (i.e., the maps showing regional variation in abundance of U, Th, and K, and the map of total gamma activity) in the area denoted by I, and from the results of radiometric measurement of the early period (i.e., the map of total gamma activity alone) in the areas denoted by II. When constructing the scheme, the minima caused both by water reservoirs and marsh were omitted and shielding caused by forests was corrected as far as possible. The scheme includes:

i) boundaries, more or less apparent, between areas characterized by higher and lower radioactivity, respectively,
ii) positive regional anomalies with abundance of radioactive elements, and their combination
iii)remarkable positive local anomalies (mostly caused by uranium),
iv)areas, where the ratio Th/U differs substantially from its average value 3.5.

The anomalies of radioactivity related to particular geological structures are discussed in respective paragraphs in the geological chapters. Only a summary concerning the regional features will be given here.

Particular geological units in the studied area differ considerably in the distribution of radioactive elements. Upper Proterozoic rocks (unmetamorphosed or slightly metamorphosed) are characterized by low level and relatively monotonous field of radioactivity. Local minima, frequent especially in the SE part, correspond to basic rocks. Positive anomalies are less frequent and usually weak. The boundary between the Upper Proterozoic rocks of the Teplá-Barrandian Unit and adjacent geological units is mostly marked a by sudden change in radioactivity level. This is especially true when the Proterozoic rocks are of basic composition. Similarily, the contact between high-level radioactivity of granitic rocks of the Karlovy Vary pluton and very low-level radioactivity of basic rocks of the Marianské Lázně Complex can be mentioned as an example. This boundary between contrasting levels of radioactivity continues along the Mariánské Lázně fault and the eastern edge of the Bor pluton. Then it continues to the west, where the difference between radioactivity levels diminishes. The Moldanubian crystalline rocks of the Bohemian Forest, having on average a low abundance of potassium, are not particularly radioactive. The SE border of the Teplá-Barrandian Unit against granitoids of the Central Bohemian Pluton or gneisses and migmatites of the main area of the Moldanubian Zone also represents a boundary in distribution of radioactive elements.

The Upper Proterozoic rocks are characterized by a negative anomaly in the ratio Th/U (values less than 3.5); on the contrary, rocks of the Saxothuringian Zone have a relative excess of Th (Hrouda-Chlupáčová 1993).

The radioactivity of Cambrian sediments and Ordovician quartzites (occurring along the NE margin of studied region) is low even when compared with Upper Proterozoic shales and greywackes.

The radioactivity of metamorphic rocks in the Krušné hory Mts., the Bohemian Forest, and the Moldanubian Zone in southern Bohemia does not differ much from the values expected for the widespread rock types. The differences in distribution of radioactive elements are not large enough to coincide with lithological boundaries. The slightly increased radioactivity of orthogneiss in the Smrčiny (Fichtelgebirge) and Tachov area (the NW part of the studied region), and migmatites in the Podolsko complex (its SE part), as well as the decreased radioactivity of granulites in southern Bohemia (due to low abundance of U and Th) may be considered exceptional.

In fact, the particular geological units differ in radioactivity variability pattern rather than in its level. This variability is given by the frequency of local anomalies, indicating dykes of granitic and related rocks, veins occupying fracture zones, and metasomatism in the aureoles of granitic intrusions. The examples of the latter case are as follows: increased radioactivity of metamorphic rocks along the SW margin of the Žandov granite pluton and positive Th anomalies caused by allanite in ferrosyenite at the NE margin of the Mutěnín pluton. The radioactivity field in the Moldanubian Zone of southern Bohemia is much affected both by distribution of granitoids and by interstratified layers in the metasedimentary complex. The occurrence of crystalline limestone is marked by a notable decrease in the radioactivity level, while porphyritic dyke rocks and lamprophyres as well as durbachites (melagranitoids) forming larger intrusive bodies have usually a high content of the radioactive elements. This is especially remarkable in the case of durbachite of the Želnava pluton. The frequency of intrusive rocks with elevated contents of the radioactive elements increases in the NW-SE direction, and so does the average level of radioactivity in the Moldanubian Zone. The abundance of radioactive elements in the mobilisates of migmatites contributes to this phenomenon (Matolín 1970). Although metamorphic rocks of the Moldanubian Zone along the boundary with the Central Bohemian Pluton are slightly less radioactive than granodiorite of the Červená type, this boundary can be hardly noticed in maps of radioactivity owing to numerous granodiorite apophyses in the contact zone.

There are some massifs of granitic rocks, that cause most remarkable positive anomalies. The following examples should be mentioned: the Karlovy Vary pluton, its eastern and central part, and the SW part of the Žandov granite, the Central Bohemian Pluton and, to a lesser extent, the Bor pluton (its granite and granodiorite part). The Sedmihoří stock represents an example of a small granitic intrusion with significantly increased radioactivity. Matolín (1970) concluded in interpretation of the radiometric map of the Bohemian Massif (scale 1 : 200 000) that the radioactivity of the Variscan granitoids is usually much higher than the radioactivity of pre-Variscan granitoids. While the older granitic rocks in the region studied, e.g., the Stod pluton, Lestkov orthogneiss, Tis granite in the Čistá-Jesenice-Louny pluton are without exception relatively low-radioactive, there are only few exceptions to rather high radioactivity of the Variscan granitic rocks. The Kladruby pluton (except for the adjacent, Variscan Sedmihoří stock) is an example; a palaeo-Variscan age is now indicated for this intrusion (Voves et al. 1993). The independent structural position of the Sedmihoří stock follows from the radiometric survey and it is confirmed by both gravity and magnetic survey. It causes a positive ring-shaped anomaly in radioactivity maps, where only the central tourmaline granite is less radioactive. Also anomalous are the Babylon and Štěnovice stocks, with only weak positive anomalies, and the Rozvadov pluton which produces nearly no contrast in comparison with the surrounding Moldanubian gneisses.

In large and composite Variscan plutons some particular petrographic types exhibit relatively high abundance of the radioactive elements. On the other hand, the distribution sometimes varies even within one type. As for the Karlovy Vary pluton, the Kfel type granite between Loket and Doubí and granite of the Jelení and Kladská types in the Žandov pluton are relatively less radioactive. Granites of the older intrusive phase have always a higher abundance of Th (e.g., a very high abundance near Bečov and Loket), while granites of the younger phase have mostly high abundance of U and relatively low Th. The most remarkable positive anomalies of uranium can be found in the southern and SW part of the Žandov pluton; although this type is usually classified as belonging to an intermediate phase, the above fact support its relationship to granites of the younger phase. The highest abundance of U in granites of the younger phase of intrusion is interpreted to be a result of autometamorphism, a process including mobilisation and redistribution of this particular element.

The Central Bohemian Pluton has on average a high level of radioactivity; however, besides granitoids with a high radioactivity, e.g., the Čertovo břemeno durbachite, Tábor syenite, Sedlčany granodiorite, etc., it contains also granodiorites and tonalites with rather low abundance of radioactive elements, e.g., the Sázava, Maršovice, and Požáry types. Other granitic rocks in the area studied have largely an intermediate radioactivity which is only slightly exceeded by the marginal type and locally by the Blatná type.

The Moldanubian Pluton in the region studied is represented by less radioactive petrographic types. The radioactivity of granitoids in the Prášily and Vydra plutons only slightly exceeds that of adjacent metamorphic rocks and a similar relation concerns also the NE margin of the Plechý pluton. The highest radioactivity in this area was found in the Weinsberg type granite near Strážný. Relatively high anomalies are caused by granitic rocks in the southern part of the studied region, e.g., by Eisgarn granite near Rožmberk nad Vltavou.

B.3. GEOLOGICAL INTERPRETATION OF THE 9HR AND 503M SEISMIC PROFILES IN WESTERN BOHEMIA

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Deep seismic reflection profiling is the main geophysical tool for recognition of crustal structure. The 9HR deep seismic reflection line, two hundred kilometre long, was shot in western and south-western Bohemia in 1991 and 1993. The profile runs from Klingenthal (FRG) to Horažďovice (south-western Bohemia) and to Prachatice (southern Bohemia), passing through the Krušné hory Mts. (Saxothuringian Zone), the Teplá-Barrandian Unit (Bohemicum), and through the Moldanubian Zone up to the granulite complex near Prachatice (Fig. 1). Moreover, the 503M high-resolution shallow seismic line was shot across the Mariánské Lázně fault near Domažlice.

B.3.1. The 9HR profile

B.3.1.1. The technical parameters of the reflection line

The technical parameters are as follows:
Source: dynamite
Equipment: 2 x SN 338HR, 192 channels
Time of registration: 24 s
Sampling: 4 m.s^{-1}

Distance of points: 50 m
Distance of shotpoints: 200 m
Average charge: 19.67 kg
Average depth of drillholes: 20.01 m
Central offset
Processing was made at the Geofyzika Inc., Brno computer centre using standard procedures.

B.3.1.2. Geological setting of the area

The 9HR profile passes from Klingenthal (at the NW) through Kraslice, Sokolov, Teplá, Stříbro, Přeštice, Rabí near Horažďovice, to Prachatice (at the SE). Through arrangement by the Niedersächsisches Landesamt für Bodenforschung in Hannover, it was possible to start the measurements along the 9HR profile near Klingenthal in Germany. This nearly provides an interconnection with the DEKORP MVE-90 seismic profile, running WSW-ENE along the axis of the Krušné hory Mts. (Erzgebirge). Kilometre 0 of the 9HR profile is located 2.7 km inside the territory of the FRG.

The profile starts in the Lower Palaeozoic phyllites of the Phycodes Formation and at km 9.5 enters somewhat higher-grade phyllites of the Frauenbach Series. At km 17 it passes to two-mica schists of the Arzberg Series which continues up to km 30.4, below the Tertiary sediments of the Sokolov basin. As follows from the gravimetric map and from the interpretation by Švancara-Chlupáčová (1994), from approximately km 24 the Arzberg Series overlies the Karlovy Vary pluton.

The Mariánské Lázně Complex (MLC), comprising meta-ophiolites with MP to HP metamorphism, is thrust on the Kladská Unit which was correlated by Kachlík (1993) with the Saxothuringian Lower Palaeozoic. The junction of both latter units is obliterated by the intrusion of the Karlovy Vary pluton.

At the north-western edge of the Teplá-Barrandian Unit there is the Teplá Crystalline Unit, which includes rocks metamorphosed both during the Cadomian and the Variscan events. The Teplá Unit was probably in a thrust position on the MLC and both units were jointly deformed and metamorphosed during the Variscan orogen (Žáček-Cháb 1993). Later, however, the contact between these units evolved into an extensional fault (Zulauf 1994). The Teplá Crystalline Unit is considered as contiguous with the Barrandian Upper Proterozoic, and thus jointly corresponds to the Teplá-Barrandian Unit (TBU). Several volcanite-rich belts, alternating with intervening belts of only slightly geochemically evolved metasediments (Jakeš et al. 1979), outline the regional structure of the TBU.

The contact of the TBU with the main area of the Moldanubian Zone is obliterated by the intrusion of the Klatovy apophysis, belonging to the Central Bohemian Pluton. The apophysis is only 600 m wide at some places and thus it is clear that the junction of nearly unmetamorphosed TBU sediments with the Moldanubian cordierite-biotite gneisses indicates an important fault. Further towards the SE the profile continues into the main area of the Moldanubian Zone, comprised of three main tectonostratigraphic units, i.e., the Gföhl, Varied, and Monotonous Units, all of which are represented along the profile.

Three major zones of the Variscan orogen are encountered along the profile. At the NW, the Saxothuringian Zone is comprised of the Thuringian and Bavarian development of the Lower Palaeozoic lying on (mainly pre-Palaeozoic) the crystalline complex of the Krušné hory Mts. which also shows evidence of Variscan deformation and 340 Ma metamorphism. The MLC is a metamorphosed relic of the Lower Palaeozoic subduction mélange, with metamorphism dated approximately to 380 Ma. Further SE, the Teplá Crystalline Unit was involved in deformation and metamorphism, thrust on the MLC and later it slipped down to the SE, in an extension event, together with the MLC. The Moldanubian Zone SE of the Klatovy apophysis (and the Central Bohemian Suture) represents a composite high-grade metamorphic unit, characterized by rather geochemically evolved metasediments, some pre-Cadomian partial units, and is distinct from the preceding units.

B.3.1.3. Interpretation of unmigrated and migrated time and depth section

The selected reflections of the migrated time and depth section are shown in Pl. 12 and 13. The original unmigrated section is shown in Pl. 11. The seismic data along the whole profile are of high quality, owing to use of dynamite charges near 20 kg in weight, exploded in boreholes 20 m deep on average. The quality exceeds that of the Vibroseis profiles, commonly used elsewhere in central and western Europe, which did not record reflections from the upper mantle depth. The 9HR profile includes several mantle reflections. The frequency of seismic events attains, in many cases, 35 Hz for duration near 8 seconds (!) Due to a high level of background noise in the brown coal mining area near Sokolov, the interval between km 21.0 and 30.4 did not produce results of acceptable quality. Only sporadic reflections from levels below 3 sec. have been recorded. Above this level, the transparency is probably caused by the industrial noise and granitoids of the Karlovy Vary pluton.

B.3.1.4. Seismic section – selected reflections and seismic characteristics

There are two main causes of acoustic events – seismic reflections in crystalline areas of the type in western Bohemia:

a) lithological boundaries of rock types with contrasting acoustic impedance

b) tectonic fault (shear) zones, either mylonitic or cataclastic; mylonite zones (involving plastic-semiplastic deformation and recrystallization) generally reflect better than brittle, cataclastic faults in the upper crust.

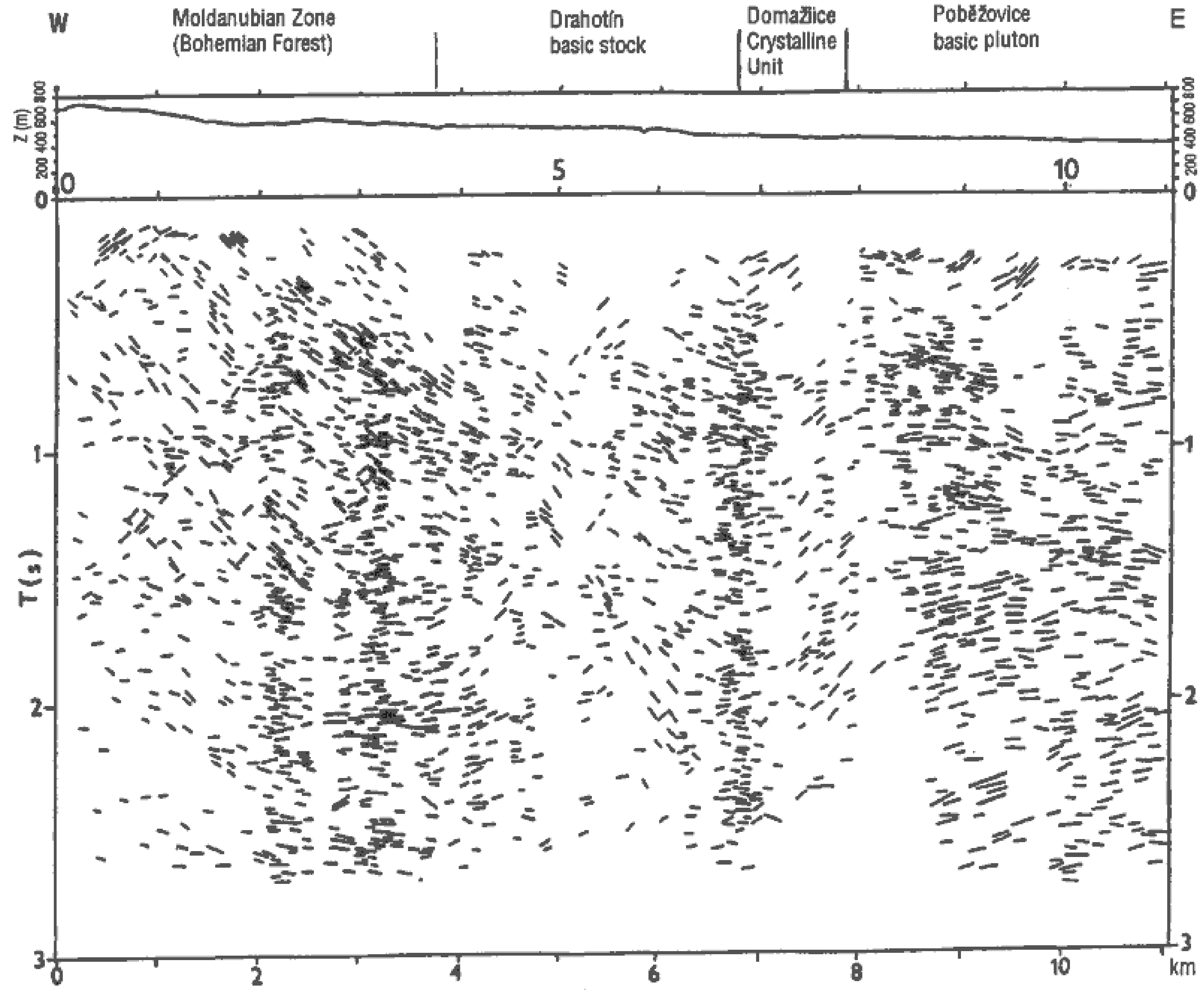
Both types of reflections occur along the 9HR profile but those of tectonic origin probably prevail in the northern and central part. Individual reflections show significant dip, increasing up to 45°. For events at deep crustal levels migration distances of up to 30 km occur. The time, unmigrated section is also shown (Pl. 11) and it was used in interpretation, but the description of the profile is based on the migrated time and depth section. The positions and dips of reflections are correct under the assumption of simple velocity distribution.

The reflections K in the Krušné hory part (Pls. 12 and 14), dipping NNW, are ascribed to (nearly monoclinal) dip of the Phycodes Formation and Frauenbach Series. It is known from the surface geology of the Krušné hory Mts. (e.g., Pietsch 1962) that respective planar structures dip NW towards the Vogtland megasyncline carrying the structurally highest sequences of weakly metamorphosed Lower Palaeozoic. The Münchberg massif is positioned tectonically higher, in the SW part of the depression (and SW of the 9HR profile). The reflections K probably represent mylonitic shear planar zones, separating NNW dipping allochthonous slices of Palaeozoic rocks of the Saxothuringian Zone. Reflections from beneath the Arzberg Series are mostly subhorizontal and differ from those of the Palaeozoic. The reflection planes L_1 are interpreted as mylonites or shear zones associated with the basal thrust below the set of Saxothuringian structures.

The reflection pattern is very different at the level below 10 km, showing a 15 to 20 km thick layer with SSE dipping reflections which continue from km 0 to 65; the DEKORP 4N profile (Bortfeld et al. 1988) suggests continuation of these reflections to the north. This reflection package is interpreted as a thick package of mylonite zones. Possibly, it could correspond to a compressional ductile deformation of the continental crust (thick-skinned stack) in the lower plate below the main Variscan thrust, associated with long-lasting continental collision. The reflection M_1 at the depth of 33 km below the Krušné hory Mts. may correspond to the Mohorovičič discontinuity.

The transparent zone 3.5 s thick between km 30 and 41 probably represents the isotropic and rather homogeneous granitoids of the Karlovy Vary pluton that intruded the crust during the Late Visean–Early Namurian (at about 325 Ma).

The reflections ML and TP are caused by an array about 5 km thick, bound at the base by a subhorizontal event L_3. The first one probably belongs to the MLC stacking events. The second one can be interpreted as mylonites formed by



15. Unmigrated time section of the 503M seismic line (see Fig. 1 for location).

an extensional shearing and metamorphism at 380 to 370 Ma. The reflections L_3 and L_2 also may correspond to subhorizontal slices of unknown duplexes beneath the MLC and they appear to dip to a root zone, indicated at km 85 to 100.

Further SSE, there are TB reflections belonging to the volcanosedimentary complex of the TBU. They form an antiformal structure and continue to the root zone R. Reflections A and SP, joining the above reflections, dip SSE up to a depth of 20 to 25 km. Altogether, the TB, R, A, and SP reflections are interpreted as a Cadomian complex modified to some extent during the Variscan orogen. A remarkable change in vergency at km 126, and in the upper crust, is considered as a steep reverse fault between the TBU and the Moldanubian Zone. In the interval 15 km from the surface it shows a very steep position. The steep boundary probably continues deeper through the whole crust and splays of this fault, where ductile compressional deformation supported the uplift, moderately dip for 30 to 40 km to the SE, to the crust-Moho boundary; the splays form remarkable features beneath the Moldanubian upper crust.

The reflections MUC, MMC, and Z occur in the Moldanubian Zone. The position of MUC indicates that granodiorites of the Blatná and Červená types form a relatively thin tabular body. The MUC and MMC reflection arrays are clearly separated at a depth of 15 km, possibly indicating two seismically distinct domains of the upper and middle Moldanubian crust.

The event M_4 is considered as the Moldanubian Moho, while M_3 indicates Moho below the TBU. When viewing the whole 9HR section, it is noticeable that the Moldanubian crust shows seismic features distinct from those of the two units occurring further NW, as well as from the Cadomian complex.

The features M_1 and M_2 probably represent Moho below the crust of reflection type E. The extensive, deep reflection B is seen as one of the most intense events in the whole profile. The position of the elevation B projects upwards to the occurrences of the Tertiary and Quaternary alkali basalts on the Earth's surface. Recent studies in several other regions of young basaltic volcanites of the hot-spot type indicate that significant volumes of Mg-rich, alkali basalt melts, produced by astenospheric melting, are trapped on rheological boundaries in the upper mantle or crust, and especially along the mantle-crust boundary (Singh-McKenzie 1993, Parsons et al. 1992 a, b).

It is also possible that the prominent reflection B corresponds to the boundary between the common type E of the crust (probably gneisses, granulites) and metapyroxenites or metahornblendites, associated with a magma chamber or a set of chambers, as indicated near Urach in SW Germany (Glahn et al. 1992). These could be sites of basaltic magma differentiation and metapyroxenites and metahornblendites are evidenced (Glahn et al. 1992) by xenoliths in the surficial basaltic volcanites. Seismic velocities in such mafic cumulates correspond to 7.8 km/s and the calculated reflection coefficient along the contact with gneisses and granulites is 0.12 to 0.15. The reflection B suggests a similar magnitude of reflection coefficient.

While the DEKORP and KTB seismic profiles in the FRG, with a total profile length of 1800 km, registered no reflections from the mantle, the 9HR profile registered several such reflections. The three most important reflections MR_1, MR_2, and MR_3, at depths of 35, 42, and 56 km, respectively, are shown in the depth section (Pl. 13). It is difficult to interpret the cause of these features, however, a petrologically acceptable alternative would suggest layers of eclogite or garnet pyroxenite with a density near 3.6 g/cm^3 and a reflection coefficient of 0.05 to 0.08. The reflections MR_1 and MR_2 may have a similar origin to reflection MR_3. Glahn et al. (1992) presented evidence for spinel-phlogopite wehrlites at a similar depth below Urach; garnet pyroxenites and eclogites could be present there as well.

B.3.2. Detailed 503M seismic profile

B.3.2.1. Geological setting

In view of persisting problems with the tectonic situation along the junction of the Teplá-Barrandian Unit (TBU) with the Moldanubian Zone in the Bohemian Forest, we decided to contribute to the solution of this problem with a detailed high-frequency seismic profile. The profile runs (see Fig. 1) from Rybník through Načetín to Poběžovice (Vejnar et al. 1978, 1984).

From west to east, the profile encounters surface gneisses and migmatites of the Moldanubian Zone (Bohemian Forest), the Drahotín gabbronorite stock, and at km 6.7 it crosses the West Bohemian shear zone (= the Bohemian quartz lode). The Moldanubian metasediments show a zonal pattern, including muscovite-biotite migmatitic paragneiss immediately W of the Drahotín stock, giving way to sillimanite-biotite migmatitic paragneiss, gradually with cordierite, passing further west to cordierite gneiss (= cordierite-biotite migmatitic gneiss). To the east of the West Bohemian shear zone there is a 1 km wide belt of the Domažlice Crystalline Unit composed of muscovite-biotite paragneiss (Vejnar et al. 1978). This unit is intruded by the gabbroic Poběžovice pluton, represented in the profile by the last 3 km.

B.3.2.2. The reflection characteristics

The profile was designated for a depth to 1 s and also the geological section is interpreted to the corresponding depth of 3 km (Dvořáková et al. 1993), though the measured data were also processed up to 5 s.

The profile shows a number of high-frequency reflections (Figs. 15, 16, and 17). Most of the reflections in the E part are subhorizontal and relatively weak. Any dip that may be real in the segment east of the West Bohemian shear zone is shallow towards the W. This shear zone forms a steep (near-vertical) boundary between the shallow (subhorizontal) reflections of the Domažlice Crystalline Unit and the distinct zone of reflections dipping E at an angle of 40° to

45° near km 2 of the profile. This zone is about 2 km wide and the intensity of the reflections is comparable to that of other mylonite zones in the Bohemian Massif. In the interpretation of this zone, strong foliation, mylonitization, and velocity anisotropy are preferred as a probable cause. Muscovite-biotite migmatitic paragneisses and cordierite migmatites show minimal differences in density and there should be no distinct difference in reflection coefficients.

B.3.2.3. Geological interpretation

The main conclusions from the high resolution seismic line across the West Bohemian shear zone (Fig. 17) are:

1. The West Bohemian shear zone is a steep (near-vertical) boundary between the TBU in the E and the Moldanubian Zone in the W.
2. Whereas the reflections in the TBU are subhorizontal, the reflection pattern within the Moldanubian Zone shows typical domal extensional structure with HT-LP cordierite gneisses in the core of the dome.

B.3.3. The 9HR geological section and its significance for interpretation of the Variscan orogen in central Europe

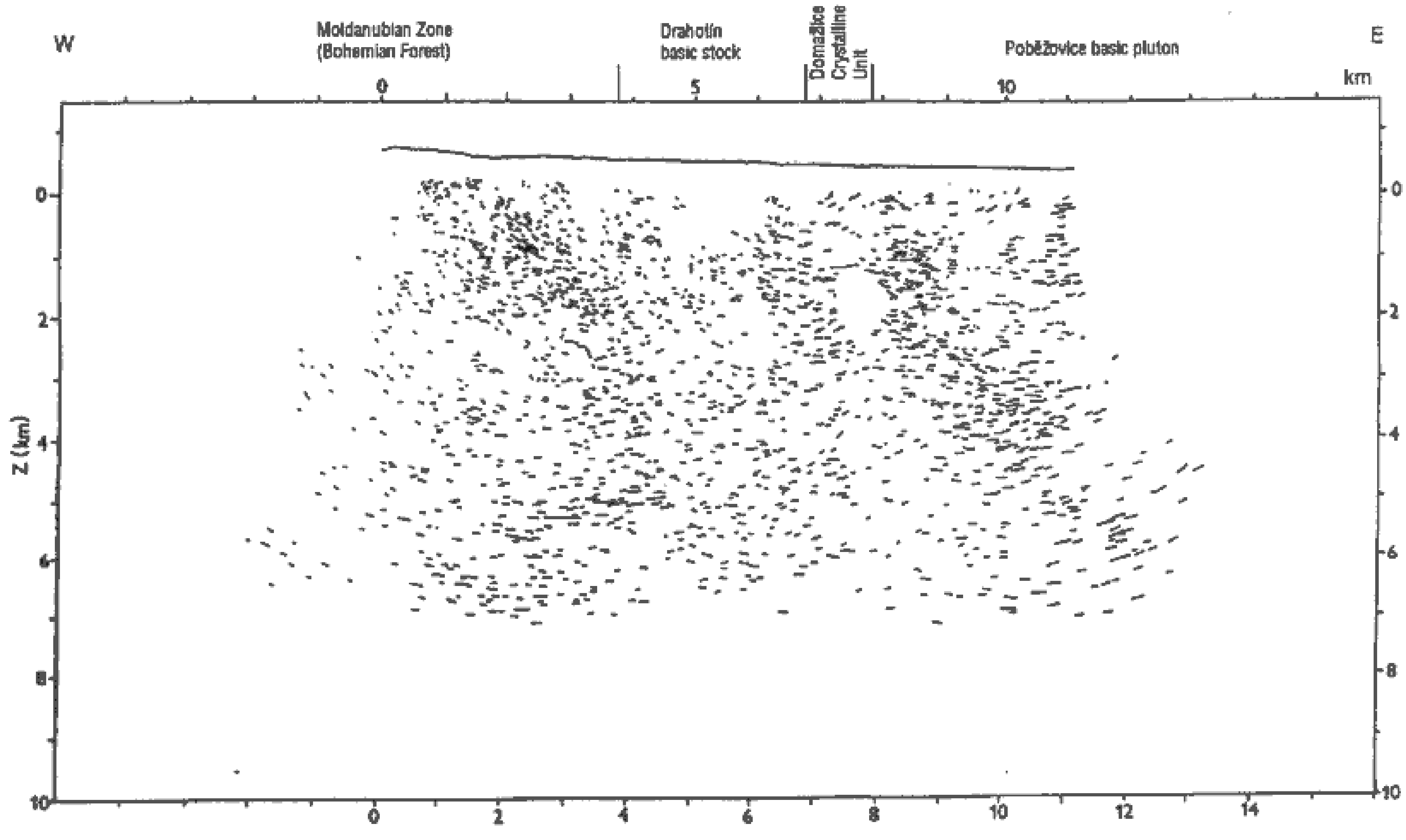
The 9HR profile has two advantages:

a) it was done with dynamite technology which results in higher energy, a better reflection definition, and responses from deeper structures. For the first time in the seismic investigation in the European Variscides, several reflections from the mantle were registered,

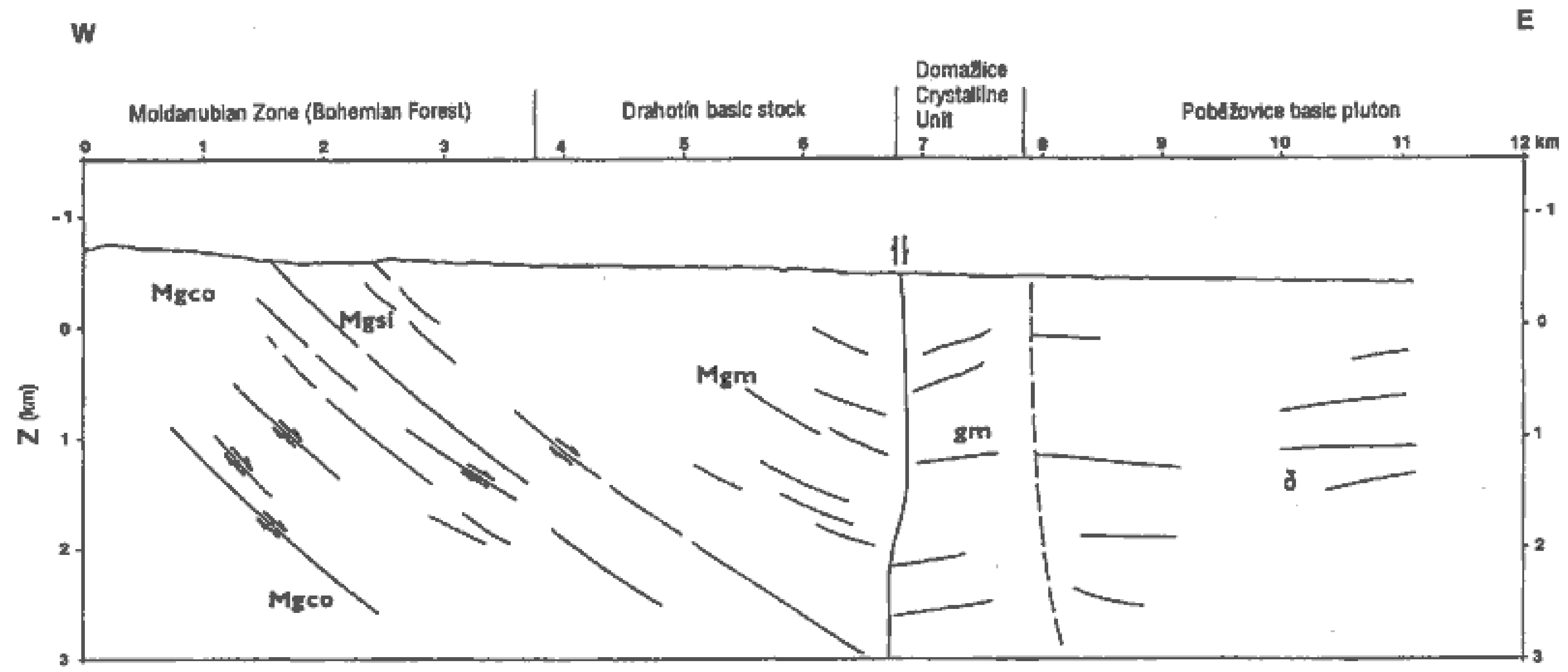
b) the region provides better situation for the location of the profile. Profiles in the FRG were located either in areas with Mesozoic platform cover (DEKORP 2S) or in areas with significant volumes of granite plutons (associated with extensional deformation).

Plate 14 shows an attempt of geological interpretation of the crustal section between Kraslice and Prachatice. The idea of a relatively thin thrust sheet of the Saxothuringian Zone, ZEV (or TBU), resting on a deeper crustal complex of unknown origin, is not new. It was already published in the interpretation of the DEKORP 4 or KTB 8506 profile (Bortfeld et al. 1988, Vollbrecht et al. 1989, Weber 1992). The interpretation of the 9HR profile supports and in part complements this interpretation.

An approximately 10 km thick (originally, prior to erosion some 15 to 20 km thick), allochthonous nappe complex is resting on the middle and lower crust with reflections dipping S. The system of horizontal reflections at a depth of some 10 km is indicated from the beginning of the profile at the NW up to km 70. This system can be considered as the main thrust fault of the Variscan orogen in western Bohemia. Overlying this fault are allochthonous units of the Saxothuringian Zone and the ophiolite suture unit (MLC), together with the TBU. The root zone of the MLC is interpreted in the interval of km 80–110. Interpretation of the intensively deformed crustal complex under the allochthon, labelled in Pl. 14 as EA, is difficult. Most of the authors who interpreted the German lines consider this lower complex as the Saxothuringian Zone. The 9HR profile ties up at the NW on the DEKORP MVE-90 profile that passes along the Krušné hory Mts. and beyond the Mid-Saxonian thrust (Kossmat 1927) to Lusatia. The reflex



16. Ray tracing migrated section of the 503M seismic line – line drawing.



17. Geological model along the 503M line. See text for explanation.

at 3 to 4 sec., considered as the main thrust fault, can be followed in the longitudinal direction up to the Lusatian thrust (Bankwitz et al. 1994); it appears to have no continuation into Lusatia.

The gravimetric map of the FRG-East (Conrad 1993), Fig. 18, shows a major, extensive positive gravity anomaly reaching to Rumburk in northern Bohemia and extending far northward up to places 50 km S of Berlin. It is suggested that this extensive anomaly could be caused by a single geological body. Although the Variscides south of Berlin are hidden under a thick sedimentary platform cover, it is obvious (Franke 1989) that in this area the continuation of the Northern Phyllite Zone occurs and S of this unit the Mid-German Crystalline Rise should also occur. It is suggested that in the Lusatian pluton the "European parautochthon" crops out, uplifted in the closing stage of the Variscan compression on the Lusatian fault. Along these lines, we interpret the lower crustal complex in the 9HR profile as the "European parautochthon" (EA) belonging to the East Avalonia (L). Its strong tectonic deformation is indicated by a series of S dipping reflections that we interpret as lower crustal stacking accompanying the Rhenohercynian collision. If this interpretation of the central European Variscan orogen is correct, then the transport distance for the upper nappe unit from the boundary of the TBU to the area north of the Harz Mts. is nearly 300 km, i.e., a distance comparable to thrust of the southern Appalachian orogen (Cook et al. 1981) or of the contemporaneous Himalayas.

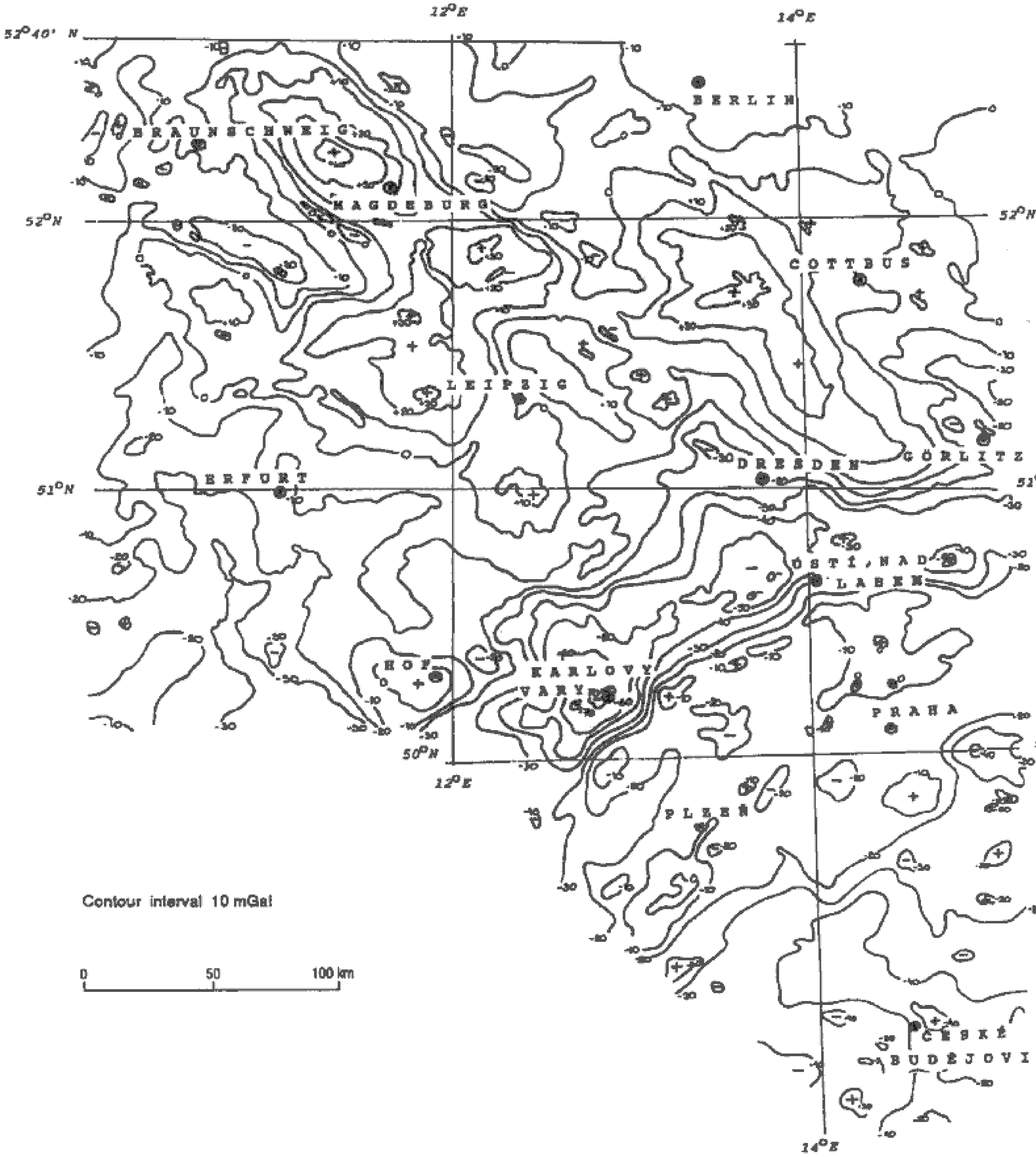
The intrusion of the Karlovy Vary pluton masked the junction between the MLC and the crystalline complexes of the Saxothuringian Zone (the Horní Slavkov Crystalline Unit). The gravimetric and seismic data indicate that the pluton is approximately 10 km thick. This thickness corresponds in the 9HR profile approximately to the thickness of the Saxothuringian allochthon. Under the seismically transparent pluton, the reflections of the lower plate can be seen. This situation suggests that the pluton was not emplaced by a diapiric mechanism. Two explanations of this phenomenon are possible: (i) It is probable that the pluton filled space formed by pull-apart extensional movements along faults trending NNW-SSE (corresponding to a part of the Jáchymov fault) and WSW-ENE (part of the Litoměřice fault). Magma was probably supplied by a system of feeder dykes (Clemens-Mawer 1992); (ii) The Karlovy Vary pluton itself is allochthonous and forms a part of the overthrust sheet complex.

The Teplá-Barrandian Unit (TBU) shows a seismic pattern similar to subduction-accretion complexes of modern arcs. The SSE dipping reflections can be considered as individual thrust faults formed during accretion. A significant package reaches the surface in the interval km 105 to 117; it is dipping SSE to a depth of 20 to 25 km where it terminates at the subvertical Central Bohemian Suture (= Klatovy fault).

The reflection patterns in the Moldanubian Zone SE of the Central Bohemian Suture are very different from patterns characteristic of the more northerly units. The upper crust shows a prevalence of reflections dipping NW, with numerous diffractions. At a depth of about 12 km, horizontal reflections occur, underlain by the lower crust with SE dipping reflections.

In both migrated sections and in the geological section, a steep position of the Central Bohemian Suture is interpreted in the upper crust and, with lesser certainty, also in the lower crust. We interpret this seismic feature as an expression of a steep thrust fault. Nearly 40 km to the SE from the surface position of the Central Bohemian Suture, this thrust is indicated, in the middle and lower crust, as a structure which splays into a number of much shallower thrust faults, some of which offset the Moldanubian Moho (M_4). The steep thrust of the Moldanubian Zone on the TBU was probably a phenomenon of lithospheric dimensions which brought the high-grade Moldanubian metamorphic complex near the surface.

The Central Bohemian Suture probably functioned dur-



18. Map of Bouguer anomalies in central Europe after Grosse et al. (1992).

ing the earlier stages of the Variscan orogen as a strike-slip fault and only later, as cordierite migmatites attained an upper crustal level, was it modified into a steep reverse fault. This should not indicate that the main features in the history of this boundary are sufficiently understood.

Granodiorite of the Blatná and Červená type forms a plate-like body 2 to 3 km thick, if the body was not significantly deformed during or after intrusion. In the Moldanubian Zone of southern Bohemia, between the Central Bohemian Pluton and the Prachatice granulite body, the middle crust is strongly reflective, while the upper and lower crust are less reflective. In the upper crust there are NW dipping reflections F and a significant, SW dipping reflection feature G. The Moho in this area occurs at a depth of 37 to 38 km. The significance of the subhorizontal reflectivity in the middle crust is not understood yet. Since a perpendicular seismic section is absent, it is uncertain if the reflections are really subhorizontal or dip sideways with the profile line. Interpretation of the complicated seismic reflection pattern of the Moldanubian Zone should be supported by a future detailed study of the superimposed regional structural patterns.

B.3.4. Information on Tertiary basaltic volcanism

In this chapter, the reflection elevation at the lower crust-mantle boundary (HSBU) and some deeper mantle reflections were interpreted as tabular intrusions of basaltic magma in the upper mantle and lower crust. In particular the rheological boundary mantle-crust functions as a trap in a number of areas of recent and past volcanism of the hot spot type (Parsons et al. 1992a, b, Singh-McKenzie 1993).

The voluminous volcanoclastic accumulations of the Doupov stratovolcano (diameter of 30 km) near the line of the 9HR profile (Hradecký 1991 and this volume) and other significant volcanic bodies such as Pila near Karlovy Vary, Podhora near Mariánské Lázně, and Blatná near Cheb, comprise basaltoid, olivine-rich rocks (compare Shrbený, this volume) as well as differentiates of the trachyte series. Subvolcanic and volcanic bodies near Toužim, in the proximity of the profile, carry trachytes with a low mafic mineral content. It is possible that differentiation took place in a magma chamber near Moho, in a similar position as in the case of volcanites near Urach in southern Germany (Glahn et al. 1992).

The DEKORP 2N and 2S profiles in Germany pass through the largest stratovolcano in the central European Tertiary volcanic province, i.e., Vogelsberg NE of Frankfurt a. M. (Meissner-Bortfeld 1990 and Franke et al. 1990). The reflection elevation under Vogelsberg is similar to our reflection B.

Wilson and Downes (1991) considered the alkali basaltic volcanic rocks of western and central Europe as derived from magmas formed mainly in the asthenosphere, with some influence by the lithosphere. Griesshaber et al. (1992) studied the role of mantle-derived ^{3}He as a semi-quantitative indicator of basic rocks intruded into deeper structures. High ^{3}He values are considered to indicate tabular intrusions under the present ^{3}He anomalies. In the Tertiary volcanic area of western Bohemia the ^{3}He anomalies are rather high, the highest values correspond to 50 % of the mantle-derived He, e.g., in Prameny or Kynžvart near Mariánské Lázně (Griesshaber et al. 1992, O'Nions et al. 1989). The latter authors concluded that such high values indicate a significant basaltic magmatism in the crust. We have suggested above that the 9HR seismic profile probably detected respective intrusions of basaltic magma at the crust-mantle interface. ^{3}He anomalies above 50 % may correspond to a 100 m thick tabular intrusion emplaced during the course of 1 Ma (Martel et al. 1989). During 30 Ma of basaltic volcanism in western Bohemia the cumulative thickness of intruded basic rocks may be 3 km; this value compares well with the thickness indicated by the seismic profile.

Large European geophysical anomalies defined by satellite magnetic measurements (Ravat et al. 1993) and geoid measurements (Marquardt-Lelgemann 1992) suggest that much of central Europe, from Ardennes to Transylvania, could be underlain by a hot mantle plume resulting in a significant asthenospheric, Mg-rich magmatism (Sleep 1992).