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Original paper

Gravity response of igneous rocks in the northwestern part of the Bohemian Massif

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A new cross-border gravity map on the scale of 1:200,000 covering 14,900 km^2 of the SE Saxony and NW Bohemia was compiled. It is limited by the sites of Grimma (NW), Karlovy Vary (SW), Neratovice (SE) and Bautzen (NE). Three positive gravity regions – (a) Lusatian Anticline, (b) SE part of the North Saxon Syncline and (c) Teplá–Barrandian Unit were delimited. Separation of the Bouguer anomalies into the regional and residual components together with the Linsser filtering provided three types of derived gravity maps (regional, residual and density boundaries) for geological interpretation. Eighteen negative residual anomalies mostly pertaining to partially buried granite or acid volcanic bodies and ten positive residual anomalies mostly caused by metamorphic complexes were identified. The map of the Linsser indications showing the density boundaries at three depth levels (1, 3 and 6 km) introduces not only numerous disjunctions but also indicates an internal structure of the individual regions. A new cross-border magnetic map covering the same area is also presented.

A "central" circular gravity low (−61 mGal) delineates the Altenberg–Teplice Caldera extending to 10 km depth. Variscan igneous bodies produce only negative gravity anomalies regardless their size. Pre-Variscan igneous bodies cause either weak negative or positive anomalies. A chain of gravity and magnetic anomalies follows the Litoměřice Deep Fault and a large pronounced magnetic anomaly between Doupov volcanic complex (SW) and the Elbe Zone (NE) delineates the Saxothuringian/Teplá–Barrandian Suture Zone.

Keywords: gravity and magnetic anomalies, Saxothuringian Unit, Teplá–Barrandian Unit, Bohemian Massif
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1. Introduction

The gravity effects of several granite bodies situated along the contact of the Saxothuringian, Moldanubian and Teplá–Barrandian units (in Oberpfalz and West Bohemia) were first evaluated by Trzebski et al. (1997) who focused on the vertical extent of these plutons. At the same time, Hecht et al. (1997) analyzed the gravity pattern of the complex and multi-phase Smrčiny/Fichtelgebirge Pluton in order to determine its root zones. Two years later, Hecht and Vigneresse (1999) published a similar study on the gravity effect of the Cabeza de Araya Pluton in W Spain and compared the results obtained there with those acquired in the Fichtelgebirge by Hecht et al. (1997).

Gravity cross-section across the most striking negative gravity anomaly of the Saxothuringian Unit (−74 mGal) pertaining to the Karlovy Vary Pluton was presented by Švancara et al. (1997). Their model drawn along the NW–SE profile shows the pluton body reaching the depth of 12 km.

A new map of Bouguer anomalies of the eastern (Lugian) part of the Saxothuringian Unit covering large neighbouring areas of E Saxony (Germany), SW Lower Silesia (Poland) and N Bohemia (Czech Republic) was compiled and interpreted by Sedlák et al. (2007a).

In the present paper, we expand this survey and compile a SW continuation of the "Cross-border Lugian gravity map" to the Erzgebirge/Krušné hory and adjacent Saxonian and NW Bohemian regions. A deep circular gravity low (Altenberg–Teplice) of −60 mGal is the main target in this area. Thus, the area of interest is a cross-border region the NW half of which is situated in the SE part of Saxony (Germany) and the SE part is located in the NW Bohemia (Czech Republic). It is limited by following localities: Grimma (NW), Karlovy Vary (SW), Neratovice (SE), Bautzen (NE); its total area is about 14,900 km^2 (Fig. 1).

2. Geological setting

The area of interest consists of the following regional geological structures (Figs 1 and 2); for a more detailed information see also the Geologische Übersichtkarte des Freistaates Sachsen 1 : 400,000 (Hoth et al. 1995), Pälchen and Walter (2008) and Geological Map of the Czech Republic 1 : 500,000 (Cháb et al. 2007):

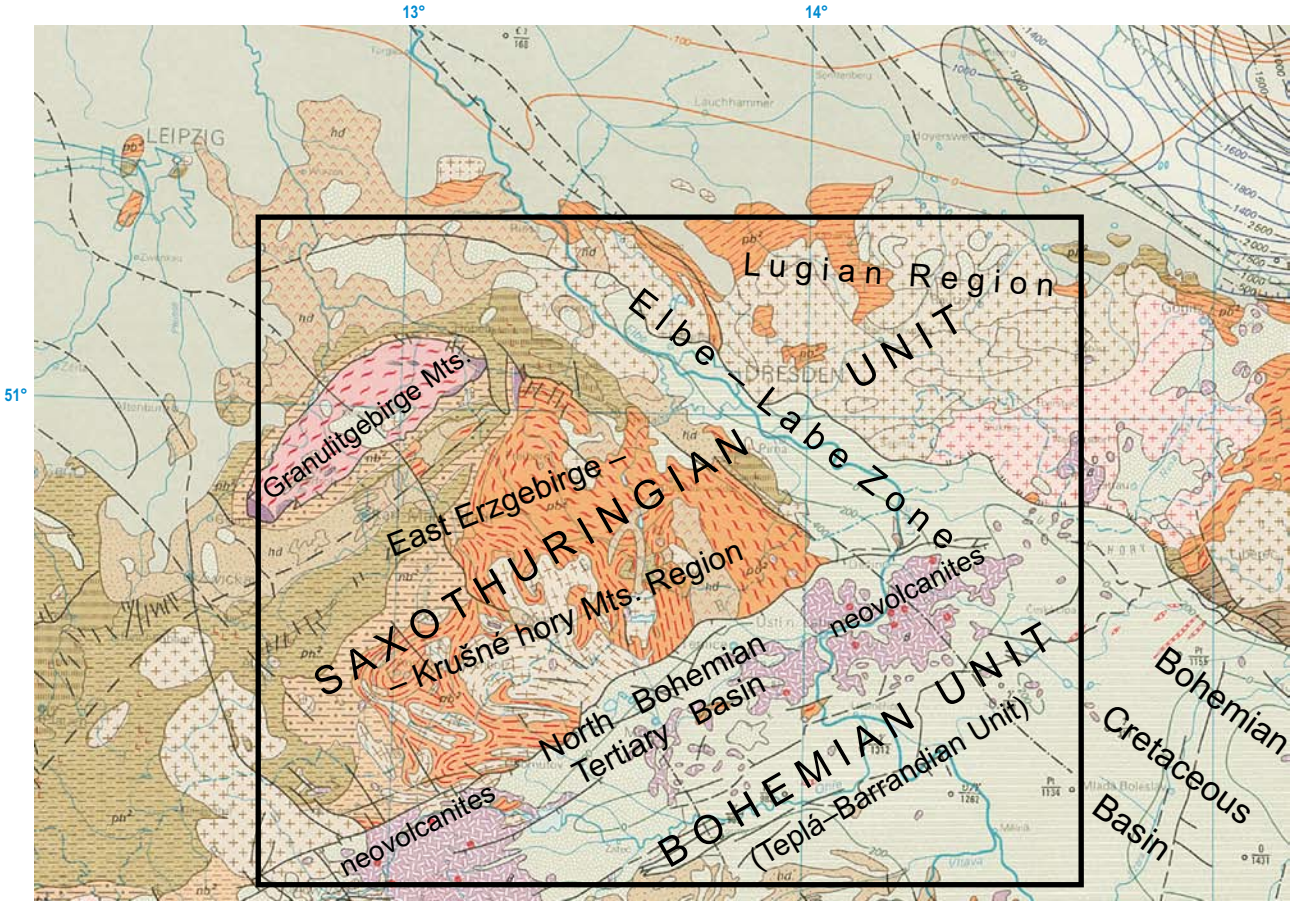

Fig. 1 Geological position of the study area. Taken from the Geological map of the Carpathian–Balkan Mountain System and adjacent areas 1:1,000,000 by Mahel' et al. (1973). The rectangle shows the area covered by the newly compiled gravity and magnetic maps (Figs 3−8).

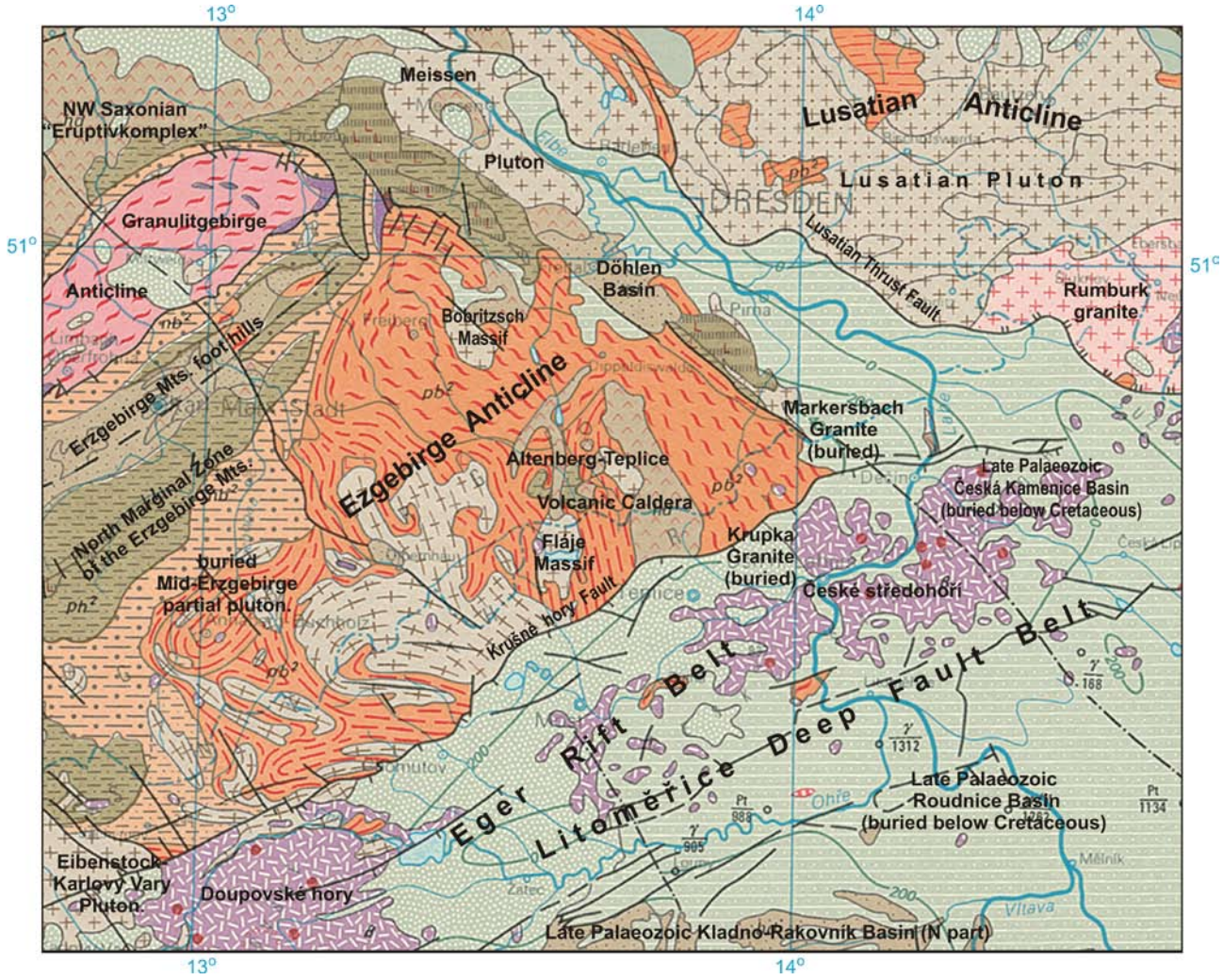

Fig. 2 Geological sketch of the study area. Taken from the Geological map of the Carpathian–Balkan Mountain System and adjacent areas 1 : 1,000,000 by Mahel' et al. (1973). For explanation – see Fig. 1.

- Erzgebirge/Krušné hory and Granulitgebirge regions of the Saxothuringian Unit (Saxothuringicum s.s. – in the N and W),
- Lugian region of the Saxothuringian Unit (formerly regarded as an independent and self-reliant structural unit called the Lugicum – in the NE),
- Teplá–Barrandian Unit – called also Bohemicum – in the SE,
- Elbe/Labe Zone, between Erzgebirge and Lugian regions,
- Late Palaeozoic Basins (mostly buried below Cretaceous sediments),
- Bohemian Cretaceous Basin (largely in the SE),
- North Bohemian Tertiary Basin with a wide range of volcanic rocks (in the SE).

The studied area is situated between two fundamental geological units – the Saxothuringian Unit in the NW and N and the Teplá–Barrandian Unit in the SE and S. They are separated by the Litoměřice Fault. The Saxothuringian Unit is composed of two geological regions – the Erzgebirge/Krušné hory Region (W) and Lugian (West Sudetic) Region (E). The Erzgebirge/Krušné hory Region is separated from the Lugian Region by the NW−SE-trending Elbe/Labe Zone. The Elbe Zone links with the NE−SW Litoměřice Fault in the E marginal part of the study area (in the S vicinity of the town of Česká Lípa, Mlčoch ed. 2001). The contact between those units is entirely covered by Cretaceous sediments of the Bohemian Basin.

2.1. The Erzgebirge/Krušné hory Region

Crystalline complexes crop out in the study area in the E part of the Krušné hory in Bohemia and in the large NE part of the Erzgebirge in Saxony. These include mica schists, paragneisses, and orthogneisses. The

whole region is a large antiform. Orthogneisses as well as a granulite dome cropping out further to the NW are overlain by autochthonous to para-autochthonous Early Palaeozoic sequences metamorphosed under amphibolite-facies conditions (Kröner et al. 1995).

The Fláje and the Niederbobritzsch massifs are the main Variscan granite bodies of this region (Fig. 2). The youngest of the Variscan granites, i.e. the Late Carboniferous to Permian, appear within Altenberg–Teplice Volcanic Structure.

To the NW the crystalline complex submerges beneath several kilometres thick Upper Palaeozoic, Mesozoic and Tertiary platform cover (Krentz in Kozdrój et al. 2001). The Permian Saxon Volcanic Complex ("Eruptivkomplex") crops out in the NW corner of the area (Hoth et al. 1995).

2.2. The Lugian Region

Basement of the Lugian Region is of Cadomian age. It consists of Neoproterozoic greywacke intruded by Early Cambrian granitoid rocks of the Lusatian Pluton. The granites and granodiorites together with the greywackes form a domal structure (the Lusatian Anticline). The Lusatian Thrust Fault and the Grossenhain Fault limit the Anticline against the Elbe Zone and Bohemian Cretaceous Basin in the S. The only representative of the Variscan granite is a small Stolpen body cropping out some 30 km E of Dresden (Krentz in Kozdrój et al. 2001).

2.3. The Teplá–Barrandian Unit

The Teplá–Barrandian Unit in the study area is concealed beneath Late Upper Palaeozoic and Mesozoic post-orogenic cover. Two structural levels are described: 1) mostly slightly metamorphosed Neoproterozoic volcano-sedimentary sequences affected by the Cadomian orogeny and 2) non-metamorphosed Lower Palaeozoic sequences (Cambrian to Devonian) overlaying unconformably the Neoproterozoic (Kachlík 2003).

Both the SE part of the Erzgebirge/Krušné hory and the SW part of the Lugian Plutonic Complex are concealed beneath a Upper Palaeozoic (Post-Variscan) and/or Mesozoic (mostly Cretaceous) platform cover. Moreover, the SE part of the Erzgebirge/Krušné hory is again covered by Tertiary sediments. Those include the North Bohemian Tertiary Basin and the Doupovské hory and České středohoří neovolcanic sequences developed within the Eger/Ohře Rift. The Tertiary volcanic rocks also locally cover the SE marginal part of the Krušné hory, the southern part of the Elbe Zone and the adjacent part of the Lusatian Anticline.

2.4. The Elbe Zone

The Elbe Zone occupies an independent position between the Lusatian Anticline in the NE and East Erzgebirge in the SW. It forms a depression zone transverse to the zoning of the Saxothuringian Region (Kachlík 2003). Two fault zones, the Lusatian in the NE and the Mid-Saxon on the SW, delineate the Elbe Zone (Fig. 2). The zone consists of Neoproterozoic to Lower Carboniferous sequences, shortened in the Elbtalschiefergebirge and stacked to the S and SW on the East Erzgebirge. On the Czech territory, the Elbtalschiefergebirge is almost completely covered by sediments of the Bohemian Cretaceous Basin; the only exception is a small outcrop in the Labe/Elbe valley some 5 km N of the town of Děčín (Fig. 2).

The Elbe Zone also includes the S margin of the Lusatian Pluton (such as the Neoproterozoic Dohna granodiorite and Ordovician Bad Gottleuba tourmaline-bearing granite; Krentz in Kozdrój et al. 2001). It also includes the Variscan topaz-bearing Markersbach granite. The latter is mostly buried and crops out only locally some 5−6 km SSE of Pirna near the SW margin of the Elbe Zone (Fig. 2). The NW part of the Elbe Zone is occupied by a large polyphase Meissen Pluton. It consists of Neoproterozoic granodiorites, Late Palaeozoic syenodiorites and monzodiorites, Carboniferous ignimbrites and acid to intermediate dyke rocks (Hoth et al. 1995; Wenzel et al. 1997).

2.5. Late Palaeozoic Basins

Two Late Palaeozoic basins are developed in the German part of the Elbe Zone. In the NW corner the Mügeln Basin continues to the W and NW with NW-Saxon "Eruptivkomplex" and in the SW with the Döhlen Basin close to Dresden (Fig. 2). Both are filled with sedimentary and mostly acid volcanic formations. Small remnants of Permian sequences were also preserved within the Flöha Fault Zone in the Czech/German borderland near the town of Olbernhau.

Larger and deeper Late Palaeozoic basins are developed on the Czech territory. Most of them are covered by Cretaceous sediments. From the SW to NE these are (Fig. 2): Kladno–Rakovník Basin, Roudnice Basin and Česká Kamenice Basin with thickness 1–1.5 km. Upper Palaeozoic fill of the Kladno–Rakovník Basin is partly covered by Cretaceous sequences.

Extremely small remnants of Jurassic sediments (sandstones, limestones, dolomites) were brought up along the Lusatian Thrust Fault some 12 km NNE of Česká Kamenice, 6 km SE of Sebnitz and 12 km E of Pirna.

2.6. Bohemian Cretaceous Basin

The Bohemian Cretaceous Basin, in the German literature called Bohemian–Saxonian Basin, contains an Upper

Cretaceous infill. The sediments are mostly sandstones in the N and calcareous and marl to clay sediments in the S and SE. They cover the prevailing NE part of the Elbe Zone and a major part of the area on the Czech territory (Figs 1 and 2). The common thickness of the Cretaceous sequences is several hundreds metres (mostly up to 400 m), their maximal thickness reaches 900 m in the Česká Kamenice Depression (Malkovský et al. 1974).

2.7. North Bohemian Tertiary Basin

The North Bohemian Tertiary Basin formed along the SW–NE tectonic weakened zone parallel to the Saxothuringian/Teplá–Barrandian suture (Kachlík 2003). The thinning of the crust along this former collision zone facilitated upwelling of the upper mantle. Alkaline magmas intruded the Eger Rift (Figs 1 and 2). The NW margin of the North Bohemian Tertiary Basin is steeply limited by the Krušné hory Fault, its SE boundary is masked by neovolcanics building the Doupovské hory Mts. (in the SW) and České středohoří Mts. (in the NE). The thickness of the Tertiary sedimentary and volcanic complexes is several hundreds of metres.

3. Methodology

The presented maps of the gravity field of the studied area are based on almost 51,000 gravity points measured by centesimal gravimeters (e.g. Sharpe Canadian Gravity Meter, Texas Instruments Worden Gravity Meter, Scintrex CG-2). The net of measured gravity points is quasi homogenous with the square density of about 3.9 points per km^2. The measured data enable us to create a single cross-border map of Bouguer anomalies for reduction density 2.67 g.cm^{-3} based on the grid cell size of 250×250 m for the whole area of interest (Fig. 3).

For the interpretation purposes, the map of Bouguer anomalies was separated to the regional and residual components. The procedure resulted in two derived maps – Regional gravity anomalies (Fig. 4) and Residual gravity anomalies (Fig. 5). Afterwards, the Linsser filtration was applied to help us in indicating the main upper crust inhomogeneities. The Linsser density indications for three different depth levels (1 km, 3 km and 6 km) were computed (Fig. 6).

The presented magnetic maps were constructed using data of detailed airborne surveys along parallel flight lines 250 m apart in the ground clearance of *c.* 100 m (partly flux-gate but mostly proton magnetometry). The magnetic maps are also based on the grid cell size of 250×250 m.

Magnetic field anomalies found out on 100 m level above the ground (Fig. 7) were transformed via analytical continuation upward to 1,000 m above the ground. Resulting map simplified the complicated anomalous picture caused by near-surface neovolcanics and enabled to reveal deeper seated magnetic sources.

4. Outline of the gravity field of the SE Saxony and NW Bohemia

The gravity field of the area expressed by Bouguer anomalies is shown in the Fig. 3. The original Bouguer anomaly map embraces gravity values ranging from −75 mGal in the SW to +20 mGal in the NE (Fig. 3). The mean level of the Bouguer values is about −25 mGal. The most profound gravity gradients are developed along the Litoměřice Deep Fault Belt (WSW–ENE) and along the Lusatian Thrust Fault (WNW–ESE).

The Erzgebirge/Krušné hory Region and its foothills have no uniform gravity pattern of Bouguer anomalies. Positive gravity field belongs to the NW part of the area and includes the NW Saxon "Eruptivkomplex", Granulitgebirge, Erzgebirge foothills and N marginal zone of the Erzgebirge. On the contrary, the area of the Erzgebirge/Krušné hory Antiform with metagranites (orthogneisses) and migmatites is characterized by striking negative gravity anomalies resulting in a pronounced gravity low (Schweretief des Erzgebirges, *sensu* Hänig and Bauer 1993) on both German and Czech sides. This gravity low follows the Czech/German border for almost 120 km. Two extreme partial gravity lows are developed there. In the SW part it is the Eibenstock–Karlovy Vary Pluton low (−75 mGal) and the Altenberg–Teplice low (−61 mGal) is in the NE. A moderate low of about −45 to −50 mGal in the area of orthogneiss and migmatite complexes links these two aforementioned dominant depressions.

The SE part of the Krušné hory Mts. situated between the Krušné hory Fault (on the NW) and the Litoměřice Deep Fault (on the SE) is mostly buried below Cretaceous and Tertiary sequences. It is characterized by a distinct gravity gradient zone with progressive increase of the Bouguer anomalies from −30 mGal to −20 mGal to the SE. This part of the gravity field is influenced by the effects of: (1) the Tertiary sedimentary and volcanic rocks of the North Bohemian Tertiary Basin, (2) the Upper Cretaceous sediments of the Bohemian Basin, and (3) the crystalline basement structures. As the thickness of the Tertiary and Cretaceous sequences is relatively small, the substantial gravity effect is determined by the crystalline basement composed of paragneisses, migmatites, orthogneisses, granulites, and granites (Mlčoch ed. 2001).

The NE quadrant of the study area shows continuous positive Bouguer anomalies increasing up to +19 mGal to the N (Fig. 3). This positive gravity field corresponds to

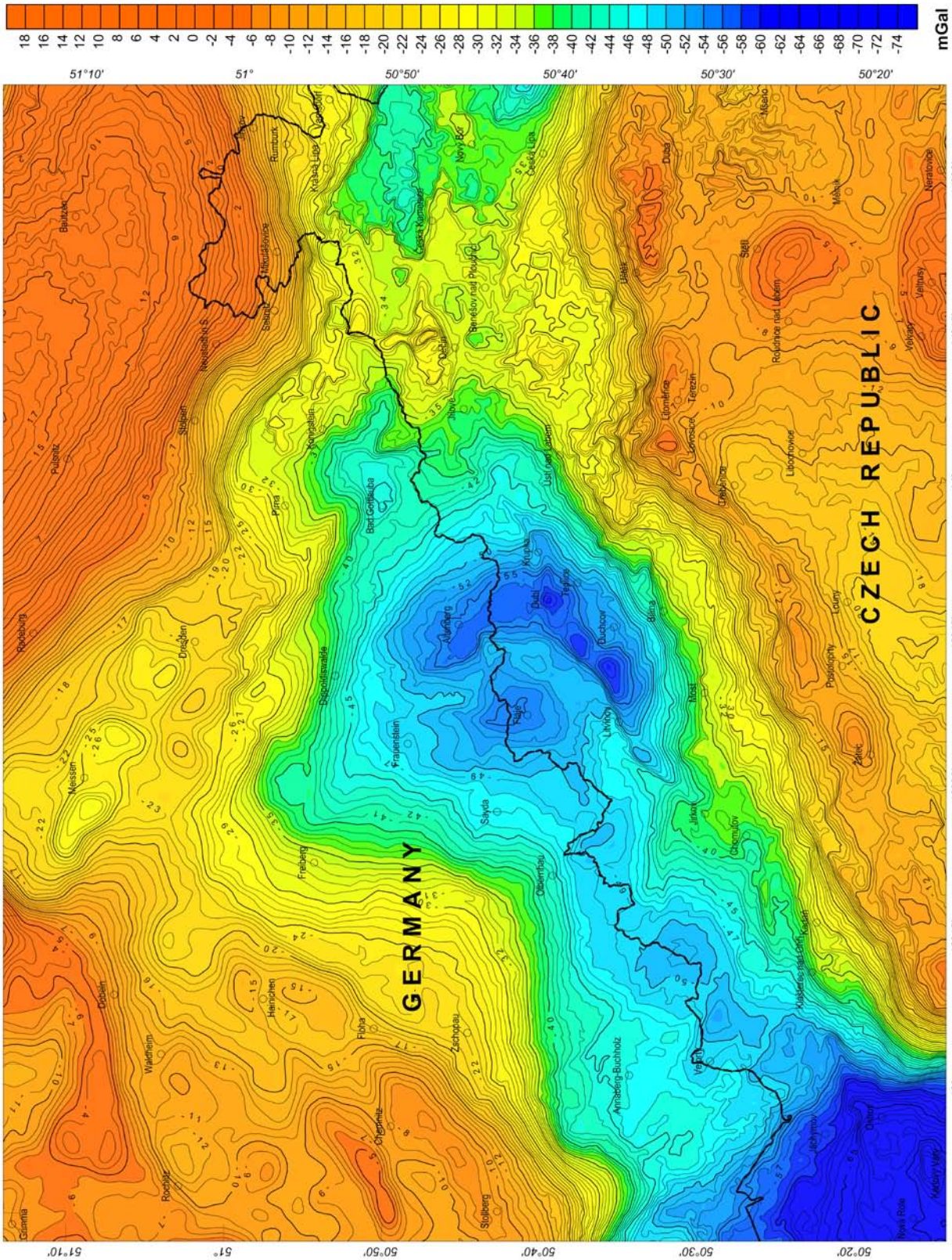

Fig. 3 Bouguer gravity anomalies (2.67 g·cm^{-3}) of the SE Saxony and NW Bohemia.

the Lusatian Anticline. On the contrary, the main feature of the gravity field of the hidden part of the Lusatian Anticline (S of the Lusatian Thrust Fault) is a large gravity low reaching up to −45 mGal. At least, two partial gravity lows can be distinguished in this area, caused by concealed southern part of the Lusatian Pluton and by the Late Palaeozoic and Cretaceous basins (Sedlák et al. 2007a).

The Elbe Zone situated between the Erzgebirge/Krušné hory Region (SW) and Lugian Region (NE) presents mostly medium gravity anomaly values. Nonetheless, the Elbe Zone is superbly traced by a string of magnetic anomalies as showed by Scheibe and Bauer (1996).

The SE quadrant of the study area belongs to the generally positive gravity field reaching up to −2 mGal. The "regional" source of this gravity high is the Teplá–Barrandian Unit.

5. Gravity field analysis

For the analysis of the gravity field was used a Bouguer map (reduction density 2.67 $g \cdot cm^{-3}$) together with the separation of the complete Bouguer anomaly (Δg_{BA}) into the regional (Δg_{REG}) and residual (Δg_{RES}) components. Finally, the Linsser filtering of the Bouguer map was applied to delineate main density boundaries (ranges of densities and representative mean values for individual geological units are summarized in Table 1).

5.1. Separation of Bouguer anomalies

The regional field was computed via approximation by 2D local splines. The degree of "regionalization" was controlled by grid cell size and by the so-called rigidity parameter. The principal equation $\Delta g_{RES} = \Delta g_{BA} - \Delta g_{REG}$ was used to obtain the residual gravity map. Results of the Bouguer anomalies separation are presented on Fig. 4 (regional anomalies) and on Fig. 5 (residual anomalies).

The map of the regional (long-wave) anomalies (Fig. 4) shows four fundamental anomalous gravity structures – three positive and one negative. The most notable positive regional anomaly (18 mGal) situated in the NE is caused by the mostly outcropping Lusatian Anticline. Another positive anomalous structure (−5 mGal) located in the NW belongs to the SE marginal part of the North-Saxon Anticline largely overlain by NW-Saxon Permian Volcanic Complex. The third positive anomalous zone (−7 mGal) extends to the SE and corresponds to the Teplá–Barrandian Unit.

The most striking regional negative anomaly (−66 mGal) is located in the SW corner of the area. It is caused by the Eibenstock–Karlovy Vary Granite Pluton from which this negative anomaly continues to the NE – creating a Gravity Low of the Erzgebirge Antiform ("Schweretief des Erzgebirges" *sensu* Hänig and Bauer 1993).

The next distinct gravity low developed in the easternmost part of the Gravity Low of the Erzgebirge, i.e. relatively close to the Elbe Zone, is caused by the Altenberg–Teplice Caldera. The German part of the low is called "Minimum von Freiberg–Altenberg" (Hänig and Bauer 1993). Nevertheless, southern half is situated on the Czech territory as a caldera structure hidden beneath the Tertiary and Cretaceous sequences. We suppose that this volcanic structure reaches down to 10 km, similarly to the Karlovy Vary Pluton body modelled by Švancara et al. (1997).

The shallower part of the Gravity Low of the Erzgebirge between the Karlovy Vary/Eibenstock extreme and the Altenberg–Teplice minimum is supposed to be caused by a large hidden plutonic complex spread there below several kilometres thick metamorphic sequences (Hejtman 1984; DEKORP Research Group B 1994; Siebel et al 1997).The Gravity Low of the Erzgebirge finally turns to the E and continues as the W part the Gravity Low of the Lugian Unit (Sedlák et al. 2007a).

The map of the residual (short-wave) anomalies (Fig. 5) indicates numerous positive and negative zones. Seventeen individual negative residual anomalies and ten local positive anomalies distinguished are marked in Fig. 5. Their geological significance is shown in the Table 2.

5.2. Linsser filtering and geological interpretation

The Linsser filtering of the Bouguer anomalies was applied to delineate vertical and sub-vertical density boundaries. Using selected grid spacing and filtering parameters, the density boundary indications were computed for depth levels 1, 3 and 6 km. The Linsser indications (Fig. 6) show density differences which are in some cases related to fault zones.

The large Gravity Low of the Erzgebirge Antiform (in the central part of Figs 3 and 4) is predominantly caused by the Altenberg–Teplice Caldera structure. The 3 km Linsser indications show only the outer boundaries of the caldera, whilst 1 km Linsser indications define also its detailed near-surface features. Those are inside-caldera partial bodies such as the pre-caldera (as showed Breiter et al. 2001) Fláje granite body (negative residual anomaly **j** in the W), autometamorphosed post-caldera (Breiter et al. 2001) Altenberg (Schellerhau) granite together with a large rhyolite complex (negative residual anomalies **k** and **l** in the E). The concealed part of the rhyolite body beneath the Tertiary sediments and volcanic complexes

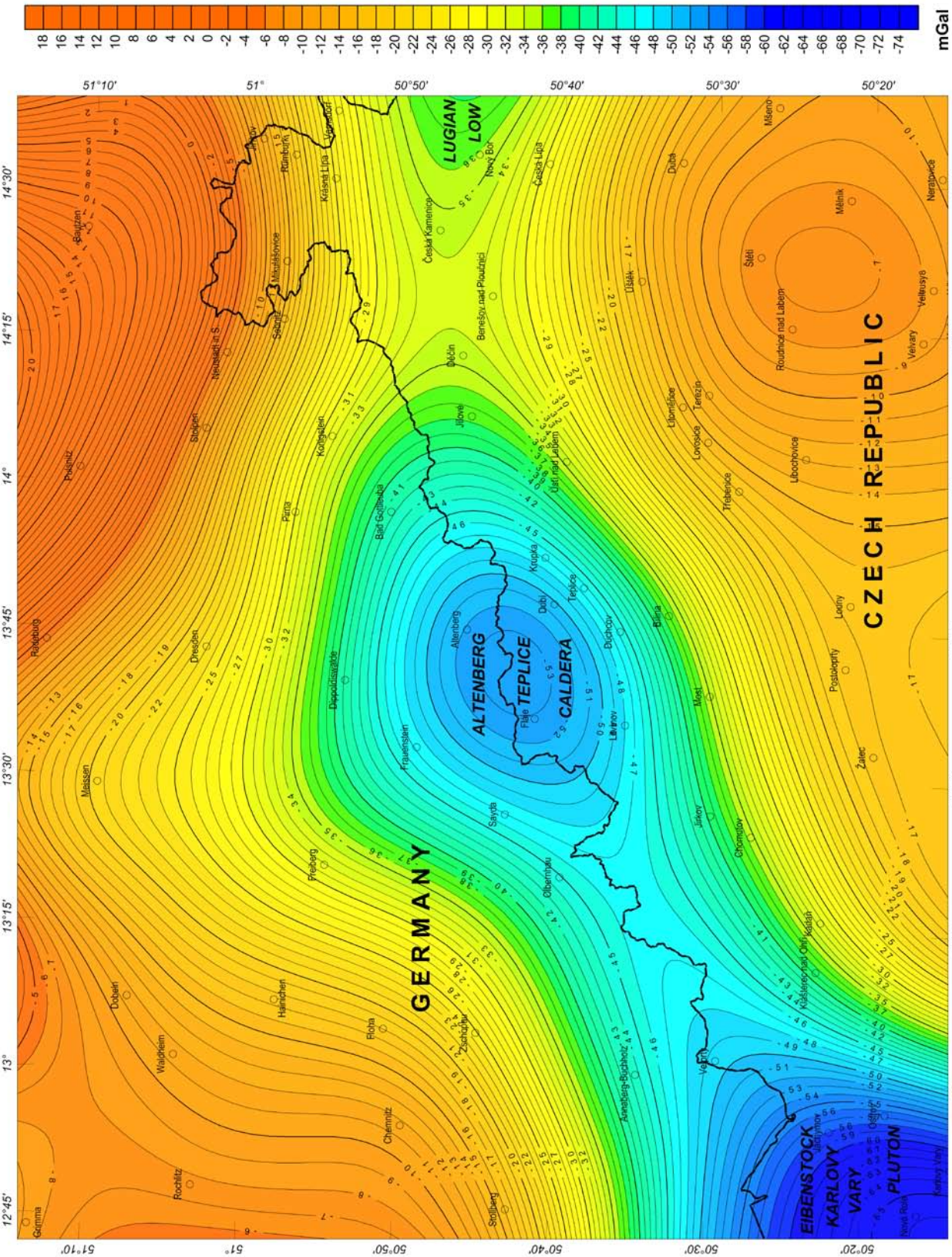

Fig. 4 Regional gravity anomalies (2.67 g·cm^{-3}) of the SE Saxony and NW Bohemia.

Tab.1 Density values of the main rock complexes used in the geological interpretation

Area/Geological structure **Rock complex**	**Range of density** **[g.cm^{-3}]**	**Mean value** **[g.cm^{-3}]**
Erzgebirge/Krušné hory Region and its foothills: Main data sources: Kopf and Oelsner (1963), Russe (1969), Carl (1987), Chlupáčová et al. (2004), DEKORP (1994)		
NW-Saxon Permian volcanic complex ("Eruptivkomplex"): acid volcanic rocks, ignimbrites	2.50–2.66	2.61
Early Palaeozoic basement of the NW-Saxon Permian "Eruptivkomplex": Cambrian, Ordovician	2.69–2.76	2.75
Granulitgebirge Anticline: granulite, granulite gneiss	2.62–2.84	2.70
Erzgebirge foothills: Early to Late Palaeozoic	2.59–2.76	2.72
Erzgebirge Metamorphic Complex (Antiform): Metagranodiorite, metagranite, orthogneiss Niederbobritzsch granite	2.64–2.69 2.56–2.65	2.66 2.65
Altenberg–Teplice Caldera: Rhyolite Granite porphyry Greisenized granite	2.60–2.63 2.60–2.61 2.57–2.61	2.62 2.61 2.60
Buried part of the Erzgebirge/Krušné hory Metamorphic Complex beneath the Bohemian Cretaceous Basin, North Bohemian Tertiary Basin and volcanic rocks of the České středohoří Mts.: paragneiss, mica schist, migmatite, orthogneiss	2.66–2.77	2.73
Intrusive rocks within the Saxothuringian/Teplá–Barrandian Suture Zone Main data sources: Chlupáčová et al. (2004), GFÚ AV ČR (2005), Sedlák et al. (2007a)		
Acid (granitic) rocks	2.62− 2.72	2.66
Basic rocks	2.82–2.93	2.90
Teplá–Barrandian Unit Main data sources: Čejchanová et al. (1971), Chlupáčová et al. (2004), Sedlák et al. (2007a)		
Proterozoic sequences: mica schists to paragneisses phyllites shale and greywacke formations Neo-Proterozoic basalts to andesites ("spilites") "Bechlín" diorite body	 2.74–2.86 2.73–2.77 2.71–2.75 2.77–2.80 2.78–2.90	 2.82 2.75 2.74 2.78 2.82
Post-Variscan cover Main data sources: Čejchanová et al. (1971), Ondra and Hanák (1982), Chlupáčová et al. (2004), Sedlák et al. (2007a)		
Carboniferous sediments (Roudnice Basin, Česká Kamenice Basin, Kladno–Rakovník Basin)	2.55–2.65	2.61
Permian sediments (Roudnice Basin, Česká Kamenice Basin, Kladno–Rakovník Basin)	2.30–2.60	2.46
Upper Cretaceous sediments Bohemian Cretaceous Basin	2.20–2.40	2.30
Tertiary sediments: North Bohemian Tertiary Basin	1.90–2.20	2.10
Neovolcanites: Volcanic rocks (mostly pyroclastics) of the České středohoří Mts.	2.00–3.00	2.50

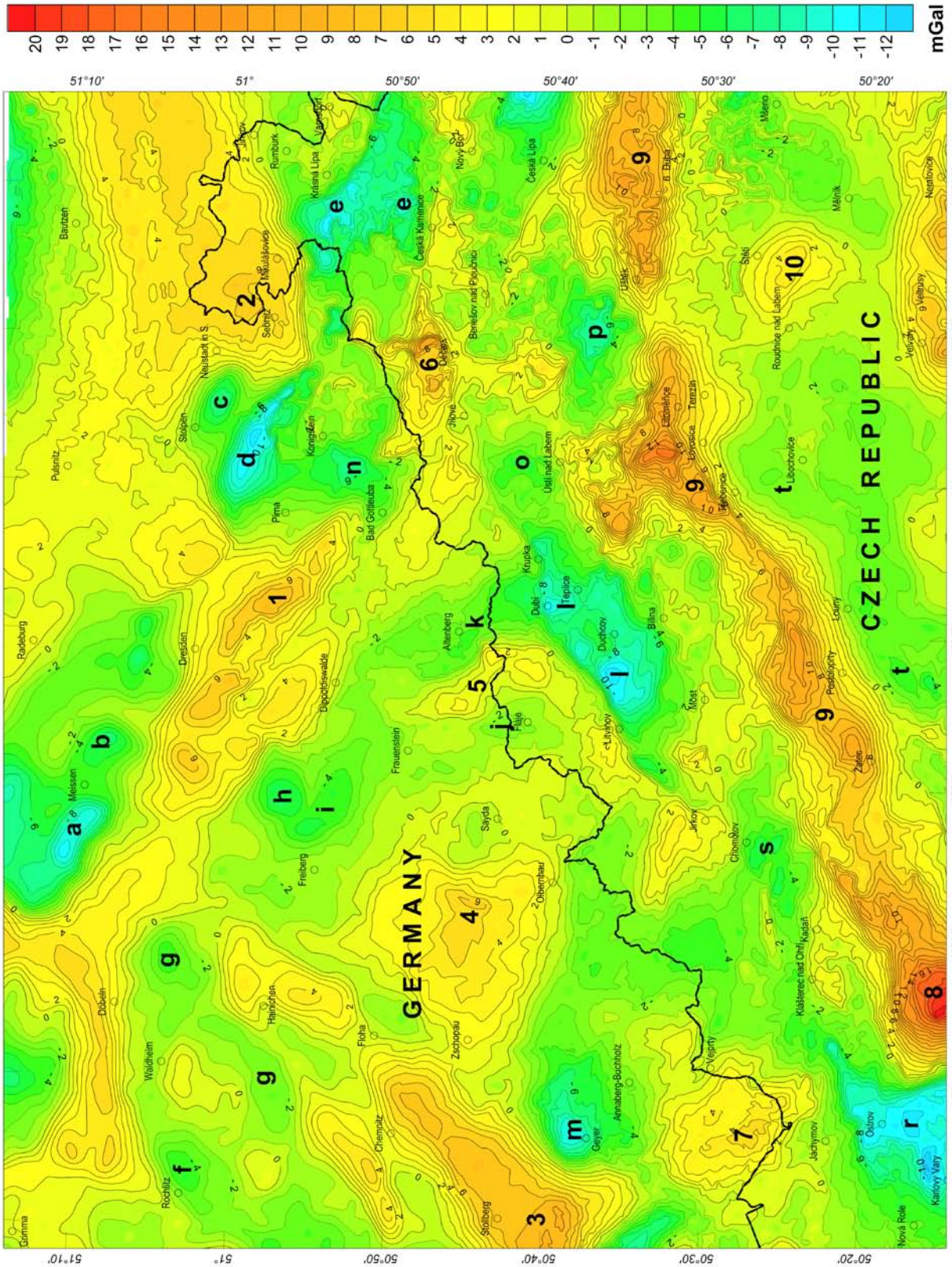

Fig. 5 Residual gravity anomalies (2.67 g·cm^{-3}) of the SE Saxony and NW Bohemia.

Tab. 2 Remarkable residual gravity anomalies

Negative residual anomalies

Sign	Location	Amplitude	Source
a, b	Meissen – W and SE	−6 to −10 mGal	Late Variscan Meissen Massif (granodiorite, monzonite, leucogranite), **a** – overlapped by Meissen–Priestewitz Volcanic Complex (rhyolite, ignimbrite, tuff), **b** – young granites buried under Cretaceous sediments
c	Stolpen – SE	−6 mGal	Variscan granite inside the Cadomian Lusatian Pluton
d	Königstein – N	−11mGal	Turonian sandstones of high porosity (20 %) plus additional effect of the underlying low-density Variscan granite
e	Česká Kamenice – N	−7 to −10 mGal	the deepest part of the Cretaceous Basin plus additional effect of the underlying Cambrian Rumburk granite
f, g	NW corner of the Fig. 5	−2 to −4 mGal	shallow residual depression of the Granulitgebirge, **f** – indicates a local low caused by orthogneiss, **g** – shows a local low caused by granite intrusion
h	Freiberg – NE	−5 mGal	Late Palaeozoic Tharandt Volcanic Complex, ignimbrite and remnants of the Cretaceous sediments
i	Freiberg – E and SE	−5 mGal	Late Palaeozoic Niederbobritzsch granite body
j	Litvínov – N	−2 mGal	Late Palaeozoic Fláje granite body cross-cut by granite porphyry dyke
k	Altenberg – W	−4 mGal	Late Palaeozoic Altenberg granite body surrounded by rhyolite
l	Teplice – N to Duchcov – W	−9 to −11 mGal	S-part of the Teplice–Altenberg Caldera, mostly Late Palaeozoic rhyolite covered by Tertiary sediments
m	Annaberg – Buchholz	−9 mGal	"Geyer top-part" of the mostly buried Variscan granite of the Mid-Erzgebirge Partial Pluton (*sensu* Pälchen and Walter 2008)
n	Bad Gottleuba – NE	−6 mGal	mostly buried, Variscan Markersbach granite body
o	Krupka – E	−4 mGal	almost completely buried Variscan Krupka granite body
p	Úštěk – NW	−7 mGal	completely buried Variscan? granitoids encountered by drill holes for uranium exploration
r	Ostrov – S, SW and ENE	−11 mGal	combined effect of the marginal part of the Variscan Karlovy Vary Pluton plus NE promontory of the Tertiary Basin
s	Chomutov – S and SW	−5 mGal	Tertiary Basin underlain by orthogneiss and granulite
t	Louny – WSW, S and E	−3 to – 5 mGal	completely buried part of the Louny Cambrian to Ordovician large granodiorite desk body

Positive residual anomalies

Sign	Location	Amplitude	Source
1	Dresden – SE	7 mGal	SW marginal part of the Lusatian Massif extending along the West Lusatian Fault in the SW margin of the Cretaceous gulf of the Elbe Zone (migmatite of the Pulsnitz Complex, metagreywacke, metapelite) and metamorphic rocks of the Elbtalschiefergebirge (Syncline of Maxen-Berggiesshübel)
2	Sebnitz – NE	6 mGal	granodiorite and migmatite of the Pulsnitz Complex, S part of the Lusatian Anticline
3	Stollberg S and E	7 to 9 mGal	Lössnitz–Zwönitz Syncline in Early Palaeozoic metamorphic complex of N marginal zone of the Erzgebirge, metapelite, basic metatuff
4	Sayda – W	6 mGal	SW part of the East Erzgebirge Antiform, Proterozoic muscovite gneiss with mafic to ultramafic rocks (gabbro, amphibolite, eclogite)
5	Frauenstein – SE	2 mGal	remnants of Early Palaeozoic phyllite, muscovite and two-mica gneiss sunken into the Altenberg–Teplice Caldera
6	Děčín – N	9 mGal	local elevation and outcrops of the Proterozoic to Early Palaeozoic granodiorite and phyllite, Elbtalschiefergebirge
7	Jáchymov – N	5 mGal	Early Palaeozoic phyllite and mica schists
8	Klášterec nad Ohří – S, SE	20 mGal	basic-rock basement equivalent to Mariánské Lázně Complex and feeder of the Doupovské hory Tertiary basalt volcano
9	Žatec – Litoměřice – Dubá	10 to 13 mGal	chain of buried intermediate to basic intrusions occurring along the Litoměřice Deep Fault Belt
10	Štětí – S	4 mGal	buried Cambrian Bechlín diorite body (Šmejkal 1968)

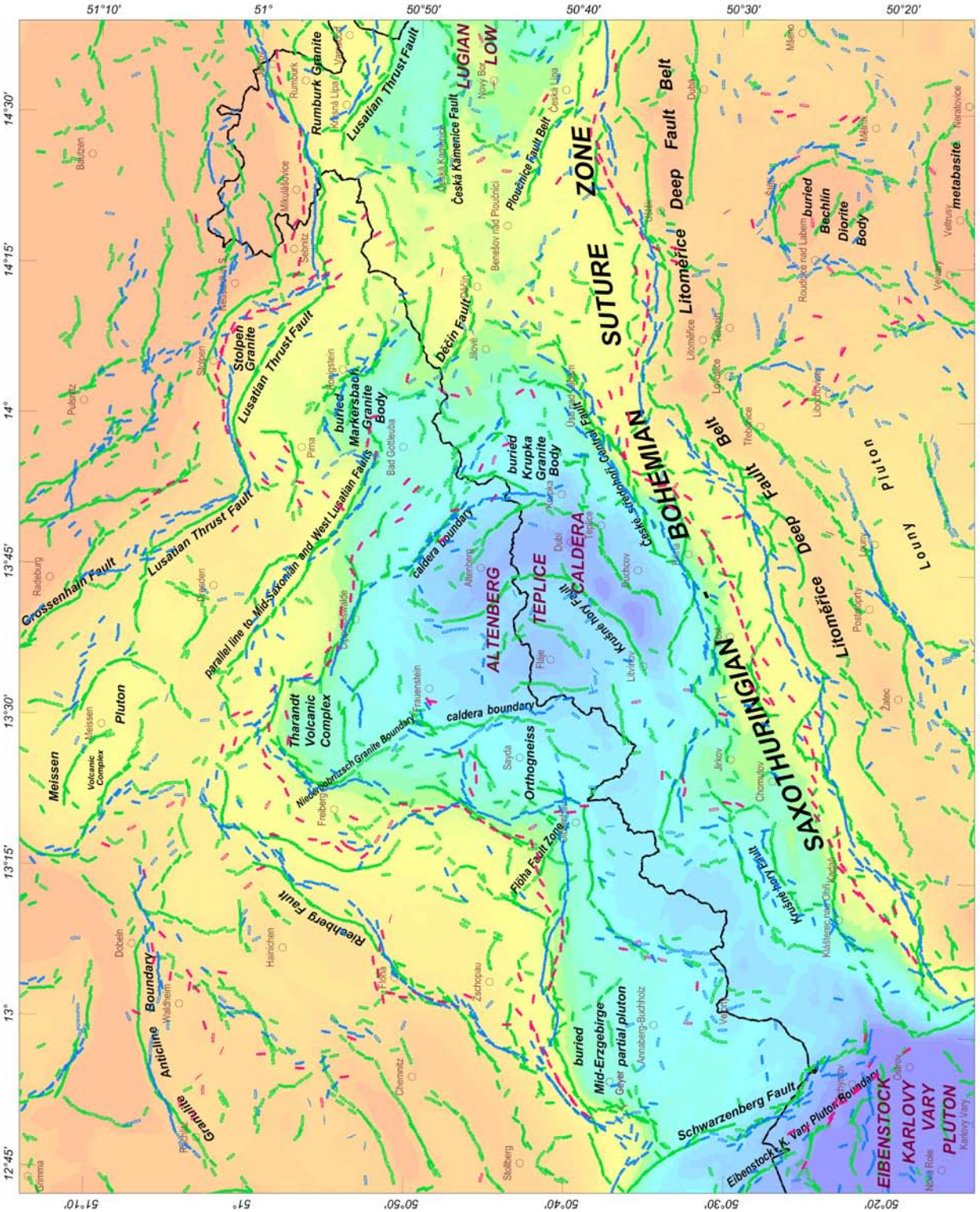

Fig. 6 Linsser density boundaries at three depth levels; 1 km (green), 3 km (blue) and 6 km (red). The long bars are oriented in the direction of density boundary, the small ticks point to higher density.

was proved by drill holes 10 km S and SE of Teplice (Mlčoch ed. 2001).

Remnants of a metamorphic domal structure are responsible for the positive residual anomaly **5** in the central part of the caldera. The associated partial gravity lows pertaining to Sayda orthogneiss (W), Tharandt Volcanic Complex (residual anomaly **h** in the NW), Krupka granite and Markersbach granite bodies (residual anomalies **n** and **o** in the E) are delimited as separate structures even for the depth of 3 km.

The Granulite Massif Antiform of the Granulitgebirge is identified by a moderate gravity low reaching from −11 to −18 mGal. It is surrounded by a relative gravity high of about −4 mGal on the N and −5 mGal on the S. The Linsser 1 km and 3 km indications delimit its N and NW margin against the orthogneisses and Cambrian to Ordovician sequences influenced by contact metamorphism. Its southern density contrast towards the Palaeozoic rocks is less continuous; it is influenced by intrusions of Late Palaeozoic granites exposed near the S margin of the granulite body (negative residual anomaly **g**).

Remarkable NNE–SSW-trending density boundary shown by 1, 3 and partly also by 6 km indications is displayed in the area where the Riechberg Fault is mapped. This density boundary probably represents a tectonic contact of the Palaeozoic Synform of the Erzgebirge Foothills with the orthogneiss, migmatite and metagranite rock complex of the Erzgebirge Antiform.

The NW–SE-trending Flöha Fault Zone regarded as the line dividing the East-Erzgebirge partial Anticline from the Mid-Erzgebirge partial Anticline is manifested solely by 1 km Linsser indication. This relatively shallow indication seems to be predominantly caused by wedged remnants of Late Palaeozoic (mostly Permian) sediments; the absence of 3 and 6 km indications signifies a weak density contrast (maybe due to similar lithology) in the subsurface level of both Mid- and Eastern Erzgebirge.

Pronounced 3 km and 6 km Linsser indications follow the line connecting Freiberg (N) and Olbernhau (S) from where they turn further to the W. This line is explained as a boundary between two density environments, i.e. phyllite, micaschists and gneiss complex with eclogite bodies in the W and "lighter" orthogneiss, migmatite and granulite complex in the E and buried Mid-Erzgebirge partial Pluton (*sensu* Pälchen and Walter 2008) in the S.

Within the Lusatian Anticline (in the NE part of the maps), mostly built by Proterozoic rocks of high densities, the Linsser indications demonstrate density boundaries almost parallel to the SW margin of the Lusatian Massif ascribed here to the Lusatian Thrust Fault. Besides that, the Linsser indications also reveal that this thrust fault does not reach the same depth along its strike. For instance, in its northern continuation towards the Grossenhain Fault seems to be relatively shallow. The Linsser boundaries 1 km, 3 km and 6 km follow the S margin of the Lusatian Massif reflecting the contrast with "lighter" granites, such as the Cambrian Rumburk granite (2.64 $g \cdot cm^3$, residual anomaly **e**) in the E and Variscan Stolpen granite (2.63 $g \cdot cm^{-3}$, residual anomaly **c**) near the central segment of this thrust fault. The 3 km and 6 km Linsser boundaries even indicate a conceivable connection of the Stolpen body to the Markersbach granite across the Cretaceous bay of the Elbe Zone at depth >3 km.

The Krušné hory Fault represents the boundary between metamorphic complexes of the Erzgebirge/Krušné hory Antiform (in the NW) and the Tertiary Basin (in the SE). It is presumably a relatively shallow tectonic line as it is not reflected by the Linsser indications of 3 km and 6 km.

The density boundaries of the Louny Cambrian granodiorite (residual anomaly **t**) are discontinuously delimited only by the 1 km and 3 km Linsser indications. It fits well the interpretation of Kopecký Jr. et al. (1997) who presumed this tabular granodiorite body as reaching the depth about 4 km. The depth response of the Bechlín diorite body (residual anomaly **10**) is similar to the Louny granodiorite; it also displays no Linsser indications from the depth of 6 km.

The Litoměřice Deep Fault is traced by all the three depth levels of Linsser indications. Their position may suggest that the fault zone dips to the NW (towards the České středohoří Central Fault). The 6 km Linsser indication portrays the suture as a zone comprising the Litoměřice Fault and České středohoří Central Fault (Fig. 6).

Franke (2000) stated that there is no evidence of subduction-related magmatic activity along the NW margin of the Teplá−Barrandian Unit. Since that time many boreholes were re-evaluated and geophysical data (gravity, magnetic and deep seismic) were analyzed. Mlčoch (ed.) (2001) noted a continuation of the Mariánské Lázně Basic Complex beneath the Doupov Tertiary Volcano 35 km further to the ENE from the E margin of the Karlovy Vary Pluton. These authors also showed that other basic rocks (amphibolite, eclogite, serpentinite comparable to the Mariánské Lázně Complex) continue from N of Postoloprty and Louny to Litoměřice (Mlčoch 2003 documents them in 5 boreholes and by xenoliths in České středohoří volcanic rocks).

Because these bodies correspond to the chain of positive gravity anomalies (No. **9** in the map of the residual anomalies) we interpret that the whole chain of anomalies protruding from the residual anomaly **8** to the ENE (along N vicinities of the towns of Žatec – Postoloprty – Třebenice – Litoměřice) represents gravity responses of magmatic bodies following the suture zone. This interpretation is also supported by the fact that the eastern E−W-trending continuation of the residual anomaly **9**

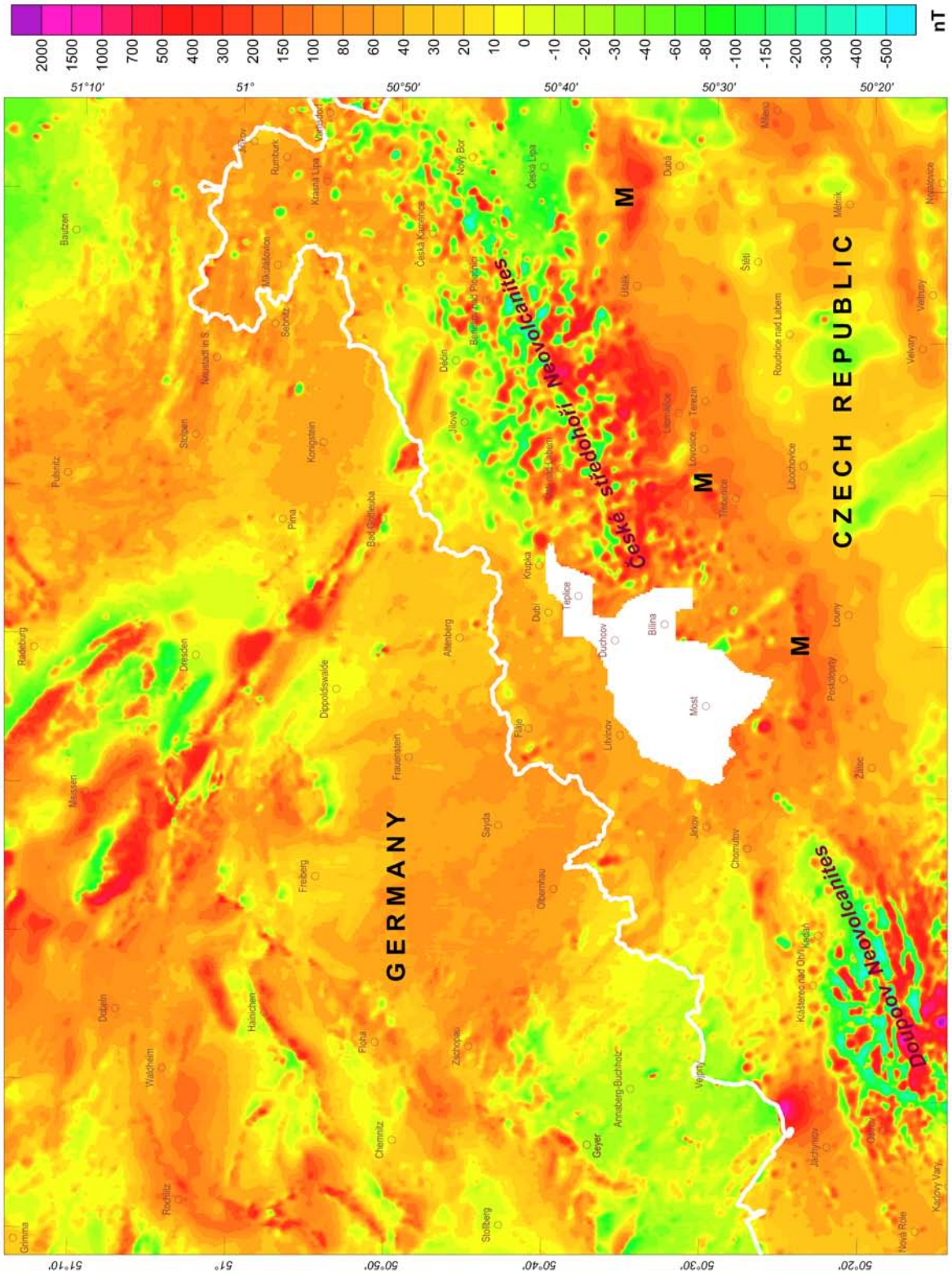

Fig. 7 Magnetic map of the SE Saxony and NW Bohemia (based on airborne survey, about 100 m above the ground, flight line distance 250 m); the Saxon part by R. Scheibe and W. Bauer, the Czech part by S. Zabadal and I. Gnojek, final compilation by S. Zabadal. The white spot shows the area of industrially disturbed geomagnetic field. The short-wave anomalies (mosaic-shape fields) are caused by neovolcanics of Doupovské hory and České středohoří Mts.

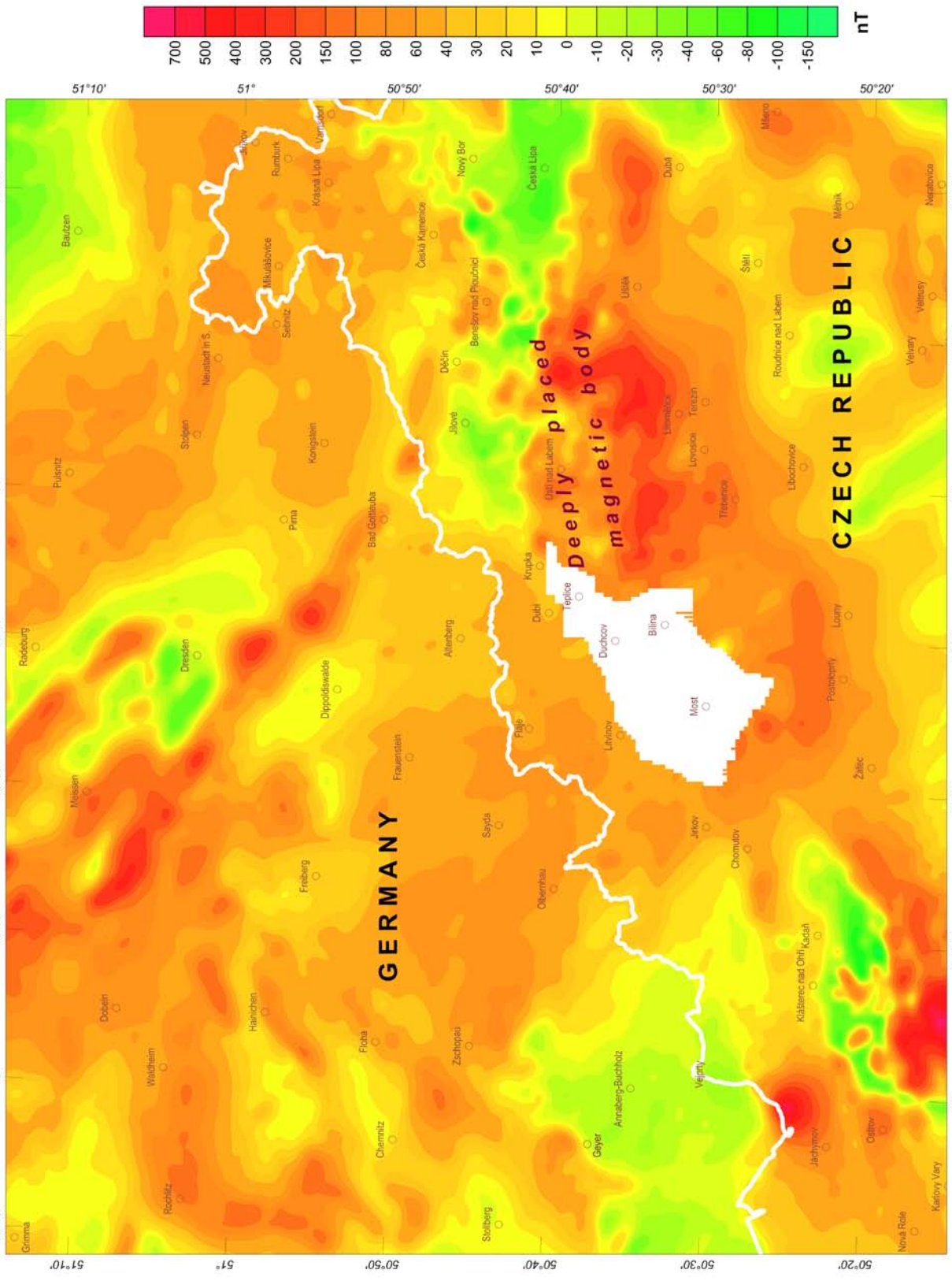

Fig. 8 Analytical continuation of the magnetic anomalies to the level of 1000 m above the ground (suppressing the short-wave anomalies of neovolcanic rocks). The source of data is the same as in Fig. 7.

(Litoměřice – Úštěk – Dubá) is caused by granodiorite and diorite intrusions proven by drill holes (Rutšek 1994).

Moreover, the chain of the discussed gravity anomalies is followed by a trail of distinct magnetic anomalies (marked as **M** in the Fig. 7) the sources of which are also interpreted as magmatic bodies (Sedlák et al. 2007b). Besides that, the area of České středohoří and North Bohemian Tertiary Basin is occupied by a notable long-wave magnetic anomaly (regional magnetic anomaly of the České středohoří, up to 80 km long and 25 km wide, between Chomutov in the WSW and Česká Lípa in the ENE) which was interpreted by Šalanský and Gnojek 2002 as a deep-seated basic plutonic body having no direct association with Tertiary volcanic complexes (deeply placed magnetic body in the Fig. 8).

Recently, this presumed basic body was also independently indicated by reprocessing of the S1 refraction profile SUDETES 2003. Novotný et al. (2009) who applied the method of depth-recursive tomography on the S1 profile (running NE−SW) revealed a high velocity anomaly (6,100–6,250 km/s) beneath the České středohoří volcanic complex at depths of 6–11 km. The source of this seismic velocity anomaly coincides with that of the large České středohoří regional magnetic anomaly.

6. Conclusions

Newly compiled cross-border gravity map of the Czech–Saxon Borderland embraces: (1) positive regional anomaly (−5 mGal) in the area mostly built by North Saxon Syncline covered by NW-Saxon Volcanic Complex (in the NW), (2) positive regional anomaly (+20 mGal) produced by Lusatian Anticline (in the NE) and (3) positive regional anomaly (−7 mGal) pertaining to Teplá–Barrandian Unit (in the SE). Among these three positive regional anomalies there is a belt of negative regional anomalies linking up the minimum of the Eibenstock–Karlovy Vary Pluton (in the SW), the Altenberg–Teplice Caldera and the Lugian gravity low (the western part of which is caused by Rumburk granite as a fundamental source in the ENE).

Residual negative gravity anomalies predominantly indicate extent of mostly covered Variscan igneous bodies, such as: Mid-Erzgebirge partial pluton in the NW vicinity of Annaberg-Buchholz, small intrusions within the Saxon Granulite Dome, younger granites within the Meissen Massif, Niederbobritzsch granite, volcanic complexes of Meissen–Priestewitz and of Tharandt, Stolpen granite, Markersbach granite, Krupka granite, Fláje Massif, Teplice rhyolite, granite bodies within the Litoměřice Fault Belt NW of Úštěk and also outline the extent of the Cambrian Louny Pluton within the Teplá–Barrandian Unit.

Residual positive gravity anomalies correspond mostly to metamorphic complexes and plutonic bodies such as migmatites of the Pulsnitz Complex in the Lusatian Anticline and in the Elbe Zone, gneiss complexes with amphibolite and eclogite in the Erzgebirge Antiform, continuation of the Mariánské Lázně Complex and basic bodies along the Litoměřice Fault as well as the Bechlín diorite in the Teplá–Barrandian Unit.

Linsser density boundaries were computed for three depth levels – 1, 3 and 6 km. The more frequent 1 km and 3 km boundaries show the inner structure of the larger geological units, delimitate various lithological boundaries, expose the contours of some granite bodies and track some of fault zones. Linsser 6 km boundaries are rather rare. The most continuous 6 km boundary is that of the NE–SW line parallel to the Litoměřice Fault which can be understood as a deep response of the Saxothuringian/Teplá–Barrandian Suture Zone. Another 6 km boundary has variable trend and is located inside the Saxothuringian Unit. It delineates the N and NW boundary of an area of the low-density Variscan granitoid bodies.

The Litoměřice Fault is followed by the chain of mid-wave magnetic anomalies (Postoloprty – Třebenice – Litoměřice – Úštěk) which run parallel to a line of gravity anomalies of similar dimensions. We interpret that the sources of these anomalies are intermediate to basic igneous bodies. The long-wave magnetic anomaly is interpreted as an igneous body at depth of > 6 km along the Saxothuringian/Teplá–Barrandian Suture Zone. Its basic character is justified by high velocities of seismic waves and also by a remarkable high-amplitude and large magnetic anomaly. Small-scale gravity and magnetic anomalies provide an evidence of other intrusive bodies occurrences along the Saxothuringian/Teplá–Barrandian Suture Zone.

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