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DIGITAL MODEL OF THE CRYSTALLINE BASEMENT AND PERMO-CARBONIFEROUS VOLCANO-SEDIMENTARY STRATA IN THE MNICHOVO HRADIŠTĚ BASIN AND CORRELATION WITH THE GEOPHYSICAL FIELDS (CZECH REPUBLIC, NORTHERN BOHEMIA)

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ABSTRACT
Correlation of boreholes and geophysical data provides the framework for 3D modelling of the crystalline basement and the Permo-Carboniferous volcano-sedimentary strata in the Mnichovo Hradiště Basin. The knowledge of depth of the individual interfaces acquired from boreholes database and interpretation of the seismic profiles enabled construction of 3D models. The Stráž crystalline block has bounded the Mnichovo Hradiště Basin on the north, its elongation is in NNW-SSE direction and maximal depth has reached near Sobotka. Its second deepest part known as Mcely or Sukorady sub-basin has been detected southeast of Mladá Boleslav. The negative gravity anomaly in the Mimoň- Český Dub- Turnov- Mnichovo Hradiště area indicated presence of „light" granitic rocks in the crystalline complex. Moreover, the highest volume of rhyolite ignimbrites with a thickness of up to 180 m is concentrated in Permo-Carboniferous volcano-sedimentary strata in this negative gravity anomaly area, which can be related to a rather deep Late Paleozoic volcanic source (up to a depth of about 10 km).

KEYWORDS: Mnichovo Hradiště Basin, crystalline basement, Permo-Carboniferous volcano-sedimentary complex, 3D model, seismic, gravity and magnetic field

1. INTRODUCTION

The area of study is situated in the northern part of the Bohemian Massif (Fig. 1), in the Bohemian Cretaceous Basin, between Česká Lípa, Liberec and Nymburk. On the northeast the Lužice Fault Zone separates it from granitoides and pre-Late Paleozoic metamorphic rocks of the Lugian Zone. The Permo-Carboniferous volcano-sedimentary complex beneath Cretaceous sediments filled the so-called Mnichovo Hradiště Basin (MHB) between the towns of Mimoň – Český Dub – Turnov – Jičín – Nymburk and Mladá Boleslav. This borders with the other Late Paleozoic basins; Mšeno-Roudnice Basin (MRB) on the southwest and Krkonoše Piedmont Basin (KPB) on the east (sine 1994).

The basement of the Bohemian Cretaceous Basin (BCB) is known only from isolated boreholes and from xenoliths. The first summarizing studies were published e.g. by Petrascheck (1910) and Hibsch (1912). The first solid map was compiled in 1959 by Pouba et al. during a project „Geological research of the basement of the Bohemian Cretaceous Basin". In the 60s and 70s a number of results were published including new drilling data and geophysical interpretation. The most important maps and results of geological mapping and exploration work were published by Chaloupský (1973) and in a monograph by Malkovský et al. (1974). Other works about geological structure of the basement of Permo-Carboniferous limnic basins were written by Dudek and Pešek (1989) and Pešek et al. (1996, 2001). The summarizing information about deep drilling in the Czech Republic was published in Suk and Ďurica et al. (1991).

Geophysical measurements, particularly seismic profiling (Fig. 2), but also gravity and magnetic data were interpreted in connection with the deep drilling. Seismic refraction profiles were carried out all over the Bohemian Cretaceous Basin in the 60s (Hrách, 1970) and some of them ran also through the Mnichovo Hradiště Basin (MHB). The seismic reflection research during the 80s enhanced the knowledge of its southern part. Seismic data of the profile 31 and in the Labe area profiles 11-20 and 36 enabled the construction of a sketch of the crystalline basement to the depth exceeding 1 km and final geological interpretation was published in Chudomel et al. (1983) and Benda et al. (1985). The character of the basement beneath Cretaceous sediments was interpreted from the gravity data by Sedlák et al. (2007). The magnetic anomalies in this region and their geological meaning were described in a monograph by Šalanský and Gnojek (2002).

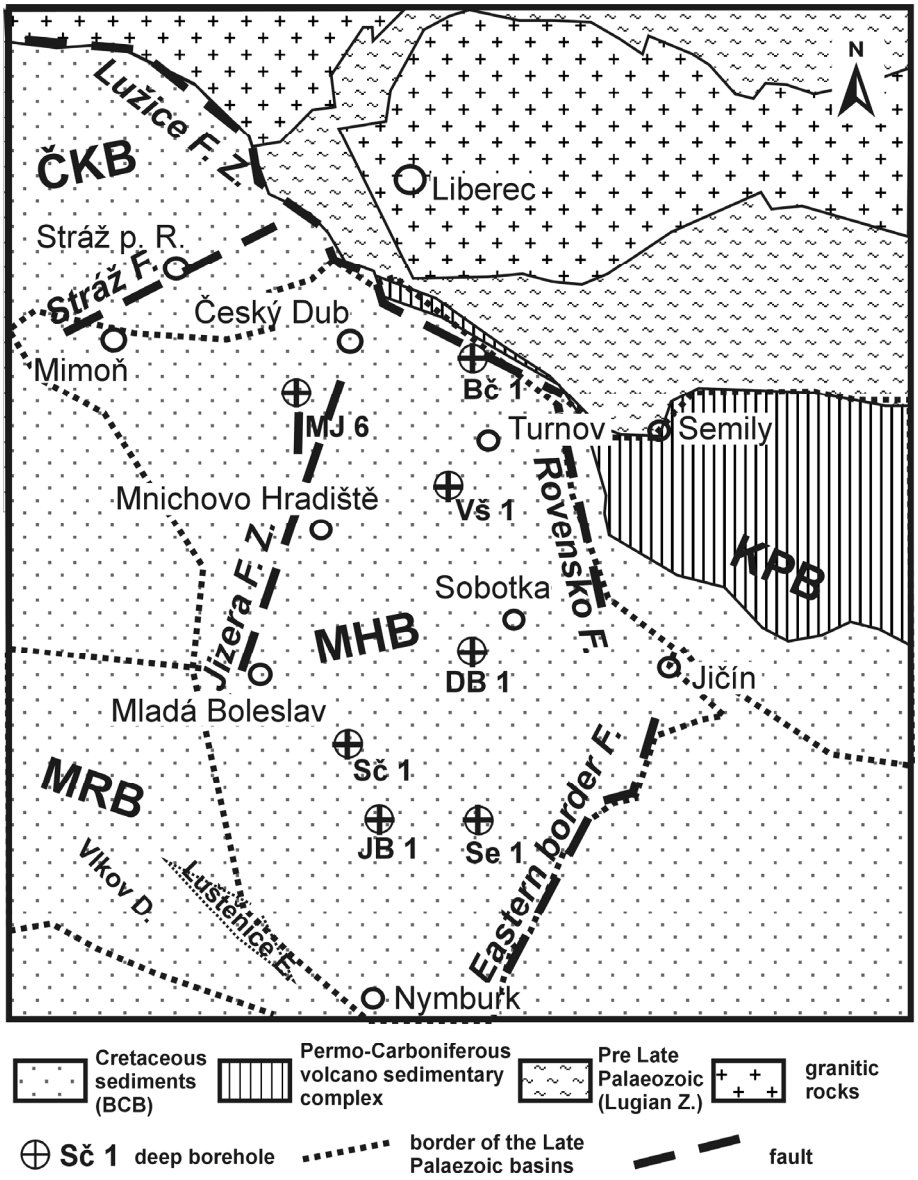

Fig. 1 Geological sketch of study area with the deep boreholes.

In total 3321 boreholes were drilled to crystalline basement in the Mnichovo Hradiště Basin (Fig. 2). Most of them are located in the northern part of the so-called Stráž block, where an intensive uranium mining exploration has been performed since the 1960s (database of the CGS-Geofond and Diamo-uranium mining company). In the middle and the southern part of the MHB only a limited number of deep boreholes were drilled and reached the crystalline basement (Fig.1), the most significant being Bezděčín Bč-1 (1017.9 m deep), Cetenov MJ-6 (1250 m deep) and Dolní Bousov DB-1 (1444 m deep). The borehole Všeň Vš-1 (1934.5 m), southwest of Turnov, terminated in Upper Carboniferous sediments.

2. GEOLOGICAL SETTING

The Mnichovo Hradiště Basin (MHB) is part of a major sedimentary area of Late Paleozoic age. Recently, it is covered by Cretaceous sediments, except for a narrow zone along the northeastern margin close to the Lužice Fault Zone, where Late Paleozoic sediments crop up on the surface. Holub in Malkovský et al. (1974) defined the WNW-striking depression (MH) north of Mnichovo Hradiště (Fig. 3a). The same author defined also the Mcely depression (M) in NW-SE direction southeast of Mladá Boleslav, which is separated from southern parallel Vlkov depression (V) by the Luštěnice paleohigh. From geophysical interpretation on the seismic profile 31 (Benda et al., 1985) the Sukorady

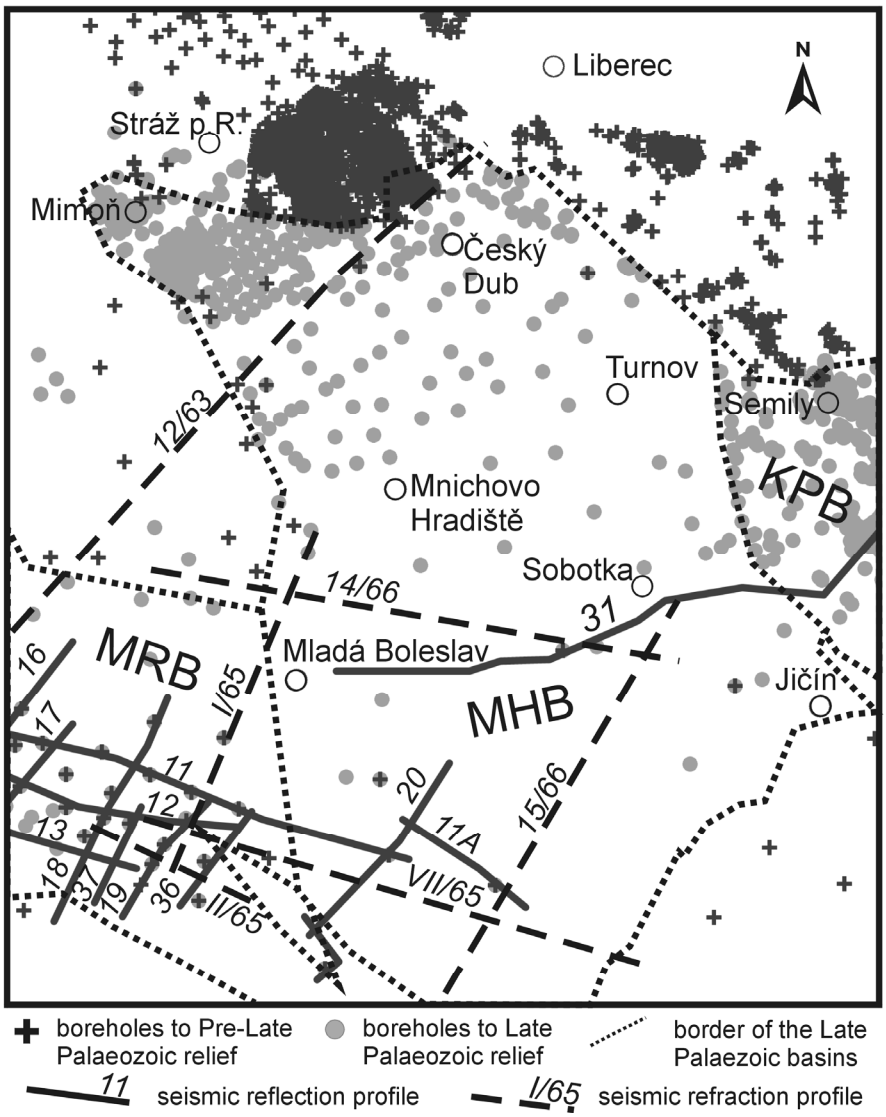

Fig. 2 Boreholes and seismic profile data used in the study area.

sub-basin was determined eastern from Mladá Boleslav. Later Pešek et al. (2001) defined two parallel NNE-SSW trending trenches (Fig. 3b) in the MHB filled by a Permo-Carboniferous volcano-sedimentary complex and their south part called the Sukorady sub-basin (S). Latest reinterpretation of seismic profiles in the southern part of the MHB (Skopec and Pešek, 2011) re-evaluates orientation of the Sukorady sub-basin and supposed its NW-SE elongation.

2.1. THE CRYSTALLINE COMPLEX IN THE BASEMENT

The basement of the Late Paleozoic volcano-sedimentary basins in the Bohemian Massif is known above all from the boreholes. In the MHB large number of boreholes is situated in its northern part, in the vicinity of Stráž pod Ralskem, Mimoň and Český Dub. To the south the bottom of the basin rises; there were only a few boreholes drilled to the basement here. The relief of the crystalline complex is known mostly from the seismic research.

The crystalline basement is composed of Early Paleozoic metamorphosed rocks of the Lugian Zone in the north and of Neoproterozoic and Early Paleozoic low metamorphosed and non-metamorphosed rocks of the Teplá-Barrandian Unit (TBU) in the south. Late Paleozoic and Cretaceous rocks cover the boundary between these both major geological areas and therefore it is difficult to determine its course. In a monograph of Bucha and Blížkovský Eds. (1994) maps of linear tectonic structures were published that had been correlated with gravity and magnetic indications (gravity gradient, zones of positive magnetic anomalies etc.). Gravity discontinuity revealed on the maps

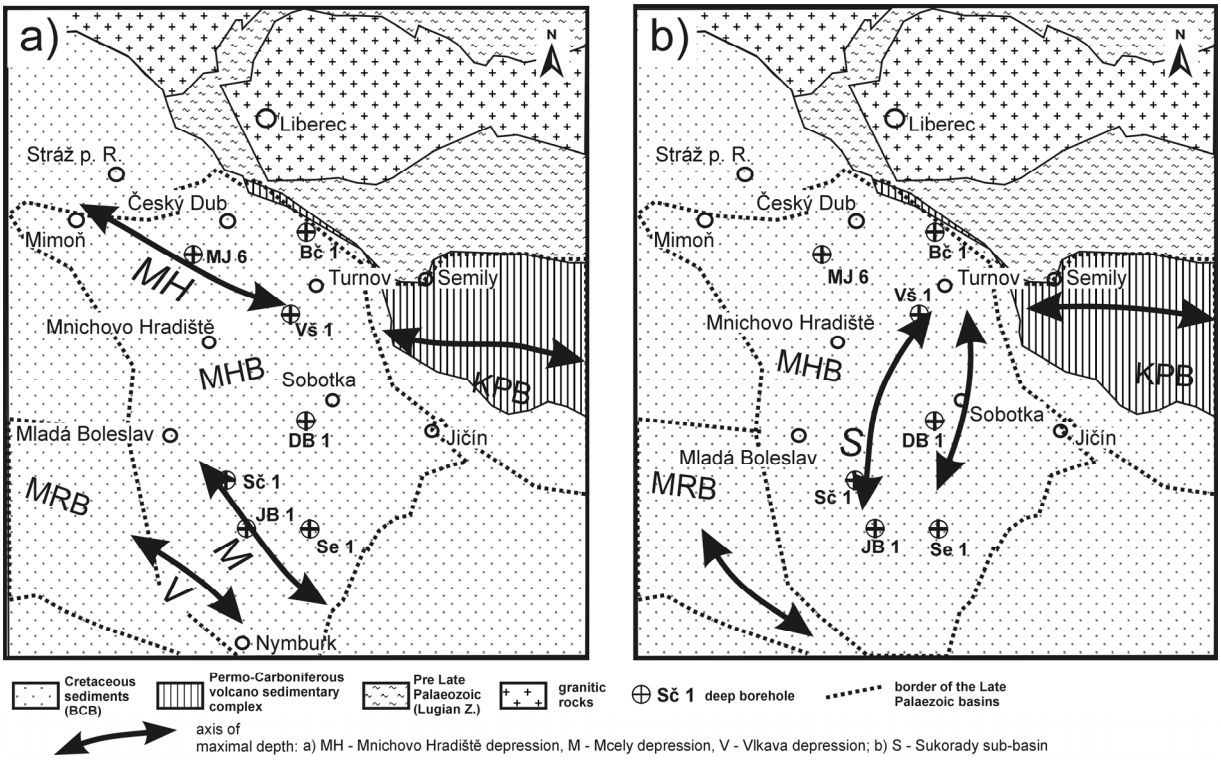

Fig. 3 Geological sketches of study area with the previous interpretation (axis of maximal depths): a) after Holub in Malkovský et al. (1974), b) after Tásler in Pešek et al. (2001).

corresponds with the deep boundary of geological units and runs south of Mimoň and Český Dub and continues to Turnov and Semily.

2.2. PERMO-CARBONIFEROUS VOLCANO-SEDIMENTARY COMPLEX

The Mnichovo Hradiště Basin (MHB) is one of the interior basins of the so-called Plzeň Trutnov Basin (Cháb et al., 2008) originated during Late Paleozoic age (Table 1) in the northern part of Bohemia. Sedimentation expanded from W to E in the newly forming individual basins to occur interconnection the Plzeň Trutnov Basin with the Intra-Sudetic Basin. The MHB adjoins with the Mšeno Roudnice Basin (MRB) and with the Krkonoše Piedmont Basin (KPB). The basal sedimentary unit of the MHB is the Kumburk Formation with a thickness of 87-229 m (Pešek et al., 2001). The consequent Syřenov and Semily formations reaching the maximal thickness on the SW of the MHB in Sukorady sub-basin (max. of the Syřenov F. is 268 m in the borehole Sč-1, Semily F. is 451 m in the borehole Se-1; see Fig. 1). The thickness of the Vrchlabí Formation is from 213 m to 440 m (boreholes Vš-1 a Sč-1). The Prosečné and Chotěvice formations form the top of the sedimentary sequence in the MHB. Their maximal thickness (about 300 m) has been recorded in the NE part of the MHB, close to KPB.

Volcanic materials form the bulk of the sedimentary filling above all in the northern part (up to 95 %). To the south their percentage in sediments decreases. First admixtures of volcanic material are known in the Kumburk Formation. During Stephanian B marked increase of volcanic activity occurred. Maximum amount of volcanic materials in the MHB is documented in the Vrchlabí and Prosečné formations in the boreholes MJ-6 and Bč-1, where multiple repeated effusions reached a thickness of about 500 m (Čadková, 1970; Műller et al., 1967). Subalkaline basalts to basaltic trachyandesite (Ulrych et al., 2006) and rhyolitic ignimbrite predominate. The stratigraphic record is probably divided by the volcanic activity to 4 phases (Holub and Tásler in Malkovský et al., 1974): 1) Semily Formation cycle, 2) Vrchlabí Formation cycle, 3) Prosečné Formation cycle and 4) Chotěvice Formation cycle (Table 1).

Tectonic character of the study area is marked by the occurrence of faults highlighting the boundaries of Cretaceous sediments with the Permo-Carboniferous volcano-sedimentary complex and the crystalline basement (Fig. 1). There are also faults disrupting the individual strata of Turonian and Cenomanian ages both on the surface and underneath. The Lužice Fault Zone is a major tectonic feature defining the boundary of the Bohemian Cretaceous Basin (BCB) on the northeast. The Rovensko fault is significant as the

Table 1 Stratigraphy of the Late Palaeozoic in the Mnichovo Hradiště Basin.

Era	System Period	Series Epoch		Stage Age	Age Ma	Formation
Paleozoic	Permian	Early		Autun	271	Chotěvice Prosečné Vrchlabí
	Carboniferous	Pennsylvanian	Upper	Stephan C	298	Semily
						hiatus
				Stephan B	305	Syřenov
			Middle	Westphal D	310	Kumburk

tectonic limitation of the Cretaceous sediments toward Permo-Carboniferous volcano-sedimentary complex crop out on the east in the KPB. The Jizera Fault Zone running in NNE-SSW (N-S) direction between Český Dub and Mladá Boleslav and the Eastern border fault of the Mnichovo Hradiště Basin between Jičín and Poděbrady are thought to be important tectonic elements of the kinematics of the BCB (Uličný et al., 2009). The Střehom Fault running in NE-SW direction was located near the town of Sobotka (Malkovský et al., 1974). The Stráž Fault (Rutšek, 1994; Mlčoch, 2003) limiting the uplifted crystalline basement from the north was located based on the geophysical investigations and boreholes.

3. GEOPHYSICAL INVESTIGATIONS

The geophysical research, particularly seismic measurements enabled the construction of Late Paleozoic relief beneath Cretaceous sediments and partly also the crystalline basement. From the refraction profiles that had intersected the Mnichovo Hradiště Basin profile I/63, II/63, VII/65, 14/66 and 15/66 (Bayer et al. 1965, 1966) the first contour map of the depth of the basin sedimentary fill was compiled (Hrách, 1970). The relief of the crystalline basement in the south of the MHB is known above all from seismic reflection data on the profiles in the MRB area and profile 31 (Chudomel et al., 1983), which runs in its deepest part. The reflection measurements from the 1980s (profiles 11, 20) reaching the MHB from the adjacent Mšeno Roudnice Basin proved the existence of a depocenter on the southwest (Chudomel et al., 1983). New reinterpretation of these profiles was published in Skopec and Pešek (2011).

The character of the crystalline basement is evident from the regional gravity and magnetic data (Šrámek et al., 1984; Sedlák et al., 2007; Šalanský et al., 1966). The gravity field is different in the south and north part and it indicates probably a boundary of major geological units in the basement. In the north part of the MHB there is a negative gravity area indicating „light" granitoids in the deeper part of the upper crust (Fig. 6a) and in the adjacent Česká Kamenice Basin (ČKB in Figure 1) high thickness of Cretaceous sediments (Sedlák et al., 2007). In the magnetic field the local negative anomalies can probably indicate the existence of volcanic rocks with inverse magnetization frequently occurring in the Upper Paleozoic (Fig. 6b). The similar situation is in the case of subalkaline basalts and basaltic trachyandesites along the Lužice Fault Zone cropping out on the surface in the northeast of the MHB

4. DATA PROCESSING AND RESULTS

The borehole databases (CGS-Geofond, DIAMO - uranium mining company) together with seismic data were used for 3D modelling of the crystalline basement and Permo-Carboniferous strata in the Mnichovo Hradiště Basin (Figs. 4 and 5). In total, 4956 boreholes were reprocessed (3321 for crystalline basement) and supplemented with seismic data and data from the recent surface outcrops. Detailed geological mapping was used to get information on surface geologic setting. The final 3D model was compiled from 567 960 points by the SURFER software in a grid 500 m x 500 m by the kriging method.

In the north of the study area the crystalline basement (Fig. 4) forms a structural high between Mimoň and Český Dub, the so-called Stráž block (SB). This is limited in the north by the Stráž Fault (NE-SW direction). In the south of the Stráž block a deep NW-SE to NNW-SSE trending depression is situated. It is the so-called Mnichovo Hradiště Basin (MHB). The steep slope (about 600-700 m in height) is obvious in the relief of the top of the crystalline basement near Český Dub. In the north the MHB is probably constrained tectonically by an E-W trending fault. In the NE part of the MHB in the Mnichovo Hradiště sub-basin (MHSb) is estimated depth of crystalline basement level about -700 to -1 700 m a.s.

The steep NNW-SSE striking slope constituted by the basement bounds the MHSb from the west, while its eastern margin dips at more moderate angles. The Lužice Fault Zone runs in NW-SE direction and is consequently transversal to the axis of the MHSb.

The crystalline ridge striking in NNW-SSE direction situated east of Mladá Boleslav, separates the NE part of the MHB from SW part. This ridge was identified on the seismic profile 31 together with the deeper SW part of the MHB called as the Sukorady sub-basin (S in Fig. 3b) and corresponds well with the gravity data. The Sukorady sub-basin (SSb in Figure 4) reaches in the north probably more than -2800 m a.s.l. This is sharp limited by the tectonic fault zone in the NNW-SSE direction from the E and by a fault in W-E direction from the N. From the SW the boundary between the Sukorady sub-basin and the Mšeno Roudnice Basin (MRB) forms the moderate slope of the Luštenice paleohigh (LH).

The undulation of the relief of Permo-Carboniferous strata (Fig. 5) in the middle part of the MHB is about 350 m. The maximal dip of the Late Paleozoic relief is between Turnov and Jičín on the Lužice Fault Zone and the Rovensko Fault in the NNW-SSE direction. This area is also marked by the maximal thickness of Cretaceous sediments. The ENE-striking trench near Mladá Boleslav dipping to the E was revealed in the 3D model.

5. DISCUSSION

5.1. RELIEF OF THE PRE-LATE PALEOZOIC BASEMENT OF THE NORTH-EASTERN PART OF THE MHB (MNICHOVO HRADIŠTĚ SUB-BASIN)

This part of the MHB is modelled as a deep sub-basin stretching in NW-SE to NNW-SSE direction occurring south of Český Dub. The model is completely different from that of Tásler (1998) published in Pešek et al. (2001) (see Fig. 3b) and is, on the other hand, in accordance with that one published in Malkovský et al. (1974). Presented 3D model (Fig. 4) assumes pre-Late Paleozoic basement at a level of over -1700 m a. s., which is supported by the deep borehole Všeň (Vš-1). It terminated at a level of –1667.62 m a. s. in the basal formation of the Lower Carboniferous sequence (Kumburk Formation) with an estimated thickness of at least 60 m.

5.2. RELIEF OF THE PRE-LATE PALEOZOIC BASEMENT OF THE SOUTH-WESTERN PART OF THE MHB (MCELY/ SUKORADY SUB-BASIN)

The 3D model presented in this article points to a fact that there is a deep depression in the southwestern part of the MHB elongated in NNW-SSE direction and extending towards the NW. It is separated from the NE part of the MHB by a NNW-SSE trending ridge of crystalline rocks. That deep depression corresponds partially to the originally defined Mcely depression and to the Sukorady sub-basin later described in seismic exploration (see Fig. 3). The assumed altitude of the early Paleozoic basement in the the SW part of the MHB lies at c. 2800 m below sea level, which is more than that published by previous authors (Malkovský et al., 1974; Benda et al., 1985), and is in accordance with the new re-interpretation of seismic profiles in this area (Skopec and Pešek, 2011). The profile 31 registered strong reflexion interfaces to occur inside Permo-Carboniferous strata, those being rather lithologic boundaries, since no volcanic material was found in the boreholes drilled in this part of the MHB. The eastern margin of the deep part of the depression is built by a steep slope that probably corresponds to a fault and correlates well with gravity data. The northern margin is also relatively steep and probably fault-bounded. The NW-SE trending Luštěnice palaeohigh bounds the whole depression in the southwest. The depth of the depression in the south is verified by two deep boreholes Sč-1 (basement level -1638.5 m a. s. l.) and Se-1 (-1185.1 m a. s. l.).

5.3. NNW-STRIKING CRYSTALLINE RIDGE

The ridge of crystalline rocks that separates the NE part of the MHB from the SW part has been recognized on the basis of geophysical data (Fig. 6). East of Mladá Boleslav interpretation of the seismic reflexion profile 31 has revealed this palaeohigh of Early Paleozoic basement, limited from the west by faults with a throw of basement level of more the 2800 m. The eastern slope of this ridge is milder and the maximal depth of the NE part of the MHB on the profile 31 has been interpreted east of the borehole DB-1 to be around 1250 m below sea level. The ridge in the basement of Permo-Carboniferous strata and its NNW-SSE direction is very well legible in gravity data. The steep gravity gradient running in a NNW-SSE line suggests a tectonic character of the western slope. The gravity minimum in the SW part of the MHB corresponds to higher thicknesses of the sedimentary fill, while the crystalline ridge is characterized by a gravity high. Only borehole drilling can tell whether the ridge originated before or during depositional processes during the Permo-Carboniferous.

5.4. TECTONICS OF THE PRE-LATE PALEOZOIC RELIEF

The major faults in the crystalline basement are simultaneously margin faults of both depressions of the MHB. The north margin of the Mnichovo Hradiště sub-basin near Český Dub is limited probably by E-W fault (evidence from borehole about depth of crystalline basement are sporadic). In this area a large number of volcanic and sub-volcanic rocks are documented in the boreholes, and for this reason the gravity and magnetic data cannot be used for clear

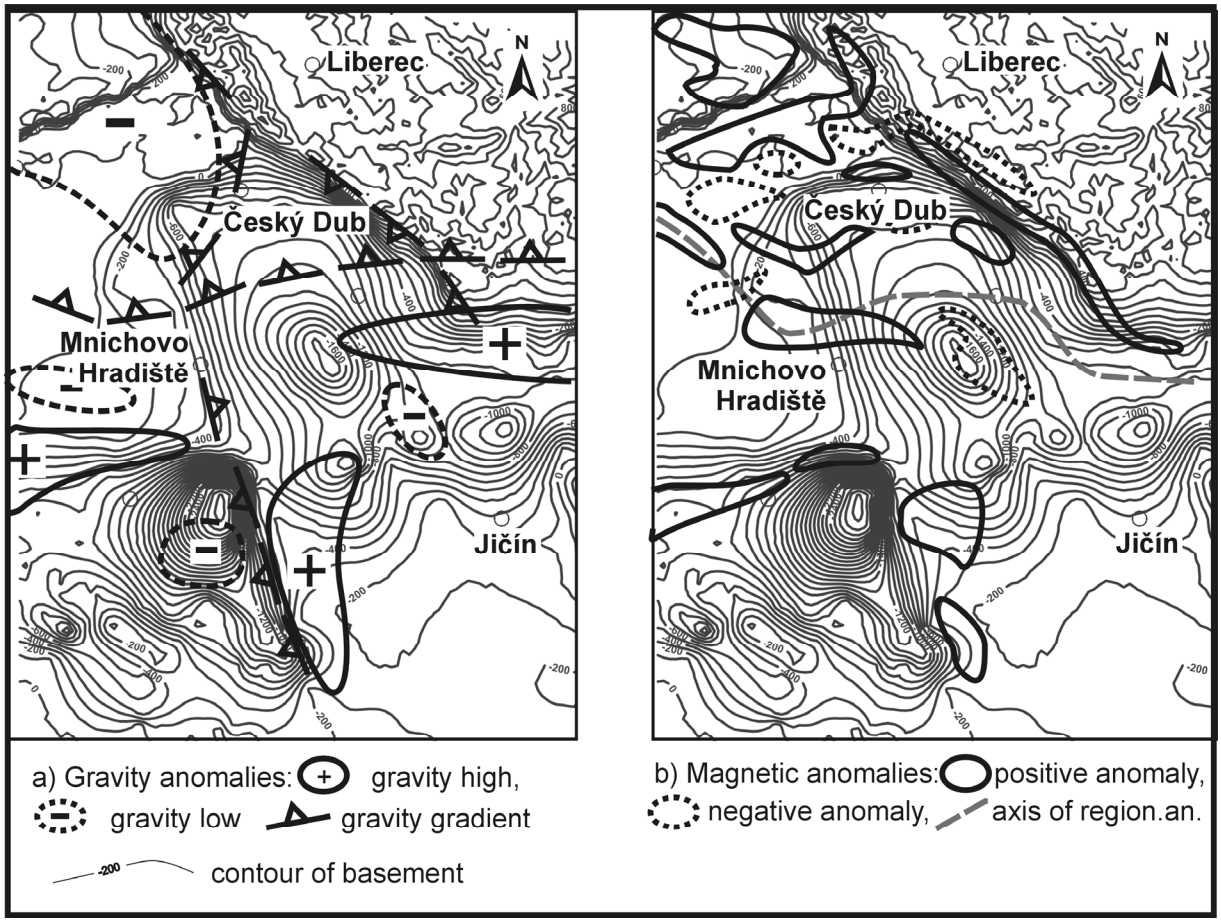

Fig. 6 Geophysical indications in the maps of the pre-Late Paleozoic basement contours in the Mnichovo Hradiště Basin area: a) gravity indications, b) magnetic indications.

interpretation. The E-striking fault limited also northern margin of the SW part of the MHB near Mladá Boleslav.

The major NW-striking faults belong to the Lužice Fault Zone limiting the MHB from northeast and the faults along the Luštěnice paleohigh limiting the MHB from southwest have the same direction. The NNW-striking faults are indicated only by the geophysics (gravity and magnetic fields). Significant among them are faults along the crystalline ridge separating the NE part of the MHB from its SW part.

5.5. PRE-CRETACEOUS RELIEF

The crystalline complex and the Permo-Carboniferous strata exhibiting both a flat relief constitute the basement of the Cretaceous (Fig. 5). The presented 3D model is in accordance with the map of the Pre-Cretaceous relief published in Malkovský et al. (1974). A shallow depression has been located only on the east, between Turnov and Jičín. A N-striking margin fault limits the MHB on the east. A shallow WSW-ENE striking trench runs near Mladá Boleslav. The Lužice Fault Zone is more distinctive tectonic zone, which forms the recent relief and separates the Bohemian Cretaceous Basin from the crystalline complex with Permo-Carboniferous strata dragged out along it.

5.6. SOURCES OF ANOMALIES IN THE GRAVITY AND MAGNETIC FIELD

The Bouguer gravity map of the study area indicates all sources of contrast in rock density (deep sources as regional anomalies, shallow as the local anomalies). While the gravity field in the southern part is relatively monotonous, in the north the regional geological sources generate voluminous gravity anomalies.

In the northeastern part of the MHB (between Mnichovo Hradiště and Turnov) the NE-striking axis of the gravity gradient indicates probably the deep boundary between Teplá-Barrandian Unit and Lugian zone. To the north the Stráž pod Ralskem partial gravity low is described (Sedlák et al., 2007). The authors suppose a granite body of the Rumburk type (bulk density 2.64 g.cm^{-3}) reaching the depth about 10 km as the source. An alternative hypothesis is the existence of a large complex of volcanic and sub-volcanic rocks (probably a Late Variscan caldera)

such as subalkaline basalts to basaltic trachyandesite (2.74-2.63 g.cm^{-3}) and rhyolitic ignimbrite (2.60-2.57 g.cm^{-3}), and granites (2.63-2.64 g.cm^{-3}). These rocks are described in numerous boreholes in the Stráž block area and northern part of the MHB. In Permo-Carboniferous strata of the NE part of MHB volcanic material predominates over sediments (after Malkovský at al., 1974 volcanics form 66 – 95 % of the sequence). Between Český Dub and Turnov the outcrops of rhyolitic ignimbrites were uplifted during tectonic movements on the Lužice Fault Zone. In the south (probably in the TBU) the isolated geological sources of the gravity anomalies are indicated beneath Cretaceous sediments. The gravity low west of Mnichovo Hradiště (Fig. 6) corresponds with a granitoid massif (Rutšek, 1995). The gravity high southeaster of Turnov can be caused by an accumulation of basalts of Late Paleozoic age (after Malkovský et al., 1974, in the borehole Vš-1, 30 % of the well log are volcanics, predominantly basalts). In the southern part of the MHB the gravity data (negative gravity anomaly) correlate well with the extension and thickness of the sedimentary filling (Cretaceous and Permo-Carboniferous). The gravity low between Turnov and Jičín is caused by higher thickness of the Cretaceous sediments.

In the SW part of the MHB volcanic rocks in the boreholes are absent. For this reason the gravity data reflect very well the thickness of sediments and the depth of the crystalline basement. The gravity low near borehole Sč-1 corresponds with the deepest part of the depression. The gravity high south of the borehole DB-1 elongated in NNW-SSE direction indicates a ridge of crystalline basement separating Mnichovo Hradiště and Sukorady sub-basins.

The magnetic map reflects the cumulative sources of the magnetic rocks in the crystalline basement (regional positive anomalies) as well as Late Paleozoic volcanics (local positive and negative anomalies). The various manifestations of the magnetic field are in the north part of the study area (Stráž block, northern part of the MHB). The positive and negative local intensive anomalies (Fig. 6) are caused by individual bodies of Late Paleozoic volcanics with normal and reverse magnetization (basalt/andesite rocks). These anomalies continue to the southeast along the Lužice Fault Zone. Less intensive anomalies are caused by deeper regional sources in the crystalline basement. They form the narrow magnetic zone (Fig. 6) along probable boundary between the TBU and Lugian Zone (S of Mimoň, Český Dub and continuing to the N of Turnov). The regional magnetic positive anomalies with sources in the crystalline basement are situated near Mladá Boleslav and correspond also with the crystalline ridge separating NE part of the MHB from SW part. It is impossible to distinguish the magnetic sources in Proterozoic and Late Paleozoic rocks without borehole verification. It may represent both: volcano-sedimentary complexes in the TBU (spillite) and/or alkaline intrusive complexes.

6. CONCLUSION

The presented 3D digital model of the pre-Late Paleozoic relief based on boreholes and geophysical and geological data enables a new interpretation of the Mnichovo Hradiště Basin area evolution. The previously published map (in Malkovský et al., 1974) demonstrates the existence of one sedimentary depression with two depth maxima: near Turnov and Mladá Boleslav. The new 3D model of the Mnichovo Hradiště Basin (MHB) shows two isolated sub-basins: NE part as Mnichovo Hradiště sub-basin and SW as Mcely/Sukorady sub-basin. Between these a NNW-striking crystalline ridge has been identified by geophysical investigations. The depths of the Mnichovo Hradiště sub-basin is probably more then 1700 m and Mcely/Sukorady sub-basin more than 2800 m.

The 3D model of the Permo-Carboniferous strata including the exposed crystalline rocks forms a relative flat relief beneath Cretaceous sediments. The character of the Permo-Carboniferous volcano-sedimentary complex differs in the north from that in the south. This is evident in the geophysical data. In the north of the MHB (between Český Dub, Mnichovo Hradiště and Turnov) volcanic rocks dominate (they are up to 95 % of total volume) and cause numerous magnetic and gravity anomalies. The source of the Variscan intermediate and alkaline volcanism can be located in the Stráž block area, where a distinctive gravity low has been detected. The SW part of the MHB is marked by a monotonous magnetic field and a gravity low, which probably reflects an exceptional the thickness of the sediments.

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REFERENCES

Bayer, V., Hrách, S. and Malý, V.: 1965, Seismický průzkum České křídy v r. 1964, závěrečná zpráva. Seismic research in the Bohemian Cretaceous Basin in the year 1964, final report. MS Geofond Praha, (in Czech).

Bayer, V., Hrách, S., Konečná, H., Malý, V. and Škárová, M.: 1966, Seismický průzkum České křídy v oblastech Roudnice n.L. – Litoměřice a Benátky n.J. – Nový Bydžov. Seismic research in the Bohemian Cretaceous

Basin in the Roudnice n.L. – Litoměřice a Benátky n.J. – Nový Bydžov areas. MS Geofond Praha, (in Czech).

Benda, V., Filková, V., Kadlečík, J., Škárová, M. and Vašinová, J.: 1985, Souborné hodnocení geofyzikálních měření v oblasti mšenské pánve z let 1979-1982, (The summary interpretation of the geophysical measurements in the Mšeno Basin from 1979 to 1982) MS Geofyzika Brno, (in Czech).

Bucha, V. and Blížkovský, M. Eds.: 1994, Crustal structure of the Bohemian Massif and West Carpathians. Academia Praha.

Čadková, Z.: 1970, Závěrečná zpráva Bezděčín Bč-1, 5120201066, surovina: černé uhlí. (Final report about Bezděčín borehole Bč 1, hard coal. Unpublished report Nepubl. Zpráva ÚÚG – Geofond, Praha, (in Czech).

Dudek, A. and Pešek, J.:1989, Geological strukture of the basement of Permo-Carboniferous limnic basins on the Bohemian Massif. Folia Mus. Rer. natur. Bohem. occident., Geol., 29, 32. Plzeň

Hibsch, J. E.: 1912, Das Auftreten gespannten Wassers von höherer Temperatur in den Schichten der oberen Kreideformation Nordböhmens. Jb. Geol. Reichsant. (Wien), 62, 311–331.

Hrách, S.:1970, Česká křída. Reinterpretace seismických měření /Reinterpretation of the sesimic measurements), MS Přír. Fak. UK Praha, (in Czech).

Chaloupský, J.: 1973, The basement of the Cretaceous and the Permo–Carboniferous of northern Bohemia. Geol Rundsch 62: 581–594

Chudomel J., Jakeš O., Jihlavec F. a kol.: 1983, Zpráva o reflexně seismických a tíhových měřeních v pánvích roudnické, mšenské, českokamenické, mnichovo-hradišťské a podkrkonošské v letech 1981–82. (Report about the seismic reflection and gravity measurements in the Roudnice, Mšeno, Česká Kamenice, Mnichovo Hradiště and Krkonoše Piedmont basins from 1981 to 1982), MS Geofyzika Brno, (in Czech).

Malkovský, M., Benešová, Z., Čadek, J., Holub, V., Chaloupský, J., Jetel, J., Müller, V., Mašín, J. and Tásler, R.: 1974, Geologie české křídové pánve a jejího podloží (Geology of the Bohemian Cretaceous Basin and its basement),. ÚÚG Praha, (in Czech).

Mlčoch, B., 2003. Character of the contact between the Saxothuringian and Teplá-Barrandian Unit. Geolines 16, A-75-1.

Műller, V., Čejchanová, B. and Láznička, M.: 1967, Strukturní vrt MJ-6 v Cetenově u Českého Dubu (Borehole MJ-6 in Cetenov near Český Dub) Unpublished report. Nepubl. Zpráva ÚÚG – Geofond, Praha, P 19759, (in Czech).

Pešek, J.: 1994, Carboniferous of Central and Western Bohemia. 64 pp., 8 pl., 24 ap. Czech Geological Survey. Prague.

Pešek, J., Holub, V., Jaroš, J., Malý, L., Martínek, K., Prouza, V., Spudil, J. and Tásler, R.: 2001, Geologie a ložiska svrchnopaleozoických limnických pánví české republiky (Geology and deposits of the Early Paleozoic limnic basins in the Czech republic), Český geologický ústav (Czech Geological Survey. Praha, (in Czech).

Petrascheck, W.: 1910, Über den Untergrund der Kreide und über präcretacische Schichtenverschiebungen in Nordböhmen. Jb. K.-kön. Geol. Reichsanst., Wien, 60, 179–214.

Pouba, Z. et al.: 1959, Geologie podloží křídových usazenin v Čechách a na Moravě (Geology of the Cretaceous sediments in the Bohemia and Moravia. MS Geofond Praha, (in Czech).

Rutšek, J.: 1995, Závěrečné zpracování prací uranového průzkumu v české křídové pánvi za léta 1959-1990, část I. Všeobecná část, závěry a doporučení.(Summary processing of the uranium exploration in the Bohemian Cretaceous Basin from 1959 to 1990. Part I. General part, conclusion and recommendation. Unpublished report CGS-Geofond, MS ČGS-Geofond,133 pp., (in Czech).

Sedlák J., Gnojek I., Zabadal S, Farbisz J., Cwojdzinski S. and Scheibe R: 2007, Geological interpretation of the gravity low in the central part of the Lugian Unit (Czech Republic, Germany and Poland). Journ. of Geosc. 52, 181–197.

Skopec, J. and Pešek, J.: 2010, Reinterpretation of seismic profiles in the southern part of the Mnichovo Hradiště Basin and south-eastern tip of the Mšeno-Roudnice Basin. Folie, 45, No, 1-2, 3–61.

Suk, M., Ďurica, D. et al.: 1991, Hluboké vrty v Čechách a na Moravě a jejich geologické výsledky (Deep boreholes in Bohemia and Moravia and their geological applications),. Nakl.Gabriel Praha, (in Czech, with English Summary).

sine 1994 : Regional Geological Subdivision of the Bohemian Massif on the Territory of the Czech Republic. Report of the Working Group for Regional Geological Classification of the Bohemian Massif at the former Czechoslovak Stratigraphic Commission. Journal of the Czech Geological Society, 39/1.

Šalanský, K., Čejchanová, B., Malkovský, M. and Řeháčková, M.: 1966, Zpráva o leteckém geofyzikálním měření v roce 1963-64, VI. Severovýchodní Čechy. (Report about airborne geophysical measurements in the years 1963-64, VI. Northeastern Bohemia. Unpublished report MS Geofyzika Praha, (in Czech).

Šalanský, K. and Gnojek, I.: 2002, Geomagnetické anomálie v České republice. Geomagnetics anomalies in the Czech Republic. Czech Geological Survey Special papers Práce Českého geologického Ústavu. Praha, .(in Czech).

Šrámek, J., Šustr, J. and Vašinová, J.:1984, Gravimetrické mapování ČR v v jz. části krkonošsko-jizerského krystalinika v měřítku 1 : 25 000. (Gravity research in the suthwestern part of the Krkonoše-Jizera crystalline complex in the scale 1 : 25 000) MS Geofyzika Brno, (in Czech).

Uličný, D., Špičáková, L., Grygar, R., Svobodová, M., Čech, S. and Laurin, J.: 2009, Palaeodrainage systems at the basal unconformity of the Bohemian Cretaceous Basin: roles of inherited fault systems and basement lithology during the onset of basin filling. Bull. Geosci. 84, 4, 577–610.

Ulrych, J., Pešek, J., Štěpánková-Svobodová, J., Bosák, P., Lloyd, F.E., von Seckendorff, V., Lang, M. and Novák, J. K.: 2006, Permo- Carboniferous volcanism in late Variscan continental basins of the Bohemian Massif (Czech Republic): geochemical characteristic. – Chemie der Erde- Geochemistry, 66, Is. 1, 37– 56.

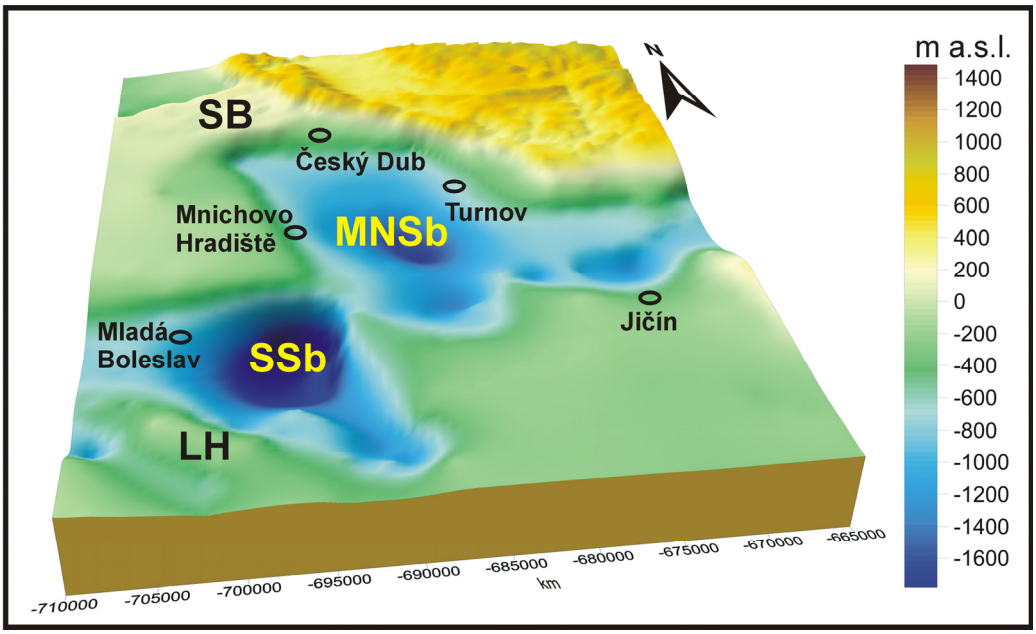

Fig. 4 3D model of Pre-Late Paleozoic relief of the Mnichovo Hradiště Basin: SB – Stráž block, MHSb – Mnichovo Hradiště sub-basin, SSb – Sukorady sub-basin, LH – Luštěnice paleohigh.

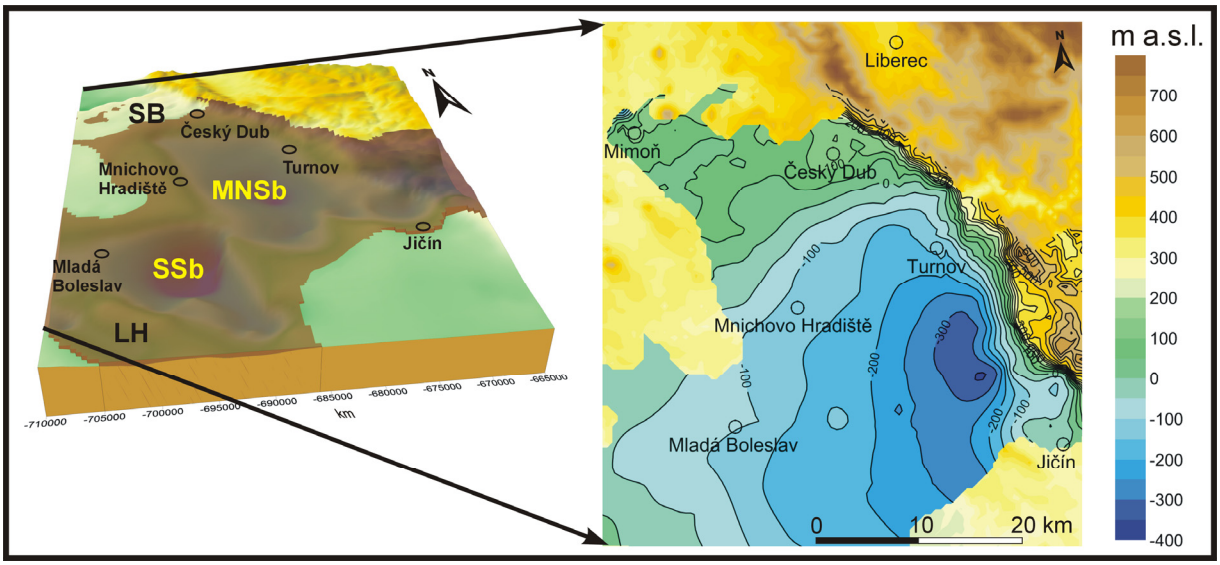

Fig. 5 3D model of the Late Paleozoic relief of the Mnichovo Hradiště Basin.