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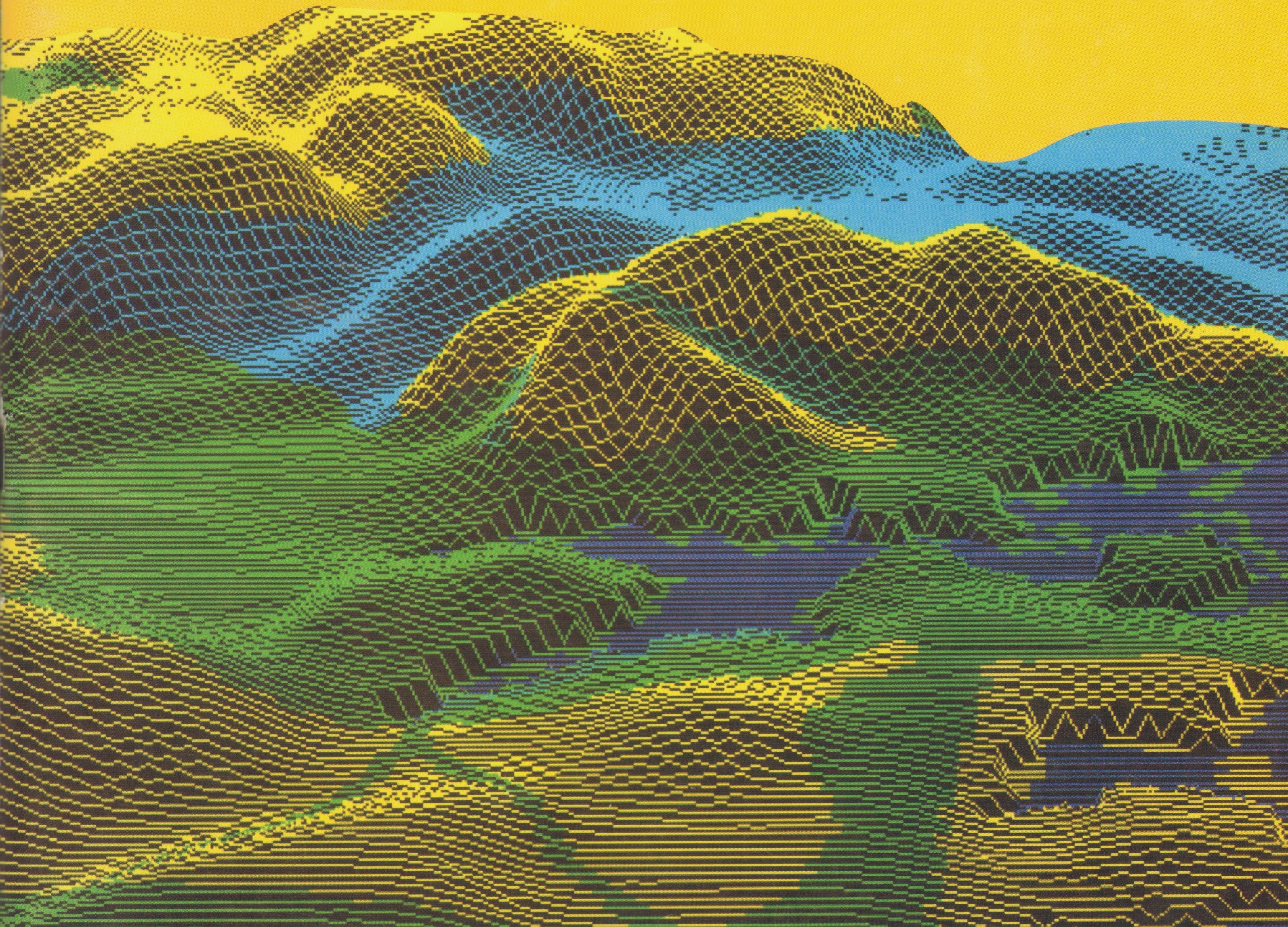

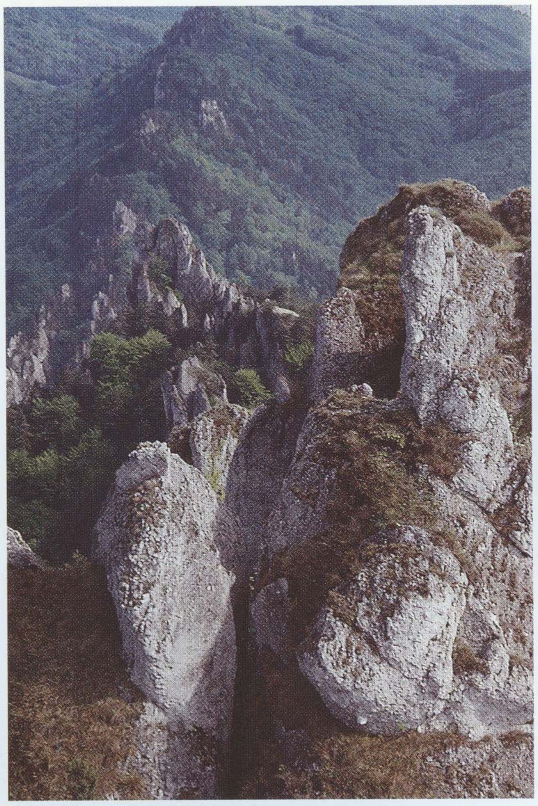

Klippen passive morphostructure of the Súľovské vrchy Mts.

Photo: J. Lacika

Illustration to J. Lacika's paper

Flooded subsidence hollows in the Karvina-Darkov mining space, which are over 100 ha in area and 15-31 m in depth, are utilizable for the sedimentation of coal sludge.

Photo Jan Havrlant, 1998.

Illustration to J. Havrlant's paper

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THE PRINCIPLES OF MORPHOSTRUCTURAL DIVISION OF SLOVAKIA

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Abstract

The contribution is in fact a proposal of morphostructural division of the territory of the Slovak Republic. It is based in Mazúr s morphostructural regionalisation which was used by the Slovak geomorphologists for more than three decades. It has preserved Mazúr s basic classification at the two highest levels discerning the Carpathians and the Pannonian basin, or the West Carpathians, East Carpathians, West Pannonian and the East Pannonian basins in the territory of Slovakia. However, the lower levels of morphostructural regionalisation presented here are different.

The proposal applies a combination of morphostructural units of the spheric and zonal type in the division of the West Carpathians. The compact part of the West Carpathian dome is broken to three spheric units of the third order while the tectonically deformed southern part of the dome is at the same level formed by two units of zonal nature. The East Carpathians are typical for belt-like arrangement of their partial morphostructures of the third order. In case of the Pannonian basin the 3rd order morphostructures overalap to large extend with the classification of lowlands to hilly lands and plains (except the Záhorská nížina lowland).

The proposal of new morphostructural regionalisation of the territory of Slovakia applies individual regionalisation up to the 5th level. The units of the 5th order overlapping to great extent with the geomorphological units are further on typologically classified.

Shrnutí

Principy morfostrukturního členění Slovenska

Článek prezentuje návrh nového morfostrukturního členění území Slovenské republiky. Vychází z Mazúrovy morfostrukturní rajonizace, kterou slovenští geomorfologové užívají už více než třicet let. Přebírá z ní základní členění na dvou nejvyšších úrovních rozlišující na území Slovenska Karpaty a Panonskou pánev, resp. Západní Karpaty, Východní Karpaty, Západopanonskou pánev a Východopanonskou pánev. Na nižších úrovních je však nová morfostrukturní rajonizace od Mazúrovy odlišná.

V předloženém návrhu se u členění Západních Karpat uplatnila kombinace morfostrukturních jednotek sférického a zonálního typu. Kompaktní část západokarpatské klenby se člení na tři sférické jednotky třetího řádu, zatímco tektonicky deformovaná jižní část klenby je na téže úrovni tvořená dvěmi jednotkami zonální povahy. Východní Karpaty mají typické pásmovité uspořádání svých dílčích morfostruktur třetího řádu. V případě Panonské pánve se morfostruktury třetího řádu do značné míry překrývají s členěním nížin na pahorkatiny a roviny (kromě Záhorské nížiny).

Návrh nové morfostrukturní rajonizace území Slovenska do páté úrovně uplatňuje individuální přístup. Jednotky pátého řádu, které se do značné míry překrývají s geomorfologickými celky, se dále člení typologicky.

Key words: morphostructure, morphotectonics, Slovakia, Carpathians, Pannonian basin

1. Introduction

Under the pressure of emerging new knowledge and facts in the field of geomorphology and geology, more than three decades used Mazúr's morphostructural regionalisation of Slovakia calls for critical evaluation or creation of a new theory.

The aim of this contribution is to explain the basic principles of here proposed new morphostructural division of Slovakia which, once submitted to a wide discussion, may by applied in similar regionalising efforts in the Czech Republic, Poland, Hungary, Austria and Ukraine, the countries where many of the geographical units characterised here reach.

2. State of the art

The Slovak geomorphologists have been using the morphostructural regionalisation of Slovakia worked out by Emil Mazúr for a comparably long time. After two slight modifications published by the author in 1979 and 1980 nothing else was done in this particular field and nobody offered a new morphostructural division or innovation of the one worked out by Mazúr.

Mazúr in his last modification as published in the Atlas of the SSR (1980) presented the following morphostructural units of the third and fourth orders:

1. Morphostructures of the Inner West Carpathians
1.1 Semi-massive morphostructure of the Slovenské Rudohorie Mts.
1.2 Folded-block Fatra-Tatra morphostructure
1.3 volcanic block structure of the Slovenské Stredohorie Mts.
1.4 Lučenec-Košice depression
1.5 Matra-Slaná block morphostructure
2. Morphostructures of the Outer West Carpathians
2.1 morphostructural depression of the peri-Pieniny (Klippen) lineament
2.2 fault-folded structures of the flysh Carpathians
3. Morphostructures of transitonal zone belt (transversal depression of Nízke Beskydy Mts.)
3.1 partial positive morphostructures
3.2 transitional morphostructures: uplands
3.3 transversal depression proper-hilly land
3.4 structure of the peri-Pieniny lineament
4. Morphostructure of Outer East Carpathians
4.1 block-folded positive morphostructure of the flysh zone
5. Morphostructure of Inner East Carpathians
5.1 block Vihorlat-Gutín structure
6. Morphostructure of the Pannonian basin
6.1 slightly elevated morphostructures within the Pannonian depression
6.2 recent subsiding morphostructures with aggradation

3. The principles of new morphostructural division of Slovakia

Presented draft of morphostructural division of Slovakia does not aspire to be an entirely new product. Many of its principal components must lean on the existing and still used Mazúr's morphostructural regionalisation which in its time was a very progressive one (one of the reasons why it was used for more than three decades).

The proposed division of morphostructures of Slovakia is a multi-leveled one. The higher levels make use of the principles of individual regionalisation, the lower levels are based in typification of morphostructures.

3.1 Application of the morphostructural regionalisation

Morphostructural regionalisation is applied on higher levels of morphostructural division of the Slovak Republic. Its first hierarchical level adopted Mazúr s division of the Slovak territory to the Carpathians and the Pannonian basin, the same on the second level where it took over the division of the Carpathians to the West and East Carpathians. At the lower levels several different principles of regionalisation were applied.

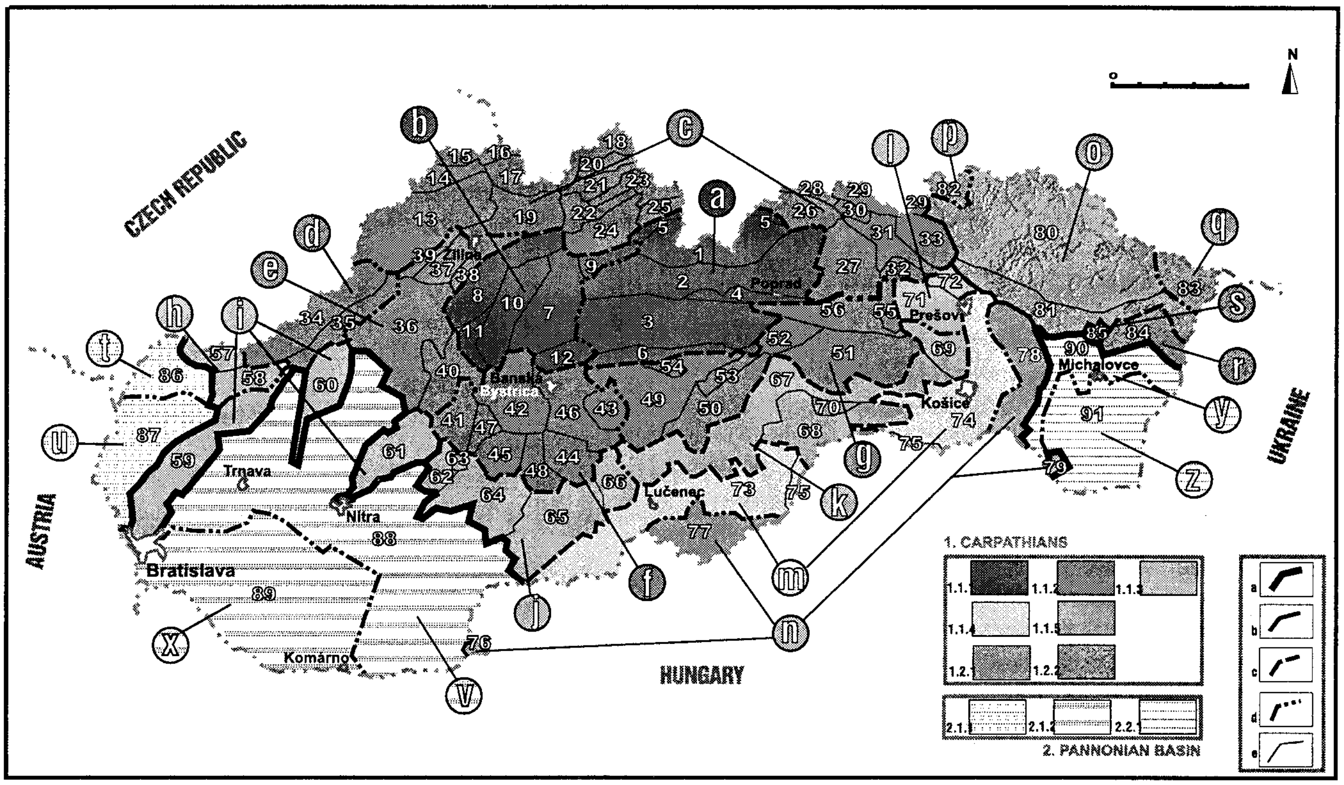
The proposed regionalisation differs from the one of Mazúr in two basic aspects - composition of units and handling the morphostructural units of passive nature. Mazúr divided the West Carpathians to zones and blocks, in spite of accepting the fact that it was a megamorphostructure of a dome type. The units of the West Carpathians in the presented regionalisation are arranged in a concentric (spheric) way which is how the dome type morphostructure should be differentiated. Certain zoning is evident only on tectonically severely destroyed southern wing of the West-Carpathian dome and in the East Carpathians. Zoning of the klippen belt is the property of this passive component of morphostructure which was not taken into account while classifying the individual morphostructural units.

Passsive structures (folding, flysch, klippen and volcanic, etc.) appear in Mazúr's division in a too exposed form, which does not respond to their contemporary role in relief-forming process of the Slovak territory. Its morphostructures are now developing only in terms of active (fault) structure which contributes to gradual and irreversible destruction of passive structure. The role of passive structure in contemporary morphogenesis of the Slovak territory lies exclusively in control of selective erosion and denudation. This is why the quality of passive structure as a criterion of classifications at higher levels of regionalisation is rather poor. It was emphasized, or rather kept only on its lower (typological) levels.

Nomenclature of the established individual units in difference from Mazúr's division strictly limits to the use of regional nomenclature, proper to the individual regionalisation (application of the principle of inadmissibility of mixing the elements of individual and typological regionalisation at the same level). Individual morphostructural units in used regionalisation of the Slovak territory are classified to the level of units and rearely subunits units and bear their names (for instance, morphostructure of the Malé Karpaty Mts. morphostructure of the Žiarska kotlina basin, etc.) They are morphostructures of the 5th order.

3.2 Application of typological morphostructural regionalisation

Typology of morphostructures is used at lower levels of the proposed division. This way of regionalisation is the best for interpretation of the properties of morphostructural units at the lowest levels of hierarchy. Presented typology is a four-level one. At the highest level the mobility of the given morphostructure is the main criterion of regionalisation. Two basic types are discerned: active (fault) and passive (rock properties) morphostructures.



Map 1 Morphostructural division of the Slovak Republic

1. Carpathians

1.1 West Carpathians

1.1.1 Central morphostructures of the West-Capathians dome

a - Tatra central morphostructure [1-6]

b - Fatra central morphostucture [7-12]

1.1.2 Transitive morphostructures of the West-Carpathian dome

c - Beskydy transitive morphostructure [13-33]

d - Moravia-Slovakian transitive morphostructure [34-35]

e - Strážov transitive morphostructure [36-40]

f - Central Slovakian transitive morphostructure [41-48]

g - Rudohorie transitive morphostructure [49-56]

1.1.3 Marginal morphostructures of the West-Carpathians dome

h - Moravia-Slovakian marginal morphostructure [57-58]

i - West Slovakian marginal morphostructure [59-61]

j - Central Slovakian marginal morphostructure [62-66]

k - Rudohorie marginal morphostructure [67-70]

l - Šariš marginal morphostructure [71-72]

1.1.4 Southern depressional morphostructures

m - Lučenec-Košice morphostructural depression [73-75]

1.1.5 Southern elevational morphostructures

n - Matra-Slaná morphostructural elevation [76-79]

1.2 East Carpathians

1.2.1 Outher zone morphostructures of the East Carpathians

o - Nízke Beskydy transverzal depressional morphostructure [80-81]

p - Busov morphostructural elevation [82]

q - Poloniny morphostructural elevation [83]

1.2.2 Inner zone morphostructures of the East Carpathians

r - Vihorlat morphostructure [84]

s - Humenné morphostructure [85]

2. The Panonnian basin

2.1 West Pannonian basin

2.1.1 Záhorie morphostructures of the Pannonian basin

t - Chvojnice morphostructure [86]

u - Bor morphostructure [87]

2.1.2 Danube morphostructures of the Pannonian basin

v - Outher Danube morphostructure [88]

x - Inner Danube morphostructure [89]

2.2 East Pannonian basin

2.2.1 East Slovakian morphostructures of the Pannonina basin

y - Outher East Slovakian morphostructure [90]

z - Inner East Slovakian morphostructure [91]

Borders of morphostructures

a. Broders of morphostructures of the 1st order

b. Borders of morphostructures of the 2nd order

c. Borders of morphostructures of the 3rd order

d. Borders of morphostructures of the 4th order

e. Borders of morphostructures of the 5th order

Note: The numbers in brackets belong to morphostructures of the 5th order and correspond to the numbers in square brackets in the text.

Active morphostructures are further broken to three levels. The morphostructures at the second highest level of the typology are classified to the lowland, basin and mountain types. To the basin morphostructure also the "podolie" (large river valleys), were aligned, as they too are individualised by faults. The third level of typology of morphostructures takes into account their situational properties (vertical and horizontal). Mountaineous morphostructures are classified by their horizontal situation to central, transitory and marginal types. The basin morphostructures were classified by their altitude above sea level to: low, moderate and high types. Typology of lowland morphostructures at the given level works with morphographic properties and distinguishes the plain and hilly types.

The criteria of the lowest regionalisation level try to characterise the inner morphostructural building of certain individual morphostructure of the 5th order in a best possible way. They express the mobility trend of their partial units, which are usually the fault-limited blocks or groups of blocks. In case of lowland morphostructure they express the absolute tendency to tectonic movement (absolute subsiding) in the Quaternary period. In case of basin and mountain morphostructures it is better to talk about the relative tendency of tectonic movements because almost all of them show the tendency of absolute uplifting in the Quaternary. The Slovak basins besides isolated exceptions show a relative subsiding, i.e. lower uplifting than the neighbouring mountain morphostructures.If the nomenclatures of basin and mountain morphostructures contains low, medium or high blocks, the said property relates only to morphostructure at the level of a whole (in some cases sub-unit). If, for instance, it concerns high block, rather than an elevated sea altitude, its highest position within the whole is meant i.e. higher than the neighbouring partial blocks. High blocks of the Malé Karpaty Mts. can be absolutely lower than the moderately high blocks of the Revúcka vrchovina Mts. They occupy the highest position only within the Malé Karpaty Mts.

Passive types of morphostructures are classified in two ranks. The highest rank discerns: morphostructures with weak application of passive structure and morphostructures with strong application of passive structure. The second type has six sub-types of passive morphostructures relating to the corresponding types of passive structures (dome-like, fault-like, volcanic, nappe-like klippen-like and erosion-tectonic ones)

4. Expression of morphostructural division of the Slovak territory in a map

For the sake of better comprehensibility the morphostructural division of the Slovak territory was divided into two maps. One of them can be characterised as a map of morphostructures defined by individual regionalisation. The other one is a typological morphostructural map which is also a map of the topical mobility tendencies of single blocks or a map of application of passive structures in relief of Slovakia. Both maps express only quality and not quantity of morphostructural relief dynamism (see Maps 1, 2a, 2b).

5. Basic characteristics of morphostructures of Slovakia

1. The Carpathians

The Carpathians on the territory of the Slovak Republic constitute the western part of the massive Carpathian arch. Its greater part is in the West Carpathians except for the easternmost part which is in the East Carpathians.

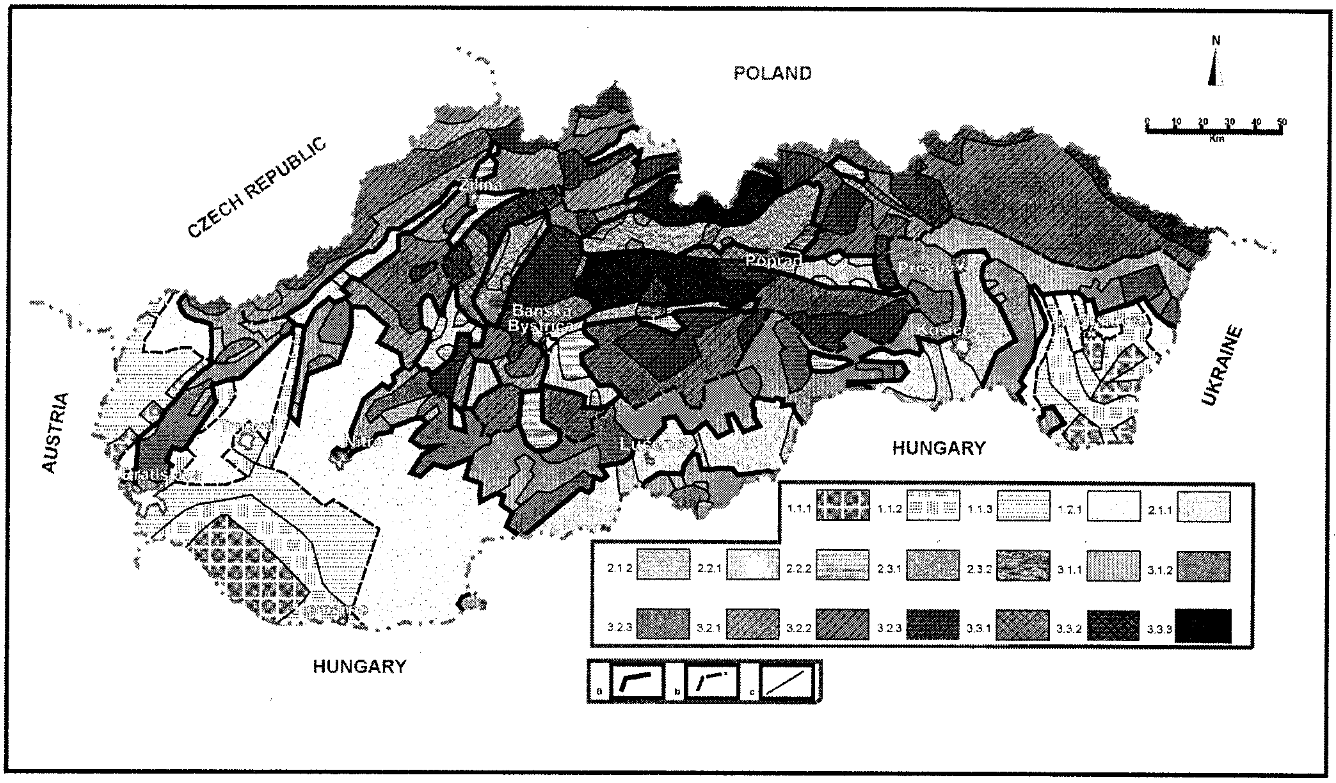
1.1 The West Carpathians

The rough form of the West Carpathians is that of huge dome, greater part of which lies on the territory of Slovakia. Mazúr (1979) noted its ground plan of elliptical shape. The top of the West Carpathian dome is not exactly in the middle. It is located next to its north-eastern fringe. The dome descends from its asymmetrically located centre over its transitive and peripheral part to the lowland areas of the Pannonian basin in the south-west and south-east and to the longitudinal South Slovakian depression in the south, still part of the Carpathians. This depression lies partly in Hungary while the transitive and peripheral parts of the West-Carpathian dome continue over to the territory of the Czech Republic and Poland.

1.1.1 Central morphostructures of West-Carpathian dome

It is the most uplifted part of the West Carpathians which is innerly also most differentiated and most contrastive one. The mountain ranges reach the most elevated altitudes above the sea level and the basins too are the highest situated in Slovakia. The differences between the mountain ranges and basins reach in the central part of the dome the highest values. Inside the central part we distinguished two different units of the 4th level.

The **Tatra central morphostructure (a)** lying east from the centre of the dome has its main geomorphic axes oriented mostly in the west-east direction. It is the highest of all morphostructures of Slovakia. It is also the only one exceeding the sea level altitude of 2,000 m. An elongated and relatively subsided depression **Podtatranská kotlina basin** [2] lies between two distinct elevations of the **High Tatra Mts.** [1] and the **Low Tatra Mts.** [3]. Also the less uplifted and elongated submountainous unit **Kozie chrbty Mts.** [4] is oriented in the same direction. The boundaries between them are fault-formed. The outer boundary of the unit is also mor-



Map 2a Types of active morphostructures of the Slovak Republic

1. Lowland morphostructures

1.1 morphostructures of lowland plains
1.1.1 strongly subsided blocks
1.1.2 moderately subsided blocks
1.1.3 weakly subsided blocks
1.2 morphostructures of the lowland hills
1.2.1 very weakly subsided blocks
2. Basin morphostructures
2.1 morphostructures of the low basins
2.1.1 low block
2.1.2 high blocks
2.2 morphostructures of the moderate basins
2.2.1 low blocks
2.2.2 high blocks
2.3 morphostructures of the high basins
2.3.1 low blocks
2.3.2 high blocks

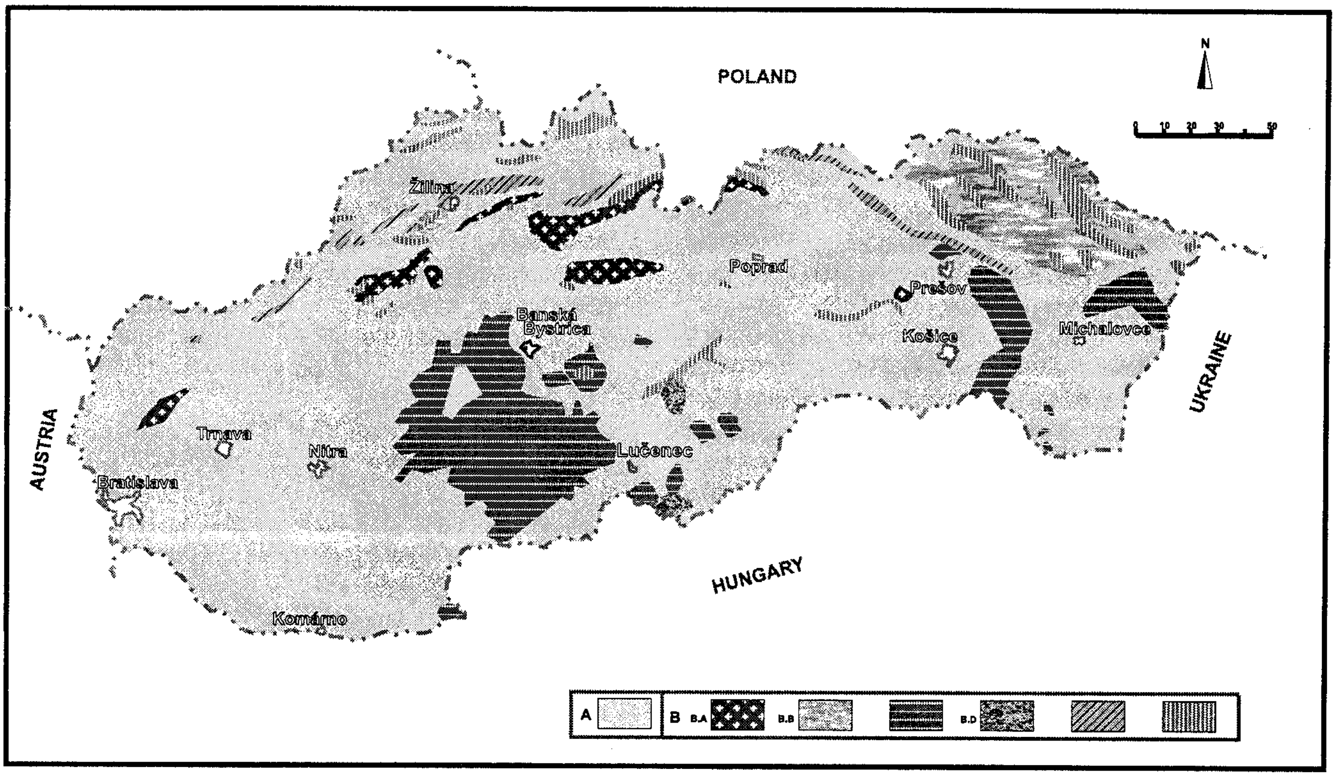
3. Mountain morphostructures

3.1 morphostructures of the marginal mountains
3.1.1 low blocks
3.1.2 moderate blocks
3.1.3 high blocks
3.2 morphostructures of the transitive mountains
3.2.1 low blocks
3.2.2 moderate blocks
3.2.3 high blocks
3.3 morphostructures of the central mountains
3.3.1 low blocks
3.3.2 moderate blocks
3.3.3 high blocks

The Borders
a. Borders of main morphostructural types
b. Borders of blocks
c. axis of tectonically tilted blocks

phologically very pronounced. It descends to **Podtatranská brázda forrow** [5] in the north and a corresponding depression fringe unit in the south is the **Horehronské podolie valley** [6]. In the eastern part of the **Podtatranská brázda furrow** a subsiding graben (a single example of absolutely subsiding basin in Slovakia) filled by glacial and fluvioglacial sediments 400 m thick (Halouzka - Raczkowski, in Nemčok et al. 1993), singled out.

The **Fatra central morphostructure (b)** is the lowest of the two central morphostructures. It lies west from the centre of the dome of the West Carpathians. It is characterised by north-south and diagonal orientation of relief. It is formed by approximately equally uplifted and innerly little differentiated blocks of Veľká Fatra Mts. [7] and **Malá Fatra Mts.** [8] with blocks of the **Turčianska kotlina basin** [10] between them. Both uplifted mountain ranges descend to the basin by fault scarps with facets. We included in the Fatra central morphostructure **also Chočské vrchy Mts** [9], **Žiar Mts.** [11], and **Starohorské vrchy Mts.** [12] mountains which represent less uplifted morphostructural units (except for the massif of Veľký Choč Mt.) and are innerly more differentiated by diagonal faults. They represent integrated groups of blocks among higher uplifted parts of the centre of the West-Carpathian dome.



Map 2b Types of passive morphostructures of the Slovak Republic

A. Morphostructures with weak application of passive structures

B. Morphostructures with strong application of passive structure

B.A Nappe passive morphostructures

B.B Flysh passive morphostructures

B.C Volcanic passive morphostructures

B.D Klippen passive morphostructures

B.E Domatic passive morphostructures

B.F Erosion-basins and forrows

1.1.2 Transitive morphostructures of the West-Carpathian dome

The transitive part of the dome is less uplifted than the central and more uplifted than the peripheral parts. The range of the uplifted partial morphostructures is less pronounced, i.e. the relief is less contrastive than in the centre of the dome. It consists of five lower morphostructural units which differ from each other by composition of their elevations and depressions and by applying the passive structure in relief. In other words, the basic building component i.e. mosaics of mountain ranges and basins changes with the changing place.

The flysch mountain range denoted by the collective name **Beskydy transitive morphostructure (c)** lies in the farthest north. The Polish part of morphostructure passes north of the Tatras and connects the western and eastern parts into one. The western and eastern parts of the Beskydy transitive morphostructure are the mirror reflections of each other. The majority of the partial morphostructures in the west find their mirror reflection in the eastern side. The example are the Skorušinské vrchy and Spišská Magura mountains. The unit is characterised by a pronounouced arrangement into belts with a bow-shaped course of the belts arranged in concentric manner in relation to the centre of the West Carpathian morphostructure. The belts are mostly identical with the axes of flysch and klippen passive structure. The contemporary valley networks is in many parts located on a young fault generation and this is the reason why there is a tendency to disrupt the older passive structure.

The composition of the morphostructure is distinctly arranged in two steps. The belts of elevations are regularly alternating with the belts of depressions. The higher step of the western wing is formed by occasional massive, plateau-like and divided uplifted block groups of the **Vysoký Javorník Mts.** [13], **Moravsko-Sliezske Beskydy Mts.** [15], **Kysucké Beskydy Mts.** [17], **Oravské Beskydy Mts.** [18], **Oravská Magura Mts.** [22], and **Skorušinské vrchy Mts.** [25]. The most uplifted blocks are located in the massive of Babia hora Mt. and Pilsko Mt. the altitude of which is comparable to both Fatra Mts. The lower step of the unit is represented by the belts of relatively subsided morphostructures ("podolie" sub-mountains, intra-mountains and basins) the **Nízke Javorníky Mts.** [13], **Turzovská vrchovina Mts.** [14], **Jablunkovské medzihorie Mts.** [16], **Kysucká vrchovina Mts.** [19], **Podbeskydská brázda furrow** [20], **Podbeskydská vrchovina Mts.** [21], **Oravská vrchovina Mts.** [24], and **Oravská kotlina basin** [23].

Similar composition exists also in the western wing of the Beskydy transitive morphostructure, distinctly differentiated to higher uplifted block groups of the **Spišská Magura Mts.** [26], **Levočské vrchy Mts.** [27], and **Čergov Mts.** [33] and relatively subsided morphostructures of the **Ľubovnianska kotlina basin** [30] and **Spišsko-šarišské medzihorie Mts.** [31]. Also the system of less uplifted blocks (intra-mountains) of **the** Pieniny Mts. [28], **Ľubovnianska vrchovina Mts.** [29], and **Bachureň Mts.** [32] is extensive.

The **Moravia-Slovakian transitive morphostructure (d)** is the westernmost unit of the 4[th] order within the transitive part of the West-Carpathian megamorphostructure. Its bigger part lies in the territory of Moravia. It includes a major northern part of the **Biele Karpaty Mts.** [34] and southern also major part of **Považské podolie valley** [35] (the Ilavská kotlina and Trenčianska kotlina basins). The composition of the morphostructure is distinctly arranged in two steps. The higher step is a horst-like mountain range of the Biele karpaty Mts. built by flysch rocks, the lower step represents a system of relatively subsided blocks. The divide among them is a klippen belt manifest by a slim chain of morphologically distinct elevations (limestone klippen). But the active component of the structure - active faults, is a more dominant relief-forming factor.

The **Strážov transitive morphostructure (e)** lies between the western fringe of the centre of West-Carpathian dome. Its core is from the geological as well as geomorphic point of view a complicated group of higher uplifted blocks of the **Strážovské vrchy Mts.** [36] and less uplifted blocks of the **Súľovské vrchy Mts.** [37]. The relief of both morphostructures was in great part formed by a comparably heterogeneous passive structure. In a fringe position of Strážov transitive morphostructure are relatively subsided groups of blocks of the upper part of **Považské podolie valley** (the Bytčianska kotlina basin) [39], **Žilinská kotlina basin** [38], and **Hornonitrianska kotlina basin** [40]).

The **Central Slovakian transitive morphostructure (f)** lies in the south of transitive part of the dome. It consists of geomorphic units of the northern part of volcanic Slovenské Stredohorie region. The territory of the unit is clearly differentiated to uplifted groups of blocks of the **Vtáčnik Mts.** [41], **Kremnické vrchy Mts.** [42] and relatively subsided groups of blocks of **Žiarska kotlina basin** [47], **Pliešovská kotlina basin** [48] and **Zvolenská kotlina basin** [46]. The original volcanic landforms in this part of Slovenské Stredohorie region are almost entirely destroyed by now. An exception are the specific volcano-tectonic morphostructures of the **Poľana Mts.** [43] and **Javorie Mts.** [44] with some partially conserved initial landforms of the Neogene stratovolcanoes. The present horst-like mountain ranges are divided into multi-directional systems of ridges and valleys. The most frequent is the north-south oriented geomorphic network proceeding to the area of the Veľká Fatra Mts. in the north and to the Danube valley in the south. A more detailed scale reveals structurally formed steps which rose in the consequence of different resistance of the stratovolcanic rocks of destroyed volcanic compounds. Occasionally a piedmont with the rests of middle-mountain planation surface (the Vtáčnik Mts.) occurs here. Asymmetry of the tilted blocks (the Kremnické vrchy Mts.) is also a frequent phenomenon. Out of the basins the most complicated inner morphostructural building is that of the Zvolenská kotlina basin. It contains several partial elevations and depressions. The Žiarska kotlina is innerly substantially simpler.

The **Rudohorie transitive morophostructure (g)** lies south-east from the centre of the West-Carpathian dome. The inner morphostructures of Slovenské Rudohorie region create a system of prevailingly massive mountain ranges - the **Veporské vrchy Mts.** [49], **Stolické vrchy Mts.** [50], **Volovské vrchy Mts.** [51], **Muránska planina plateau** [53], and **Slovenský raj karst** [52]. Uplifted blocks are comparably distinctly individualised in the north where there is an oblong depression of Horehronské podolie valley with the **Breznianska kotlina basin** [54] or **Hornádska kotlina basin** [56]. Morphologically distinct horst of the **Branisko Mts.** [55] is situated in the north-eastern edge of the unit orientation of which copies that of meridian. In the south they incline to a peripheral sub-mountains in a step-like and fluent manner. (An exception is a steep fault contact with the Rožňavská kotlina and Košická kotlina basins in the south-east). Tectonic lines are manifest in the Rudohorie region only in its ground plan (for instance the Muráň fault line), and less in its inner vertical differentiation. The western and eastern parts of morphostructure are wide enough in north-south direction while the central parts (around town Dobšiná) tapers to the most immediate contact with the centre and periphery of the West-Carpathian dome.

1.1.3 The marginal morphostructures of the West-Carpathian dome

The marginal morphostructures are the least uplifted unit of the 3[rd] order of a compact part of the West-Carpathian dome. Compared to transitory morphostructures the differentiation to uplifted and subsided blocks changes its nature and intensity. The mountain ranges descend directly into wide bay-like lowland proturbances between the mountains or to an elongated depression of South Slovakian morphostructures. There are five units of the 4[th] order in the periphery of the dome:

The **Moravia-Slovakian marginal morphostructure (h)** is one of the smallest. It continues also beyond the frontier to Moravia. It represents a group of fringe blocks in south-western wing of flysch belt and includes **Žalotinská vrchovina Mts.** [57] (SW of the Biele Karpaty Mts.) which is only slightly higher than the neighbouring **Myjavská pahorkatina hilly land** [58].

The **West-Slovakian marginal morphostructure (i)** consists of uplifted block groups which compose the horsts of the **Malé Karpaty Mts.** [59], **Považský Inovec Mts.** [60] and **Tríbeč Mts.** [61]. Their limits with lowlands are mostly distinct and as a rule with fault slopes. The composition is a two-step one and asymmetry. There are well conserved rests of the middle-mountain planation surface in several places. The bays of lowland originated as early as in the Neogenne and they are tectonically subsided blocks.

The **Central-Slovakian marginal morphostructure (j)** lies further to east of the periphery of a compact part of the West-Carpathian dome as a group of plain moutain ranges built by volcanic rocks. They are formed by slightly uplifted blocks with comparably small inner differentiation. Here belong the following mountain ranges: the **Pohronský Inovec Mts.** [62], southern part of **Štiavnické vrchy Mts.** [64], **Krupinská planina plateau** [65], **Ostrôžky Mts.** [66] and a small part of **Novobanská kotlina basin** [63] filled by the Quaternary basalts. The uplifted edge is discernable only in the south of Krupinská planina plateau.

The **Rudohorie marginal morphostructure (k)** lies in the south of the Slovenské rudohorie region. It consists of a group of slightly uplifted blocks of the **Revúcka vrchovina Mts.** [67], **Čierna hora Mts.** [69], **Slovenský kras karst** [68] and **Rožňavská kotlina basin** [70]. Tectonic differentiation of the unit is bigger than in the north of Slovenské Rudohorie region. The single steps of Revúcka vrchovina upland are separated from each other by valleys of tectonic origin oriented from the interior of Slovenské Rudohorie region to Juhoslovenská kotlina basin. In the eastermost part of the periphery of the dome there is a group of morphostructures, part of which a is the plateau-like Slovenský kras karst, part of Holíčka in Volovské vrchy and Čierna hora. The surface forms of Slovenský kras are dominated by well-developed surface planina karst. All three parts of the unit are very sharply separated from the depressions of South-Slovakian depression and Slovenský kras karst also distinctly marks off the Rožňavská kotlina basin in the opposite side.

The **Šariš marginal morphostructure (l)** is a small unit similar to Moravia-Slovakian marginal morphostrucure at the western edge of the dome. It consists of **Šarišská vrchovina Mts.** [71] and the south-eastern part of **Spišsko-šarišské medzihorie Mts.** [72]. The unit is in a depressed position with regard to the Branisko Mts. and Čierna hora Mts.. There is a continuous furrow at the contact with the mentioned mountain ranges. It is higher situated than Košická kotlina basin. All these boundaries are of tectonic origin.

1.1.4 Southern depressional morphostructures

Both South-Slovakian belt morphostructures are considered parts of the West-Carpathian dome which originated by tectonic deformation of its southern wing. The **Lučenec-Košice morphostructural depression (m)** consists of the **Juhoslovenská kotlina basin** [73] and **Košická kotlina basin** [74] separated from each other by intra-basin elevations - the **Bodvianska pahorkatina and Abovská pahorkatina hilly lands** [75]. Elongated depression between Slovenské stredohorie or Slovenské Rudohorie regions in the north and Maďarské stredohorie region (Matra-Slaná region) in the south was a part of larger space of repeated sea transgressions in time of the Palaeogene and Neogene. It was covered by the products of the neighbouring volcanic regions in the period of Lower Badenian. It is obvious that also the processes of selectively acting erosion and denudation, and tectonic movements of block type contributed to the origin and development of the depression. The question which of the two processes was dominant is subject to discussions yet.

1.1.5 Southern elevational morphostructures

This unit of the 3rd order consists of the only unit of the 4th order **- Matra-Slaná morphostructural elevation (n)**. This otherwise compact unit is artificially (the state border) divided in three independent groups of higher uplifted blocks. Low massive volcanic mountain range the **Burda Mts.** [76] lies farthest in the west, the central part is the **Cerová vrchovina Mts.** [77] and the north-eastern end of zonally arranged volcanic-tectonic morphostructure is formed by the **Slanské vrchy Mts.** [78], and an isolated group of blocks of the **Zemplínske vrchy Mts.** [79] uplifted above the Východoslovenská nížina lowland. The Cerova vrchovina Mts. is a very young and dynamic morphostructure which acquired a form of dome-horst with inverted relief on a distinctly contrastive volcano-sedimentary structure in the Upper Pliocene and Quaternary. The study of the river system of planation surfaces points at high values of its Quaternary uplifting over 300 m.

1.2 The East Carpathians

Only the western edge of the East Carpathians reaches the territory of Slovakia. Here belong the Nízke Beskydy Mts., Podbeskydská vrchovina Mts., Busov Mts., Bukovské vrchy Mts. and Vihorlatské vrchy Mts. They are classified in two units of the third order with belt (zonal) arrangement.

1.2.1 Outher zone morphostructures of East Carpathians

The nature of the territory is that of a transversally widely open depression (intra-mountains) between the West Carpathians and the higher part of the East Carpathians. The axis of the depression is north-south oriented. It follows the valley of the Ondava river. Depressed Nízke Beskydy Mts. are the northern continuation of the Východoslovenská nížina lowland, its tectonical subsiding. In the north-east there is higher uplifted group of blocks of Bukovské vrchy Mts. and in the north-west there are higher blocks of the Busov Mts.

The **Nízke Bskydy transversal depresional morphostructure (o)** is formed by three geomorphic wholes. It is the **Ondavská vrchovina and Laborecká vrchovina Mts.** [80] and **Beskydské predhorie foothills** [81]. The morphostructure is distinctly separated from the surrounding landscape. It is higher situated than the Čergov Mts., Bukovské vrchy Mts. and Slanské vrchy Mts.

The Busov Mts. [82] is the only partial morphostructure of the **Busov morphostructural elevation (p)**. Both sides of higher uplifted blocks are formed by fault slopes separating them from the lower blocks of Nízke Beskydy mountains. The remaining two sides are artificial as the unit passes to the territory of Poland. The inner differentiation is little, the block mountain range is massive the same as the nearby Čergov. Busov is built by the rocks of outer flysch, sandstone lithology of which emphasizes the elevation of the morphostructure, prevails.

Bukovské vrchy Mts. [83] are the only partial morphostructure of the 5th order in the **Poloniny morphostructural elevation (q)**. Morphostructure towers above the Nízke Beskydy Mts. Its massive central ridge reaches its highest altitude above the sea level (more than 1,300 m) in the territory of Poland and Ukraine. It is composed of two steps with extensive foothills. It is an active morphostructure, as the ground plan and altitude difference compared to the lower environs cannot be attributed to the differences in passive geological building.

1.2.2 Inner morphostructures of East Carpathians

We included the Vihorlatské vrchy Mts. in the inner part of the belt of the East Carpathians. The territory of the unit is tectonically very differentiated. The faults are both in its boundary and inner areas. Morphostructure of the inner belt was divided in two partial morphostructures of the 4th order without any further classification.

The **Vihorlat morphostructure (r)** is volcanic and commparably massive. It consists of larger, eastern part of the Vihorlatské vrchy Mts. (the Vihorlat and Popriečny Mts.) [85]. The system of diagonal tectonic faults divides the morphostructure by a lowering in two massives with higher blocks. The massive of Vihorlat Mts. is individualised by faults oriented in a NE-SW direction with regard to the Beskydské predhorie foothills in the north-west and to the Východoslovenská nížina lowland in the south-east. The transversal faults in the massive of Popriečny Mts. become longitudinal and the central ridge of the whole morphostructure turns and squares. The fault divide of the inner side of morphostructure is indicated by massive and broad alluvial cones.

The **Humenné morphostructure (s)** in the western part of Vihorlatské vrchy Mts. (**the Humenské vrchy Mts.)** [84] is not either volcanic or massive. It is built mostly by the Mesozoic rocks lying in a distinctly isolated position. It is depressed compared to the Vihorlat volcanic morphostructure. The morphostructure is fault-limited and innerly differentiated by transversal faults. One of the transversal faults is the gorge of Laborec river flowing from the Beskydské predhorie foothills to the Východoslovenská nížina lowland. The eastern ending of the klippen belt is in the area of Humenské vrchy Mts.

2. The Pannonian basin

The Pannonian basin consists of three Slovak lowlands. All of them are parts of larger lowland regions and their greater parts are outside the Slovak territory. The inner dissection and limits of all of them is formed by fault tectonics. The West Pannonian basin comprises the Záhorská nížina and Podunajská nížina lowlands, morphostructure units of the 3rd order.

2.1 The West Pannonian basin

2.1.1 Záhorie morphostructures of the Pannonian basin

The Záhorská nížina lowland is a part of larger lowland region which continues also beyond the frontier river Morava to Austria and the Czech Republic. Its limits with the neighbouring elevation morphostructures is mostly formed by faults (more distinct with regard to the Malé Karpaty Mts. and less distinct with regard to the Myjavská pahorkatina hilly land).

In the northern part of the lowland is **Chvojnice morphostructure (t)** including **Chvojnícka pahorkatina hilly land, Gbelský bor forest**, and the Slovak part of **Dolnomoravský úval valley** [86]. It is formed by a group of prevailingly high blocks within the lowland which are massive, innerly little differentiated and ending in plains. Near town Holíč, the western part of morphostructure, there lye subsiding Quaternary blocks.

The **Bor morphostructure (u)** occupies **Borská nížina lowland** [87] without Gbelský Bor forest. Longitudinal faults proceeding in parallel with the axis of the Malé Karpaty restrain the narrow belt of Podmalokarpatská zníženina depression where there alternate relatively higher blocks with subsiding blocks (the Zohor, Pernek, and Sološnica depressions) on transversal blocks. The western part of Záhorská nížina lowland appears comparably stable (with zero to slight subsiding). The moderate tectonic mobility of this territory is indicated by asymmetry of the terrace system of the Morava river, which is better developed on its left bank (the Slovak side).

2.1.2 Danube morphostructures of the Pannonian basin

The Podunajská nížina lowland is prevailingly distinctly fault-limited with regard to the neighbouring elevation morphostructures. Active faults limit the lowland protuberances into the marginal mountain ranges of the West Carpathians. The Podunajská nížina lowland is innerly divided in two morphostructures.

The only partial unit of the **Outher Danube morphostructure (v)** is the **Podunajská pahorkatina hilly land** [88]. It is rather gemorphologically variegated. It represents some kind of transitory morphostructure between the intensely subsiding centre of the lowland and the surrounding positive mountain morphostructures. Its bay-like protuberances enter between the mountain ranges of the West Slovakian outer morphostructure and the Central Slovakian marginal volcanic morphostructure. The Bánovce protuberance touches the units of transitive part of the West-Carpathian dome. Morphostructure is characterised by arrangement into a system of wide valleys which alternate with lowland hills. Also several subsiding areas (the valley of the Váh river between towns Nové Mesto nad Váhom and Sereď, environs of the city Trnava and village Cífer and a belt of lowering at the foot of the Malé Karpaty Mts.) are also its parts.

The **Inner Danube morphostructure (x)** has the only one unit of the 5th order - the **Podunajská rovina plain** [89]. It is formed by the most distinct Quaternary tectonic depression of Žitný ostrov island and by contiguous less subsided blocks. The Danube loses its transporting energy after passing the Devínská brána gate and deposits the carried material in subsiding depression. The contemporary main bed of the Danube proceeds in direction of the principal subsiding of a complex stepped structure into the centre of the depression. The thickness of accumulation of massive inland Danube delta reaches in its central part more than 500 m.

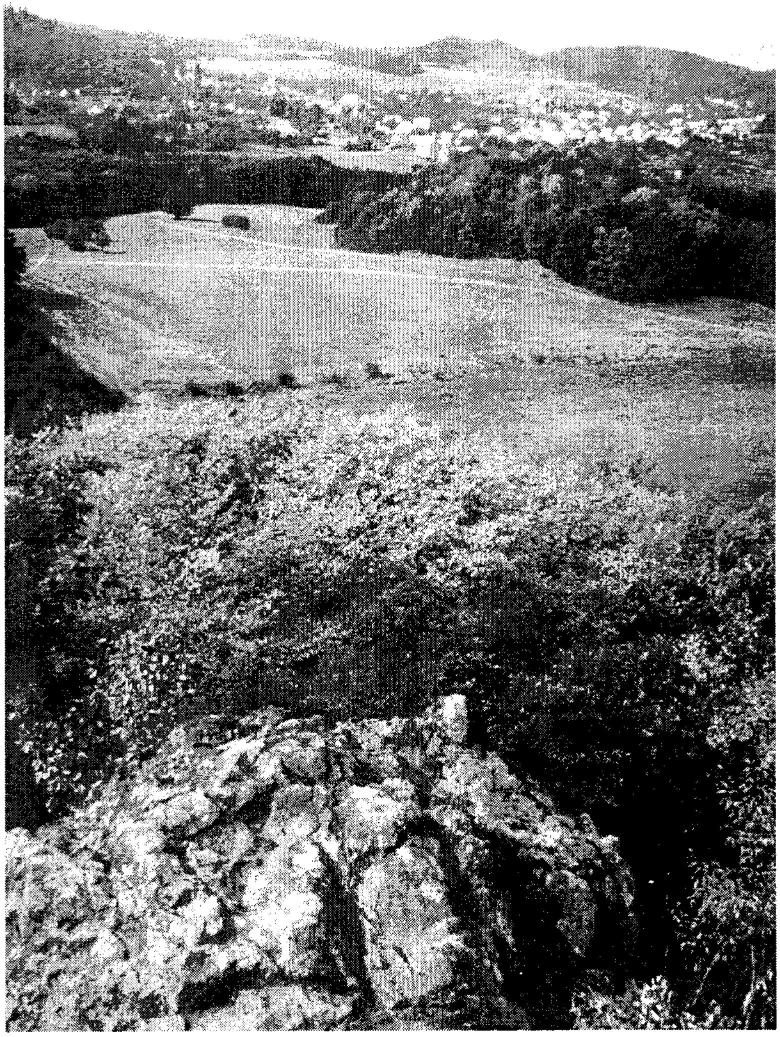


Fig. 1 Morphostructural border between the Vtáčnik Mts. and Hornonitrianska kotlina basin. Photo: J. Lacika

2.2 The East Pannonian basin

2.2.1. East Slovakia morphostructures of the Pannonian basin

Tectonic and morphostructural construction of the Východoslovenská nížina lowland is complex. Its basic characteristics is a large share of the Quaternary subsiding blocks in overall area of the lowland.

The **Outher East Slovakian morphostructure (y)** represents the smaller circumferential part of the Východoslovenská nížina lowland. It is represented by the only unit of the 5th order - the **Východoslovenská pahorkatina hilly land** [90]. The margin of the hills is a system of higher uplifted blocks within the lowland which are relatively subsided with regard to the neighbouring mountain ranges. Out of all lowland areas of Slovakia this morphostructure comes closest to the centre of the West-Carpathian dome in the north-west. This is the dynamising factor of the local fluvial geomorphic systems. Longitudinal elevation between the valleys of the Ondava and Laborec (Pozdišovský chrbát ridge) runs far inside the Východoslovenská nížina lowland. The system of blocks under the Vihorlatské vrchy Mts. is complicated. There are partial high blocks (south of Zemplínska Šírava lake and environs of town Sobrance). A massive alluvial cone rose on the blocks in the corner of the lowland closed by the Vihorlat Mts. and Popriečny Mts. in the north-east. Its origin is a reflection of the Quaternary subsiding of the territory lying south-west of town Sobrance.

The **Inner East-Slovakian morphostructure (z)** roughly coincides with the **Východoslovenská rovina plain** [91]. It represents a complex system of the Neogene and Quaternary subsiding blocks. Here belong Laborec and Ondava grabens with aggrading main rivers. In the north of Laborec graben (south of town Michaľovce) has been burried the Quaternary fillings exceeding 50 m. Description of the south-eastern depression near the bed of the Tisa river is similar. Subsided blocks are mostly limited by the faults of north-south and west-east orientations. The subsided blocks join in the central part of the lowland. The relief on subsiding blocks is flat and poorly drained.

6. Conclusion

The new division of the morphostructures in the territory of Slovakia represents in part also preparation for the creation of a new general geomorphological regionalisation which may substitute or at least update the division of Slovakia used so far as worked out by Lukniš - Mazúr in 1979.

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References

HALOUZKA, R. - RACZKOWSKI, W. (1993): Kvartér. In: Nemčok, J. et al.: Vysvetlivky ku geologickej mape Tatier 1:50 000, GÚDŠ Bratislava.

MAZÚR, E. (1965): Major features of the West Carpathians in Slovakia as a result of young tectonic movements. In: MAZÚR, E. - STEHLÍK, O. eds. (1965): Geomorphological problems of Carpathians. SAV, Bratislava, p. 9-54.

MAZÚR, E. - LUKNIŠ, M. (1978): Regionálne geomorfologické členenie Slovenskej socialistickej republiky. Geografický časopis, 30, 2, p. 101-124.

MAZÚR, E. (1979): Morfoštruktúry Západných Karpát. Acta Facultatis Rerum Naturalium Universitatis Comenianae. Geographica, 17, Bratislava, p. 21-34.

MAZÚR, E. (1980): Morfoštruktúry 1:1 000 000. In: Mazúr, E. - Jakál, J. eds. (1980): Atlas SSR. Veda, Bratislava.

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RNDr. Antonín IVAN, CSc.

THE INFLUENCE OF RIVER NETWORK ARRANGEMENT ON VALUES OF GEOTECTONIC INDICES (ON THE EXAMPLE OF THE OSLAVA RIVER BASIN)

Michal BÍL - Zdeněk MÁČKA

Abstract

The contribution brings an assessment of river network topology influence on values of geotectonic index (SL-index) introduced by Hack (1973) to evaluate the spatial distribution of stream power. A result of adapting the index to conditions of the system of rivers draining the SE margin of the Bohemian Massif was the use of stream magnitudo M (sensu Shreve, 1966) which both takes into regard the effects of river network topology and better approximates discharge in the equation for stream power. The newly formulated SM-index was applied as a model at analyzing the Oslava River gradient status.

Shrnutí

Vliv uspořádání říční sítě na hodnoty geotektonických indexů (na příkladu povodí Oslavy)

Příspěvek hodnotí vliv topologie říční sítě na hodnoty geotektonického indexu (SL-index) zavedeného Hackem (1973) pro hodnocení prostorové distribuce energie toku. Výsledkem přizpůsobení tohoto indexu podmínkám systému řek odvodňujících jihovýchodní okraj českého masívu bylo použito magnituda M (sensu Shreve, 1966), Které jednak zohledňuje vliv topologie říční sítě a dále lépe aproximuje průtok v rovnici pro energii toku. Nově vytvořený SM-index byl modelově aplikován pro analýzu spádových poměrů řeky Oslavy.

Key words: stream gradient curve, geotectonic indices, stream power, river network topology, Oslava River basin, Czech Republic

1. Introduction

The analysis of stream longitudinal profile (stream gradient curve) is an integral part of the basin geomorphology. For a relief modelled by river erosion the shape of longitudinal profile is the indicator of the variability of bedrock litology, geological processes and geomorphological history of the area. A special attention at analysing the stream gradient curve is usually paid to knickpoints. Irregularities of the stream gradient curve reflect sudden increases or decreases of gradient values, which can be induced by a whole range of causes such as the erosion base subsidence, the presence of discontinuities in the riverbed floor caused by selective erosion of rocks with different resistance, by vertical movements on faults running across the stream or by the character of material in the riverbed. Many experiments were made in geomorphology which tried to carry out a quantitative interpretation of changes occurring in the longitudinal profiles (e.g. Hack, 1957; Setunskaya, 1969).

The presented contribution is an attempt at a quantitative analysis of gradient situation in the Oslava River basin, directed to specify reaches with a realistic possibility of their being influenced by active tectonic movements on faults. The work is methodologically based on Hack (1973), Stearns (1967) and McKeown et al. (1988) although the methodological apparatus was modified to fit the conditions of spatial scale chosen by the authors and could thus be used for the analysis of river network of the system of streams draining the SE margin of the Bohemian Massif.

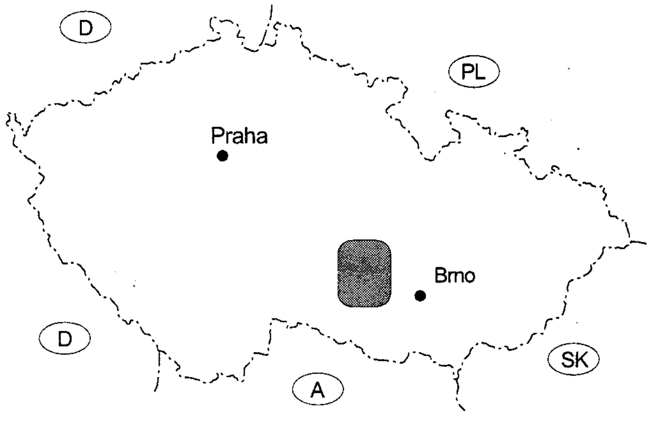

Fig. 1 Map of the Czech Republic with the marked area under study.

2. SL-index theory

According to Hack (1973) it is possible to define the so called stream gradient index (SL-index) for any stream reach, and use it for the comparison of gradients of streams of different sizes. Hack claims that the index reflects available stream power (stream performance capacity) and combines in a simple way two morphometric gradient curve parameters: stream gradient in the given reach and distance of the centre of this reach from the spring (measured upstream the longest water course). Thus, at any relief arrangement the SL-index values depend on the total exaggeration of the catchment area and the stream regime. It is therefore necessary at interpreting the SL-index value changes along the stream to take into consideration a whole complex of variables such as variability of bedrock litology, amount of material supplied into the stream, climatic and technical events, and geomorphological history of the area with the litological and tectonic factors seeming to have the greatest impact on the course of stream gradient index values.

The general relation for the calculation of SL-index is derived from the equation of a function which is a mathematic description of idealized stream gradient curve. The starting point is a graphical illustration of gradient curve of individual water course in a simple semi-logaritmic graph in which the beginning is considered to be the water course spring near the watershed. The vertical coordinate is on arithmetic scale and illustrates altitude or elevation above the chosen reference area. The horizontal coordinate is on logarithmic scale and illustrates the distance from the stream beginning. In such a graph the realistic gradient curve is transformed directly on the straight line and can be then expressed mathematically by the following logarithmic equation:

$$H = C - k^* \ln L$$

where H - the altitude of the given point on the gradient curve [m], *L* - the water course length (horizontal distance from the beginning of the water course to the given point, measured along the main stream [m]), *C*, *k* - constants.

Gradient curve slope tangent in the given point as derived from the above equation is as follows:

$$dH^*dL^{-1} = kL^{-1},$$

or

$$S = k^*L^{-1}$$

The equation for slope (gradient) can then be expressed in the following form:

$$S^*L = k$$

However, the great amount of rivers do not have the logarithmic profile along the entire stream length and their gradient curves are rather composed of more mutually interconnected reaches of various lengths each of them having the logarithmic profile. This means that value *k* is variable within the water course as a whole but constant for any concrete logarithmic segment of the stream. Since value *k* is an expression of lofarithmic profile slope for the given segment, it can be used as an index of relative slope of actual gradient curve in the given point. The result of SL relation (which is equivalent of constant *k* in first equation) is called stream gradient index (SL-index). The procedure of practical specification of SL-index from longitudinal profiles is illustrated in Fig. 2.

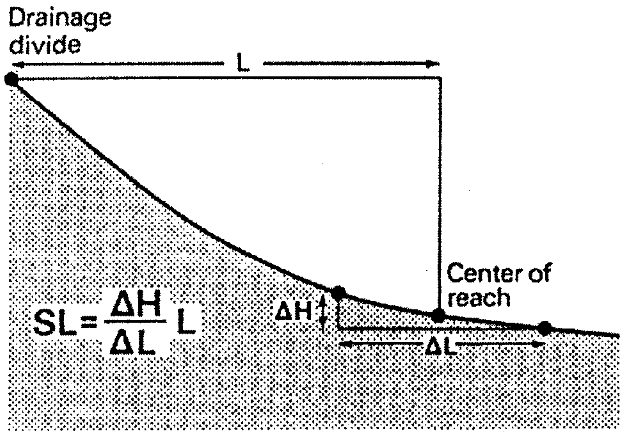

Fig. 2 Method of SL-index determination by stream gradient curve graphic illustration (after Hack, 1973).

The SL-index is an important characteristic since it is a rough expression of stream capacity to transport materials (stream power) of a certain size and also relates to characteristics expressing the riverbed resistance to flow. The conclusions were confirmed empirically as shown in Hack's study (1957) which deals with water courses in the catchment of the Potomac River (U.S.A.) where significant correlations were found between the size of bottom material, stream length and gradient.

However, the SL-index is a characteristic derived for large catchment areas with main stream length of several hundred kilometers, and it is therefore not entirely fitted for the analysis of considerably shorter water courses draining the SE margin of the Bohemian Massif.

The linear increment of length from the beginning of the water course, used in the relation for SL-index determination, does not correspond with the step discharge increment along the stream. An important factor influencing the energy distribution in shorter water courses is therefore river network topology. The discharge increment in the main water course of the catchment is to a certain extent affected by irregular opening of branches variable in size that bring different amounts of water from their catchments. In longer streams, at working on a larger spatial scale, the uneven discharge increment is more or less eliminated; however, the employment of SL-index as a measure of energy distribution along the water course in shorter streams may be misleading. It is therefore useful to replace the upstream reach length by a characteristic that would better approximate the irregular discharge increment along the water course.

3. SM-index derivation

In an ideal case, the upstream length of the reach would be directly replaced by discharge although this cannot be made in practice due to the insufficient density of hydrological measurements on the streams. A suitable quantity for discharge substitution is therefore considered the magnitudo of the stream (*M*) as in Shreve (1966). This is one of methods to express the hierarchy of water courses in the catchment area. Each of reaches between two confluences is marked as a link which is ascribed a size (magnitudo) that is a sum of sizes (magnitudos) of all links situated upstream. Collecting channels with no affluents have the magnitudo value of 1, and these reaches are then summed up arithmetically. Magnitudo is a description characteristic of river network topology with a high measure of correlation with the catchment area as it was tested on a sample of forty watersheds of the 3rd order in the territory drained by the Oslava River (see Fig. 3).

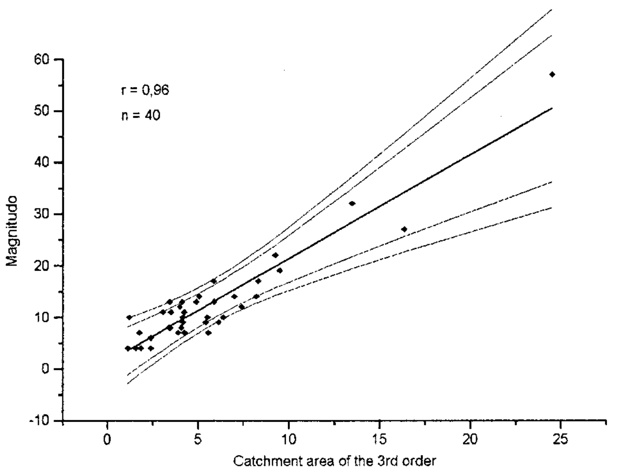

Fig. 3 Regression dependence between catchment area [km^2] and magnitudo (realiability belts α = 0.01 and α = 0.05).

The catchment area is widely used in many an excercise for the substitution of discharge (*Q*) where the required hydrological data are not available. The close correlation between discharge and catchment area was first empirically proven by Schumm (1956). This is the reason why upstream length (*L*) in the relation for SL-index determination was substituted by magnitudo (*M*) and the given relation modified in a following way:

$$S*M = k$$

where *k* - SM-index value, *S* - gradient of the given reach, *M* - magnitudo of the given reach.

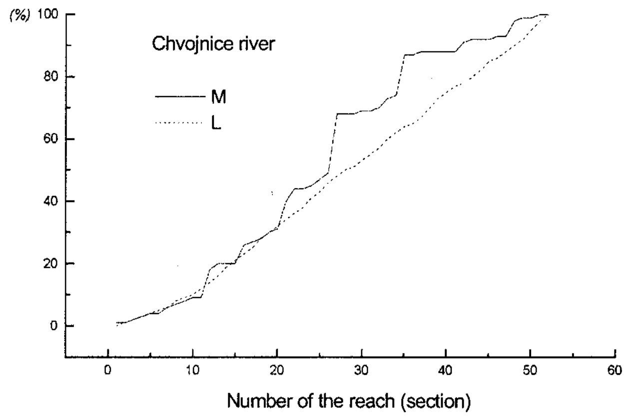

Fig. 4 Comparison of upstream length increment (L) and magnitudo (M) for the Chvojnice River (increment by sections of unit exaggeration).

It is now clear that we have introduced a so called SM-index which - to our opinion - can better express the distribution of power available to perform work in the catchments of shorter water courses. The concrete course of SM-index and particularly its anomalous deviations towards higher values then reflect not only the effects of rapid fluctuation of rocks with different resistance or tectonic effects, but also the river network topology.

The SM-index calculation was practically applied in the Oslava River basin where the research did not only concern the main water course of the catchment (the Oslava River), but the analysis included all streams, even those of fourth and higher order. The magnitudo and order of the stream were determined according to Strahler (1952) for a complete valley network of Oslava catchment area, which means not only for the network of permanent water courses. The valley network delineation made use of topographic maps 1:25 000, the network of dry valleys being delineated on the basis of Bauer's recommendations (1980). The result of working out SM-indices in the Oslava River basin is illustrated in Fig. 7. There are four reaches along the Oslava River, in which tectonic interventions can be presumed into the development of fluvial system - either directly by means of active movements on faults running across the stream, or indirectly due to the subsidence of erosional base. The reaches in question upstream from the Oslava mouth are as follows: at the Ketkovický meander, at the Sedlecký castle near Hartvíkovice, near Tasov, and near Mostiště. The parameters of the valley and longitudinal profile in these areas will be a subject of further research.

To verify the influence of active tectonics would call for the employment of adequate methods of geological research. The identical gradient values in the spring reaches of the stream and in the lower-situated parts of the catchment area will show in the different SM-index values the reason being the fact that towards the mouth the water course has a larger discharge available to perform work (see Fig. 5). The found reaches with anomalously high values of SM-index thus represent "hot spots" in the Oslava River basin, on which exceptionally high energy expenditures to perform work occur. This is the reason for us to assume the places to be the points at which external disturbances are brought to balance and a new equilibrium in the fluvial system is established.

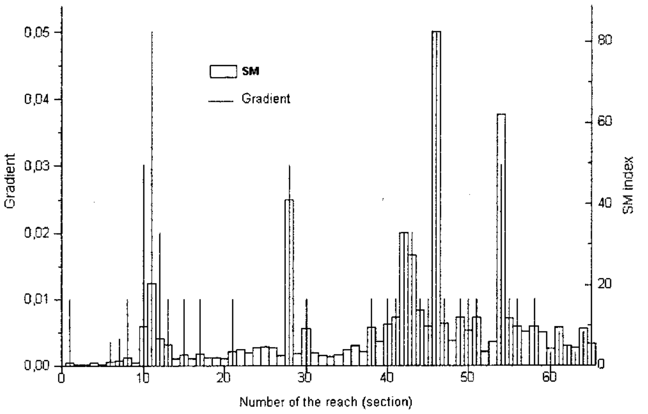

Fig. 5 Comparison of gradient values course and SM-index for the Oslava River (increment by sections of unit exaggeration).

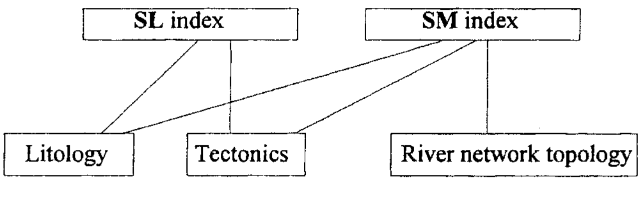

Fig. 6 Main factors influencing anomalous values of SL- and SM-indices.

4. Conclusion

At the quantitative analysis of gradient situation of rivers draining the south-eastern edge of the Bohemian Massif with the use of the so called SL-index a problem was struck relating to non-respecting the river network topology as a factor significantly influencing the increasing discharge values with the increasing upstream length. The shortcoming manifests itself in the distorted information about the distribution of power available to perform work along the water course and in the restricted capacity of evidence of this index about the flubial system tectonic disturbances. The succeptibility to this factor is lower at water courses long several hundred kilometers; it is necessary, however, to pay a certain attention to the factor in the conditions of our spatial scales. This is why we suggest a modification of the relation for SL-index determination and the substitution of

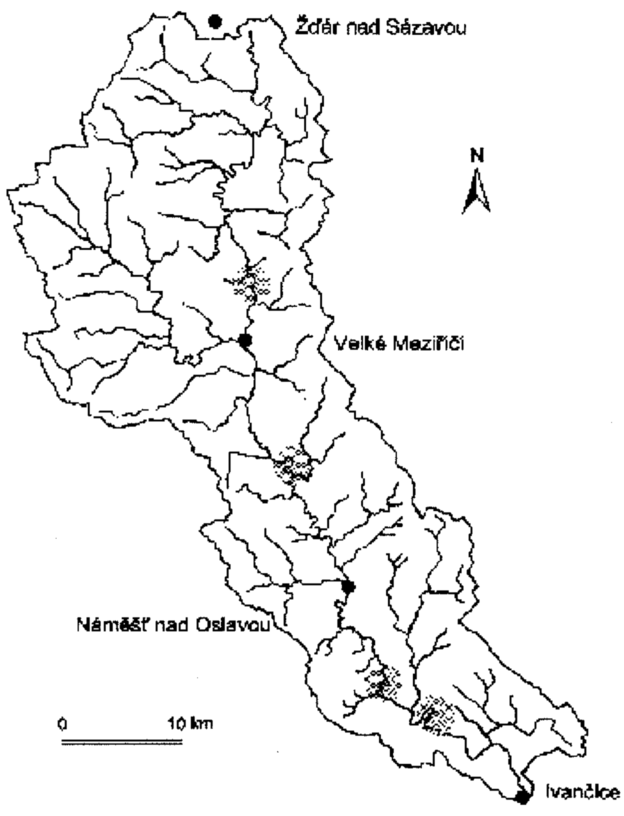

Fig. 7 Distribution of SM-index anomalous values across the Oslava River catchment.

"upstream length" L quantity with magnitudo M (sensu Shreve, 1966) which is a good approximation of discharge in the equation for stream power. The new SM-index was used as a model for the analysis of gradient conditions in the Oslava River catchment where four reaches were defined with a possible gradient curve shape influenced by the tectonic effects.

References

BAGNOLD, R. A. (1966): An approach to the sediment transport problem from general physics. United States Geological Survey Professional Paper 422-I, 37 pp.

BAUER, B. (1980): Drainage density-an integrative measure of the dynamics and the quality of watersheds. Zeitschrift für Geomorphologie, vol. 24, p. 261-272.

HACK, J. T. (1957): Studies of longitudinal stream profiles in Virginia and Maryland. United States Geological Survey Professional Paper 294-B, 97 pp.

HACK, J. T. (1973): Stream profile analysis and stream-gradient index. Journal of Research of United States Geological Survey, vol. 1, p. 421-429.

McKEOWN, F. A. et al. (1988): Analysis of stream-profile data and inferred tectonic activity, eastern Ozark mountains region. United States Geological Survey Bulletin 1807, 39 pp.

SCHUMM, A. S. (1956): Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geological Society of America Bulletin, vol. 67, p. 597-646.

SETUNSKAYA, L. E. (1969): Karty uklonov gydrosfery. In Gerasimov, I. P. ed. Primenenie geomorfologičeskich metodov v strukturnogeologičeskich isledovanijach. Izd. Nedra, 296 pp.

SHREVE, R. L. (1966): Statistical law of stream numbers. Journal of Geology, vol. 75, p. 178-186.

STEARNS, R. G. (1967): Warping of the western highland rim peneplain in Tennessee by ground water sapping. Geological Society of America Bulletin, vol. 78, p. 1111-1124.

STRAHLER, A. N. (1952): Dynamic basis of Geomorphology. Geological Society of America Bulletin 63, p. 923-38.

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GEOMORPHOLOGICAL ASPECTS OF LATE SAXONIAN EPIPLATFORM OROGENY OF THE BOHEMIAN MASSIF (PART 1)

Antonín IVAN

Abstract

A characteristic feature of the Bohemian Massif (BM) relief connected with the post-Cretaceous (late Saxon) epiplatform uplift is the contrast between the nearly closed intramontane Bohemian Basin (BB) with a centripetal drainage pattern and the ring of marginal elevations whose height ranges between 800-1600 m. The massif uplift was considerably affected by intensive orogeny in the Eastern Alps and Western Carpathians. The Bohemian Basin is a heterogeneous, less uplifted, but relatively stable block with a very differentiated internal structure. The trend towards the development of a depression in the central part of the massif occurred as early as in the Upper Proterozoic. A culmination of earlier subsidence tendencies was probably the extensional collapse at the end of Variscan orogeny with its morphological manifestation being numerous Carboniferous and Permian molasse basins. Weak negative tendencies occurred also in the early period of platform stage (prior to Upper Cretaceous marine transgression).

The post-Cretaceous uplift of southern Moldanubian marginal elevations of the Bohemian Massif (those of the Šumava Mts. System and Bohemian-Moravian System) which are built of an older and more consolidated basement, but have a direct contact with the Alpine-Carpathian area was of a more prolonged character and led to a deeper denudation of the basement. In the northern Saxothuringian marginal elevations (those of the Krušné hory Mts. and Sudeten Mts.) which are geologically more complex but less consolidated, the uplift probably started later and it was perhaps more rapid. Manifestations of the uplift and extension here are young volcanism and the Ohře rift. The Upper-Cretaceous sediments and the height of their base provide a so far more reliable groundwork for considerations about the data and nature of young tectonic movements than the imaginary Palaeogene planation surface. The evidence about the movements can be provided by neovolcanic rocks, Tertiary sediments and by Pliocene and Quaternary river terraces. There is a preliminary hypothesis of the post-Cretaceous differential uplift being associated with the existence and reactivation of mantle elevation under Central Europe, whose activation most probably relates to the plate collision in the Alpine-Carpathian area. The coming into existence of the Bohemian Basin and the marginal elevations is also a manifestation of the inherited basement heterogeneity. The greater uplift in the southern part of the massif is a continuation of the trend from the pre-platform era.

The aim of delimitation of the Bohemian Basin as a stable intracontinental unit of the massif is a more realistic model of the Bohemian Massif.

Shrnutí

Geomorfologické aspekty mladosaxonské epiplatformní orogeneze a zdvihu Českého masivu (1. část)

Charakteristickým rysem reliéfu Českého masivu (ČM) spojeným s pokřídovým (pozdně saxonským) epiplatformním zdvihem je kontrast mezi téměř uzavřenou vnitrohorskou Českou kotlinou (ČK) s centripetální říční sítí a věncem okrajových elevací, vysokých 800-1600 m. Zdvih masivu podstatně ovlivnila intenzivní orogeneze ve Východních Alpách a Západních Karpatech. Česká kotlina je heterogenní, méně vyzdvižená, ale vnitřně velmi diferencovaná relativně stabilní kra. Tendence k vývoji deprese v centrální části masivu se projevovala již od svrchního proterozoika. Vyvrcholením starších poklesových tendencí byl pravděpodobně extenzionální kolaps v závěru variské orogeneze a jeho morfologickým projevem byly četné permokarbonské molasové pánve. Slabé depresní tendence se projevovaly i ve starší části platformní etapy (před svrchnokřídovou mořskou transgresí).

Pokřídový zdvih jižních moldanubických okrajových elevací ČM, Šumavské a Českomoravské, které mají sice starší a více konsolidovaný fundament, ale na druhé straně mají přímý kontakt s alpskokarpatskou oblastí, byl dlouhodobější a vedl k hlubší denudaci fundamentu. V severních, geologicky pestřejších a méně konsolidovaných saxothuringských okrajových elevacích, krušnohorské a sudetské, začal zdvih pravděpodobně později a byl asi rychlejší. Projevy zdvihu a extenze jsou zde mladý vulkanismus a oherský rift. Svrchnokřídové sedimenty a výška jejich báze poskytují zatím spolehlivější základ pro úvahy o hodnotách a charakteru mladých tektonických pohybů než imaginární paleogenní zarovnaný povrch. Doklady o mladých pohybech mohou poskytnout neovulkanity, terciérní sedimenty a pro pliocén a kvartér říční terasy. Předběžně předpokládáme,že pokřídový diferenciální zdvih *pravděpodobně souvisí s existencí a reaktivací plášťové elevace pod Střední Evropou. Její aktivizace asi souvisí s kolizí desek v alpskokarpatské oblasti. Vznik České kotliny a okrajových elevací je také projevem zděděné heterogenity fundamentu. Větší zdvih v jižní části masivu je pokračováním trendu z předplatformního období.*

Cílem vymezení České kotliny jako stabilní intrakontinentální jednotky masivu je formování výstižnějšího morfostrukturního modelu Českého masivu.

Key words: Bohemian Massif, Bohemian Basin, marginal elevations, morphostructures, post-Cretaceous epiplatform uplift

1. Introduction

As a compact part of the West-European platform the Bohemian Massif is a complex and well individualized rhomboid-shaped horst situated in the WNW-ESE direction. With the projection of the Thuringer Forest the horst's length amounts to some 500 km and width reaches up to 350 km. The massif relief is very complex with the difference between the highest point and the edge of the massif being nearly 1500 m. A mere glance onto a hypsometric map will reveal a striking contrast between the two major morphostructures, i.e. the Bohemian Basin (BB) and the marginal elevations, which surround with their four branches in the shape of a ring the basin from all sides. The feature was well described by Kunský (1968, p. 261) according to whom the whole massif elevation has the character of a "mountain basin" (as a counterpart to the Western Carpathians forming a "mountain dome").

The horst of the Bohemian Massif is considered a consequence of young differentiated epiplatform orogeny of the extraordinarily complex basement and its sedimentary cover. In addition, the massif is situated in the close vicinity of the Eastern Alps and Western Carpathians where very intensive Alpine orogeny took place in the collision zone of intercontinental orogene simultaneously with the massif uplift. The extreme complexity of BM uplift is manifested by the fact that axial sections of all four marginal elevation branches also became sections of the Main European Divide of the Danube, Rhine, Elbe and Oder, thus delineating the Bohemian Basin as a large intramontane depression with the pronounced centripetal drainage pattern and with a single outflow through the transversal valley of the Elbe River towards NW. However, the borders between the Bohemian Basin and the individual marginal elevation branches are for the main part vague and unexplicit.

Some authors take the Bohemian Massif for a ring structure (Procházková and Zeman, 1982; Bouška, 1990; Rajlich, 1993). Although the shape of the Central Bohemian Basin suggests the interpretation, the marginal elevations and the "angularity" of the massif ground plan are rather a controversion. The arrangement of granitoid plutons suggesting the plutonic ring structure (Klomínský and Dudek, 1978) and numerous arcuate features (Holubec, 1990) could speak for the "ring" interpretation. On the other hand, the very old (Cadomian) block structure of the Bohemian Massif is beyond any dispute today (Šťovíčková, 1973; Zeman, 1978) and rather speaks against it. The elevation position of the massif led to its long-term denudation which is documented from the central part of the Bohemian Massif (Barrandian) already in Upper Proterozoic and Lower Palaeozoic. An enormous denudation occurred also towards the end of Variscan orogeny (at some places more than 10 km). It is probable that the massif contours were affected by plate collision, large strike-slip faults and thrusting of nappes in the course of Variscan orogeny. Some parts of the massif are considered foreign elements (displaced terranes, e.g. Brunovistulicum). These processes rather led to the destruction and obscuring of possible ring features.

The hitherto opinions about causes, character and temporal course of the young, strongly differentiated BM uplift very much differ. Some authors generally connect the rise of major BM macroforms with the formation of the Eastern Alps and Western Carpathians (Hromádka, 1956), other with the inheritance of massif structures that came into existence in the course of past orogenies (Kopecký, 1971, 1989). According to the author, the concepts do not eliminate but rather complement each other. There were active impulses coming from the Alpine-Carpathian area, which were responded to by individual parts of the geologically very complex massif basement in a different way. According to Roth (1980), the influence of the Carpathians on the Bohemian Massif (documented by neovolcanic rocks) showed to the distance of 350 km. Nevertheless, the significance of Variscan and earlier geological structure of the massif is also undisputable. This is the reason why the discussion of individual parts of the massif also includes a broad issue of relief development in the pre-platform stage. The Bohemian Massif is marked by permanent mild mobility whose causes are according to Zátopek (1979) pressures which are directed from the Alpine area to the North and which manifest mostly in the marginal elevations.

In this work, a special attention is paid to the morphostructural aspects of young BM uplift that should also manifest themselves in the geomorphological division of the massif. However, the present geomorphological division of the relief in the Czech Republic has become common and stabilized. On the other hand, the morphostructural division is still missing. Some proposals and ideas presented in this work can therefore be comprehended either as an outline of the BM relief morphostructural division or an introduction into a new discussion over some issues concerning the BM geomorphological division.

The complex character of the BM young (post-Upper Cretaceous) differential uplift can be illustrated by six years of complex research in the neighbouring Rhenish Massif (Fuchs et al., 1983). The authors can see the cause of its uplift in a mantle diapir at the depth of 50 to 150 km, which is documented by P-waves low velocity channel and related to partial melting. The mantle diapir was found also in the western part of the Bohemian Massif (see however Zeman, 1988; Bucha, Blížkovský eds., 1994, Fig. 2.28). The conclusion about the uplift character is in a good harmony with results from the geodetic measurements of recent vertical movements. The research included a relief analysis, particularly of geomorphological levels, planation surfaces and river terraces (Semmel in Fuchs et al., 1983). According to H. Bremer (1985), the detailed geomorphological research of planation surfaces and river terraces indicated a variable character of the uplift both in space and time. It also showed that the use of pre-Quaternary planation surfaces for the solution of problems connecting to the uplift of the Rhenish Massif would apparently call for further detailed research (comp. Semmel, 1991).

2. *The reasons for delimitation of the Bohemian Basin; some terminological problems*

The Bohemian Massif is situated in the territories of four (until recently five) countries. Only a little bit more than a half of the massif surface can be found in the territory of the Czech Republic (Fig. 1) including the major key areas. An unequivocal opinion about the geomorphological division of the massif does not exist yet. In the most used and most frequently quoted geomorphological divisions of the CR relief (Hromádka, 1956; Czudek ed., 1972; Demek ed., 1987) the Bohemian Basin is neither described nor cartographically delineated as a unit and the quoted authors divide the massif directly into five or six geomorphological systems (Tab. 1). With the regard to the role attributed to young tectonics in the relief development, the fact that can hardly be understood.

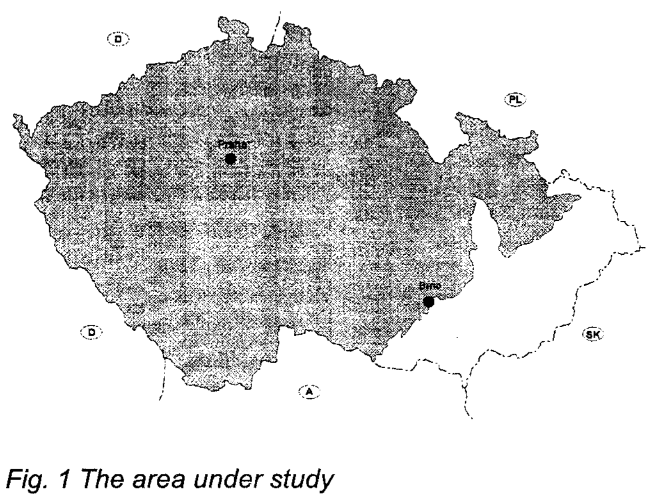

Fig. 1 The area under study

The problem can also be formulated in such a way that from the morphostructural point of view we are still missing a category in these divisions (an intermediate stage) that would include the marginal mountain ridges as a counterweight to the depression structure in the central part of the massif. The basin heterogeneity creates a good possibility to propose the units of the corresponding significance. Our preliminary proposal, meant for the necessary morphostructural division of the Bohemian Massif eliminates the shortcoming, distinguishing two units of the higher order (macroregions) in the Bohemian Massif. The macroregion of marginal elevations connects four units of marginal systems which are re-defined for the purpose as morphostructural areas while three areas (Tab. 2) are distinguished in the new macroregion of Bohemian Basin.

In the proposed morphostructural division the BB basis is formed by the Berounka River area and the Bohemian Cretaceous Basin. It is suggested that these two be adjoined by the Southern Bohemian area which came into existence via the connection of the Southern Bohemian Basins and the Central Bohemian Upland. Frontiers of these lower units (legalized in the geomorphological division by Czudek et al., 1972) are left without changes with some exceptions. The BM marginal elevations are formed by four areas: Šumava Mts. area, Bohemian-Moravian area, Krušné hory Mts. area, and Sudeten Mts. area. Certain changes in the division of these units (not their frontiers) are proposed on the contact point of the Bohemian Cretaceous Basin with the Bohemian-Moravian and Sudeten Mts. areas (see also Section 7.1). Sizes of morphostructural areas and their relations after the modifications are illustrated in Tab. 3.

It should be noted that the issue of Bohemian Basin delimitation is not entirely new. We can meet with it in works by Machatschek (1927) and Novák (1947), although under different names and in different concepts. In Machatschek's (1927) division of natural landscapes of the former Czechoslovakia the areas belonging to our concept of the Bohemian Basin would be those marked as Innerböhmische Rumpflandschaft and Nordböhmische Kreidegebiet. Even closer to our concept of the Bohemian Basin is the high-order orographic unit of "Centre of Bohemia" in Novák's work (1947). The two delimitations were published on small-scale maps and apart from the fact that they considerably differ in details, they are also rather schematic.

The contrast between the marginal elevations and the Bohemian Basin is generally known even to the non-professional public and the name of the Bohemian Basin with the concept of surrounding mountain ridges

Tab. 1 Geomorphological systems of Bohemian Massif according to Hromádka (1956), Czudek (ed., 1972) and Demek et al. (1987)

Hromádka (1956)	Czudek ed. (1972)	Demek et al. (1987)
	Šumava Mts. System	Šumava Mts. System
Southern Bohemian System		
	Bohemian-Moravian System	Bohemian-Moravian System
Krušné hory Mts. System	Krušné hory Mts. System	Krušné hory Mts. System
Berounka River System	Berounka River System	Berounka River System
Sudeten Mts. System	Sudeten Mts. System	Krkonoše-Jeseníky Mts. System
Bohemian Cretaceous Tableland	Bohemian Tableland	Bohemian Tableland

Tab. 2 A preliminary proposal for the morphostructural division of the Bohemian Massif

Bohemian Massif	
Macroregion of marginal elevations	Macroregion of Bohemian Basin
Šumava Mts. area	Berounka River area
Bohemian-Moravian area	Bohemian Cretaceous Basin
Krušné hory Mts. area	Southern Bohemian area
Sudeten Mts. area	

Tab. 3 Acreage and the highest points of Bohemian Massif morphostructural areas

Macroregion of marginal elevations		36 584 km^2	
* Šumava Mts. System	6 700 km^2		Velký Javor (1 452 m)
* Bohemian-Moravian Systém	13 176 km^2		Javořice (837 m)
* Krušné hory Mts. Systém	6 975 km^2		Klínovec (1 244 m)
* Sudeten Mts. System	9 738 km^2		Sněžka (1 603 m)
Macroregion of Bohemian Basin		29 705 km^2	
* Berounka River System	8 045 km^2		Tok (865 m)
* Bohemian Cretaceous Basin	13 332 km^2		Ralsko (696 m)
* Southern Bohemian System	8 328 km^2		Drkolná (729 m)
Bohemian Massif		66 408 km^2	

as a mountain barrier can be often met with in the mass media. However, the name of the Bohemian Basin can also be found in the above quoted (Hromádka, 1956, p.280) and other geomorphological works (Demek in Embleton ed., 1985, p. 216). In Germany, Hassinger (1925, p. 53) used the term of böhmische Becken; in Poland e.g. Walczak (1968) the term of Kotlina Czeska. The trend towards the delimitation of the depression situated in Central Bohemia was clearly suggested by the name of Central Bohemian Basin (Demek, 1995, p. 8) - but again with no integration into the hierarchy of units or delineation of its borders. Regarding the fact that the basin's projection reaches as far as to the Austrian territory in southern Bohemia, we prefer the name of Bohemian Basin in spite of being aware of a not exactly fitting cummulation of the adjective "Bohemian".

Thus, it is evident that the issue of BB delimitation should be opened and discussed again despite the efforts spent in the geomorphological regionalization of the Bohemian Massif, at the best in the context of the young massif uplift and together with some problems of terminological nature as suggested by Balatka et al. (1983). The very first term to be discussed is the Bohemian Massif as a common name for one of complex mountain ranges in the Western European platform (comp. e.g. Massif Armoricain and Massif Central in France). The names of these and many other large geographical units (the Alps, the Carpathians) are common to all natural historical sciences although their frontiers may become a subject of discussions. It is useful to point out at this moment that in all countries on the territories of which the Bohemian Massif is situated the name of Bohemian Massif (Masyw Czeski, Böhmische Masse or Massiv) has been used in geomorphology and geology already a long time and should therefore be preferred to the name of Bohemian Highlands used

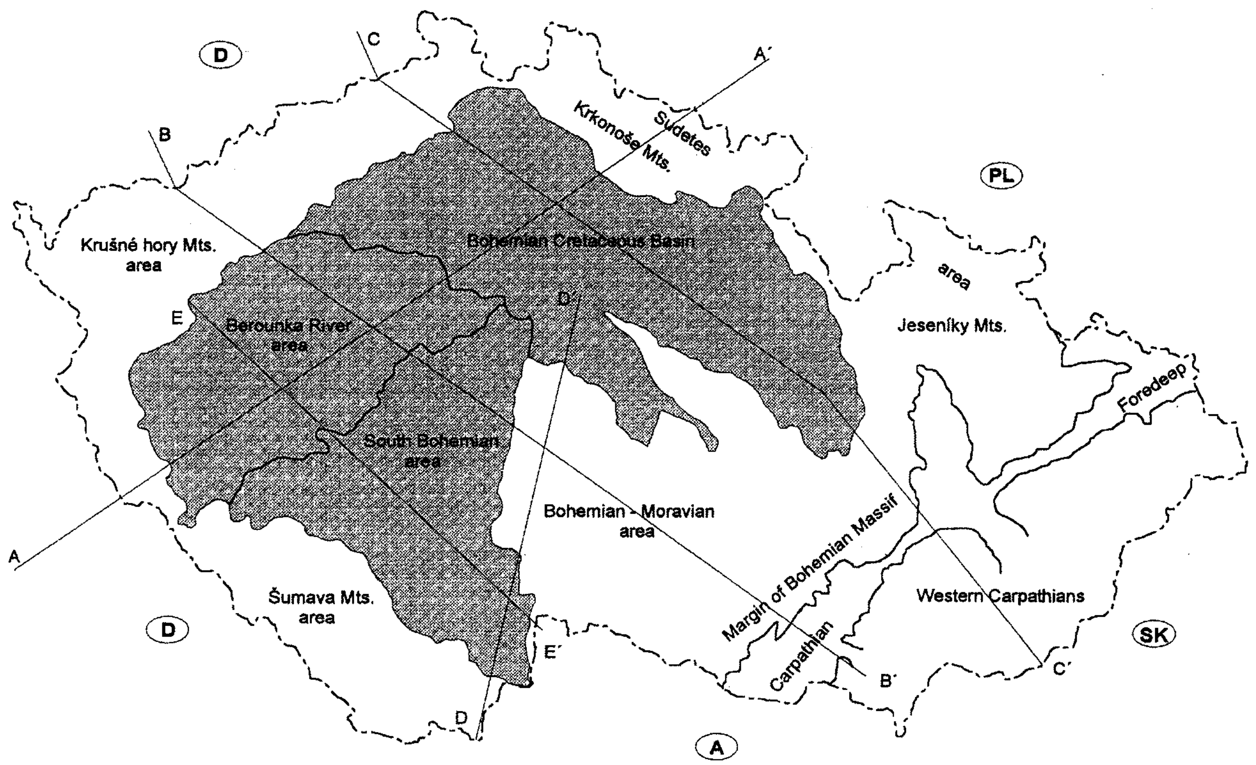

Fig. 2 The position of the Bohemian Basin (grey) and its three parts situated in the Czech Republic with lines of five profiles. Sketch: M. Bíl.

by Hromádka (1956) and his followers. The marginal elevations or their parts have been given established historical names that differ in details in the individual countries (see Czudek ed., 1972). The complementation and modifications in the CR relief geomorphological delimitation by Czudek ed. (1972), published in Demek (ed., 1987) brought in some problematic terminological changes of which the probably most disputable one was a replacement of the name of the "Sudeten Mts. System" situated in the northern part of the Bohemian Massif by the name of the "Krkonoše-Jeseníky Mts. System". Similar changes of names were made in the geological literature (comp. e.g. Svoboda et al., 1966; Mísař et al., 1983). They apparently represented a unnecessary and delayed response to post-War political changes and resulted in a less clear arrangement and misunderstandings. This is why we assume that it would be useful to return to the original name of the "Sudeten Mts. System" and to the derived terms since the name is old and historical, known as early as in the 2[nd] century (the map of Claudius Ptolemaius). In addition, the northern part of the system is situated in the Polish territory where the name continuity of "Sudeten" has been maintained (e.g. Kondracki, 1977). It can be recommended that the geomorphologists endorse an opinion that the Bohemian Cretaceous will be marked as the Bohemian Cretaceous Basin. The name would suggest its morphologically important synclinal structure and the predominating flat weak topography while the name of the Bohemian Cretaceous Tableland (Hromádka, 1956) or the Bohemian Tableland (Czudek ed., 1972) rather suggests the hard topography on subhorizontal resistant rocks with sharp edges (which occur only is some northern parts of the basin).

3. Notes to the delimitation of the Bohemian Basin

The difficult and contradicting issue of the delimitation of the Bohemian Basin is suggested by the fact that the highest point of the Berounka River area (Tok, 865 m) is higher than the highest point of the lowest branch in the ring of marginal elevations, the Bohemian-Moravian area (Javořice, 837 m). Therefore it stands to reason that at considering the classification with the Bohemian Basin we will consider the less uplifted internal parts of Bohemia with the remainders of the originally more extensive cover of Cretaceous sediments or the localities where the existence of such a cover in the past can be expected.

From this point of view, the wedge-shaped depression of South Bohemian Basins in the southern part of the massif belongs unambiguously to the Bohemian Basin. Hromádka (1956) includes the South Bohemian Basins into the Southern Bohemian System and Czudek (ed., 1972) into the Bohemian-Moravian System. These are the largest, relatively shallow subsidence structures on the Moldanubian basement. The South Bohemian Basins are separated from the relatively high south-eastern part of the Berounka River System and the low southern edge of the Bohemian

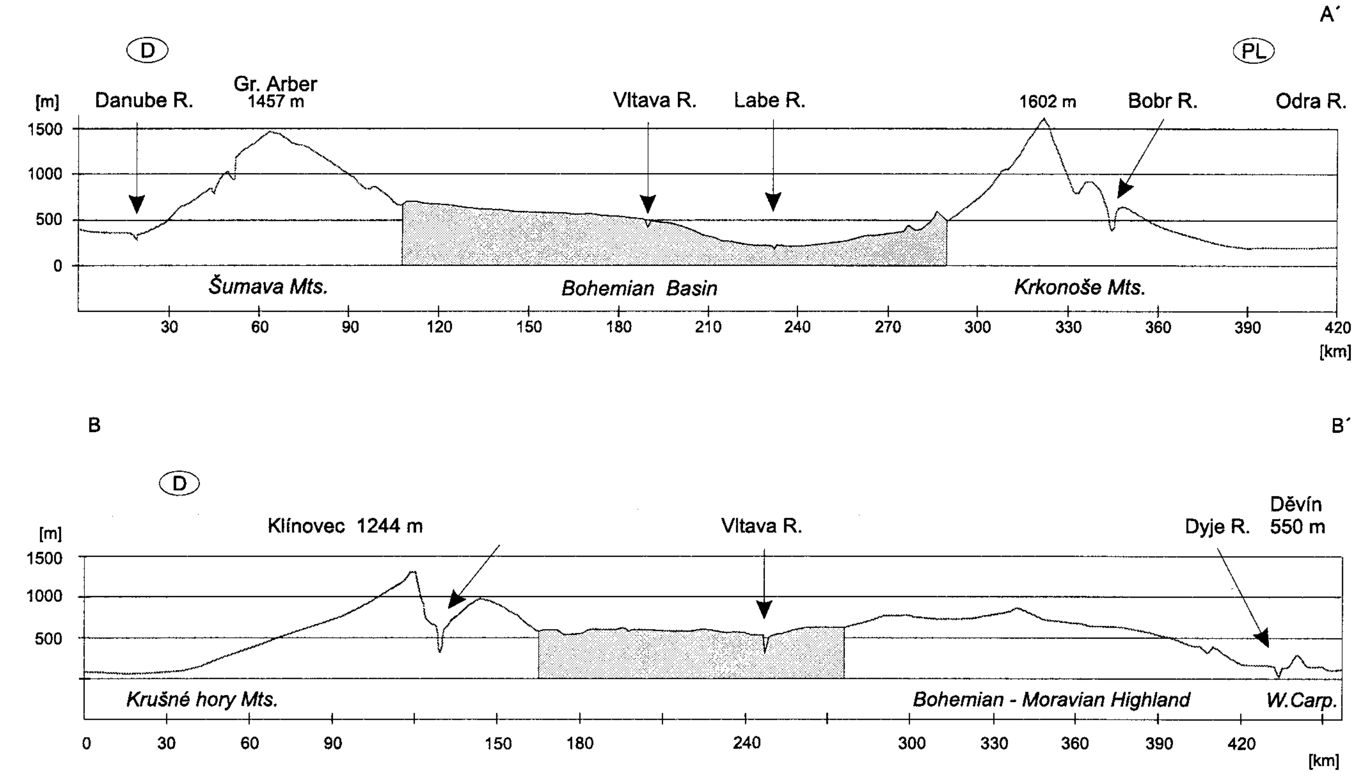

Fig. 3a,b Schematic profiles across the Bohemian Massif show the topographic contrasts between the marginal mountains and the Bohemian Basin (heavily exagerrated); profile A-A' from SSW to NNE, profile B-B' from NW to SE. Sketches: M. Bíl.

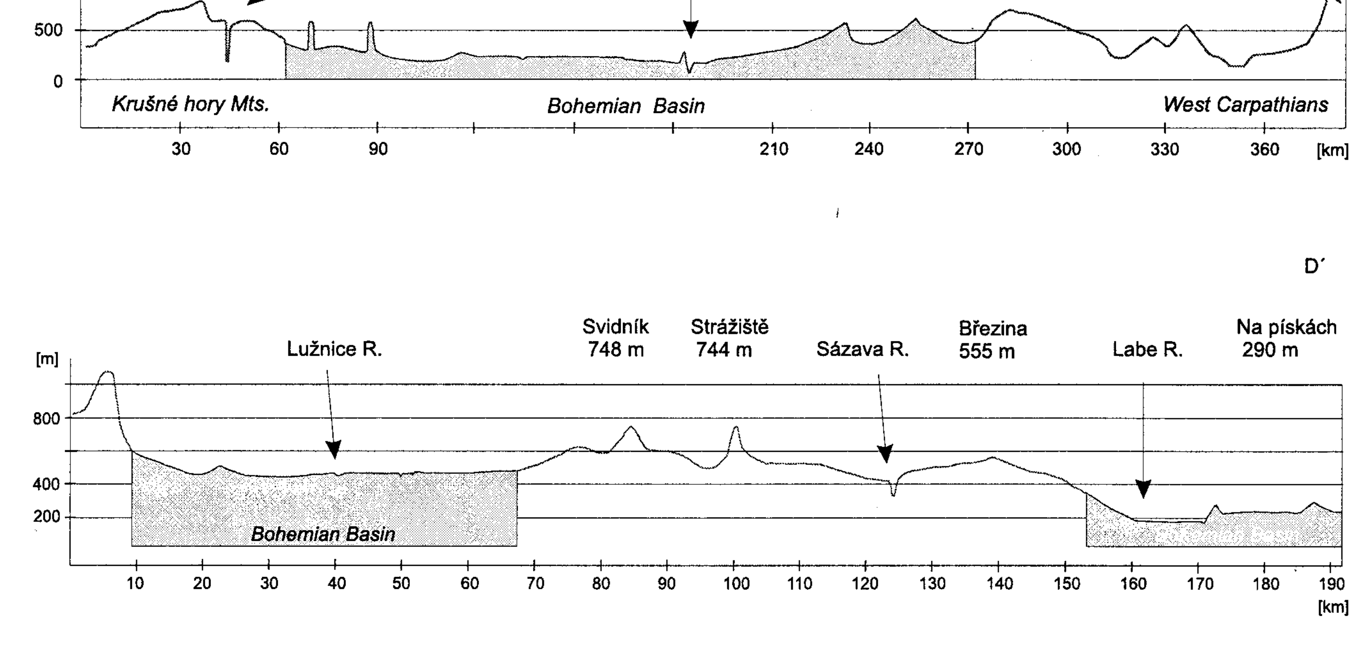

Fig. 3c,d Schematic profiles C-C' from NW to SE, D-D' from S to N. Sketches: M. Bíl.

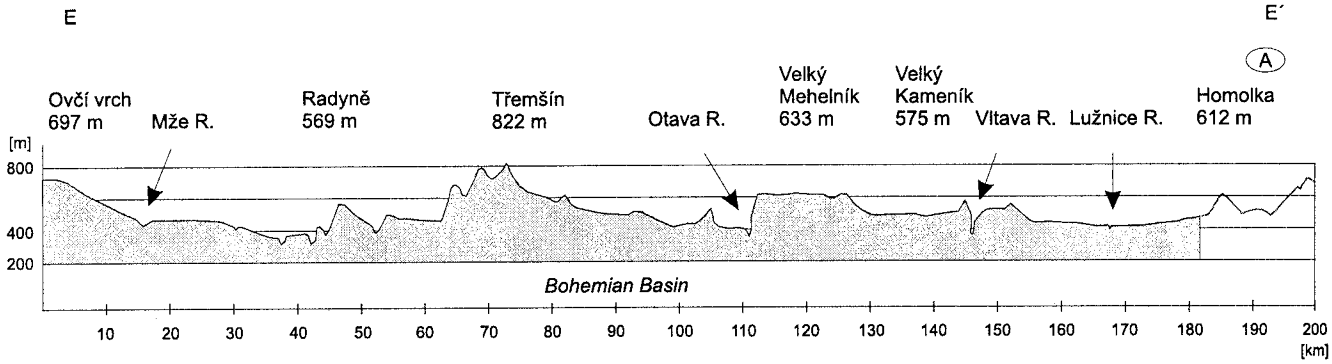

Fig. 3e Schematic profile E-E' from NW to SE. Sketch: M. Bíl.

Cretaceous Basin by the Central Bohemian Hilly Land whose elevation reaches up to 729 m. In the SE-NW profile between the South Bohemian Basins and the Berounka River System the Central Bohemian Hilly Land has the character of an intermediate block. In contrast, in the S-N profile, from the South Bohemian basins up to the southern edge of the Bohemian Cretaceous Basin, its character is that of a threshold (Figs. 2, 3). This is a good illustration of the checker-like structure of the massif, first pointed out by Hromádka (1956). The classification of the Central Bohemian Hilly Land to the Bohemian Basin with its relief closer to the mentioned neighbouring units than to the considerably higher Šumava Mts. area thus appears substantiated.

Especially difficult is the determination of the BB eastern frontier against the western part of the Bohemian-Moravian area where the eastern edge of the Třeboň Basin and its northern linking with the line of the Blanice Furrow Deep Fault (comp. Novák, 1947) seems an acceptable border line. Eastwards of the fault the Bohemian Basin (namely the Bohemian Cretaceous Basin) includes a not entirely unambiguous territory of the Kutná Hora Plateau and the Havlíčkův Brod Hilly Land. According to Malkovský (1974), Cretaceous rocks originally reached to about as far as Havlíčkův Brod. The remainders of Cretaceous sediments subsided along the Železné Hory Fault at the south-western foot of Železné Hory wedge-shaped block (Prachař and Ambrož, 1971) indicate their originally much larger extent. The Železné Hory Mts., belonging to Bohemicum and built by Proterozoic and Paleozoic sediments, however, are not ranked with the Bohemian Basin in spite of the fact that they were unequivocally covered with the Cretaceous sediments.

A less pronounced enlargement of the Bohemian Basin is being proposed in the Orlice Piedmont on the north-eastern edge of the Bohemian Cretaceous Basin and its contact with the Sudeten Mts. area. The Upper Cretaceous sediments in the central and eastern part of the Orlice Hilly Land were nearly entirely denuded due to germanotype tectonics, thus uncovering the sediments of Orlice Permian. In the Náchod Highland situated in the north-western direction the relief shows predominating uplift features and this is the reason why the unit is considered a part of the Sudeten Mts. area. The most severe denudation occurred along the south-eastern part of the Orlické hory Mts. (Žamberk Hilly Land) and the western edge of the Zábřeh Highland (Moravská Třebová Hilly Land). Southwards of Moravská Třebová the Upper Cretaceous sediments were entirely denuded from the axial part of the Litice anticline and the relief inversion resulted in a depression on the bottom Permian depression, which was later filled with Miocene marine calcareous clays. Delimitated as it is the Bohemian Basin takes up nearly 30 000 km^2, thus being the largest unit of the Bohemian Massif in the Czech Republic. Nevertheless, the macroregion of marginal elevations reaches far beyond the state border and the Bohemian-Moravian area with the Waldviertel ranks with the largest ones even after the Southern Bohemian area having been additionally incorporated into the Bohemian Basin. However, we point out that the Bohemian Basin delimitation is not always unequivocal and will call for a detail analysis or expert discussions where disputable areas are concerned.

4. Cadomian and Variscan basements as a basis of the present topography

The complex relief of the Bohemian Massif with a basin-shaped cross-profile of the Bohemian Basin reminding basins behind the escarpments of passive continental margins of southern hemisphere cratons (Ollier, 1985). The gentle basinwards slopes and the centripetal drainage pattern have apparently more causes. The basis of the present BM relief is a very complex block mosaic. The configuration of present major morphostructures was forming as early as in the pre-platform stage and its development was briefly outlined by e.g. Hirschmann (in Kukal ed., 1992). The Upper Proterozoic disintegration of the large continental plate was followed by the convergence of microplates, separated by rift systems with the oceanic or thinned continental crust (on the contact of Moldanubicum and Saxothuringicum). The plate convergence and subduction of the parts of former rift systems followed in Upper Proterozoic and Cambrian. The groundwork of the arc configuration of Central European Variscides came into existence during Cadomian orogeny and the system of intercontinental rifts in the NW-SE and NE-SW directions appeared in the period between Ordovician to Devonian. At those times, Moldanubicum and Bohemicum were an elevation area. From the beginning of Upper Devonian the sedimentations and volcanism shift into the area of Saxothuringicum and Variscan orogeny saw the collison, rise of groups of nappes and the final configuration of units. The configuration was made even more pronounced by the rise of the Permian and Carboniferous basins.

Older opinions about the BM geological structure were based on the geosynclinal theory and interpreted the massif as a zonal Variscan orogene. Considered were also effects of older orogenies: the clearly demonstrable Cadomian orogeny and the more problematic Caledonian orogeny. The development of opinions concerning the geological division of the massif was even more complicated than the development of theories concerning the geomorphological division (see Buday et al., 1963; Svoboda et al., 1966; Suk, 1995). Máška and Zoubek (in Buday et al., 1963) distinguished two following areas in the BM basement:

1) The Bohemian intermontane block with the loosely attached Moravian block (Brunnia). The intermontane block is an eastern part of the originally extensive Bohemian-Rhenish block and consists of a large compact Moldanubicum block and two smaller Cadomian-consolidated areas - the Teplá-Barrandian region in western Bohemia and the Železné hory Mts. region in eastern Bohemia. The two smaller regions were recently redefined by Malkovský (1979) as Bohemicum.
2) The area of intensive Variscan tectogenesis forms Saxothuringicum which surrounds the Bohemian intermontane block on three sides: in the Krušné hory Mts. (NW) it is Saxothuringicum s.s. ; in the western and central part of the Sudeten Mts. System it is marked as Lugicum, and in the eastern part of the Sudeten Mts. System as Moravosilesicum.

The position of the loosely attached Moravosilesian block is not entirely clear. In addition to the Variscan-folded Moravosilezicum it is also formed by the Cadomian unit of "Brunnia" (now marked as Brunovistulicum) which was originally a part of Fennosarmatia (Suk et al., 1983). Another possibility would be its origination in the foreland of Gondwana as a part of the Pan-African orogenic belt (see Finger et al., in Dallmayer et al. eds., 1994). Brunovistulicum became a part of the Bohemian Massif as late as in the course of Variscan tectogenesis. The unclear terminology used for the eastern part of the Bohemian Massif is further complicated by the Moravian block (Weiss, 1977).

Moldanubicum which forms the Šumava Mts. System and the western part of the Bohemian-Moravian System is the oldest and most consolidated part of the Bohemian Massif. Its structure, age and development have been a subject to many different opinions (comp. e.g. Fuchs, 1992 in Kukal ed., 1992; Zoubek et al. ibidem). Important from the geomorphological point of view is the fact that doubts were cast upon the role of Moldanubicum in the course of Variscan orogeny as a stable intermontane massif. According to Suk (1995), Moldanubicum was on the contrary an area of extensive orogeny (see also Beránek et al., 1980) where the intermediate mass was Bohemicum. The development could possibly be documented by the enormous pre-Variscan and Variscan denudation which would be a good explanation to the absence of pre-Variscan granitoid plutons that intruded into parts of the upper crust and were rapidly denudated (e.g. Stettner in Mahel, 1974). An indirect evidence could also be considered gravels of granitoid rocks of a so far unknown provenance in Paleozoic and older sediments. Saxothuringicum is generally considered to be the area of intensive Variscan orogeny. Tectonic uplifts and subsidences of the whole post-Variscan period occurred on the consolidated, partly cratonized basement with their character being mainly that of germanotype; they are marked as Saxon tectonics. In the earlier part of this period, the platform tectonic regime of the Bohemian Massif was relatively quiet with the occurring regional planation, accompanied by an isostatic uplift and interrupted by the Upper Jurassic marine transgression.

The rise of the Bohemian Cretaceous Basin was a dividing line which corresponds in time with the collision of the Africa and Euroasia plates. This was the beginning of the younger stage of Saxon tectonics in the Bohemian Massif, with a greater palaeogeographical differentiation of the relief and gradually growing uplift tendencies. There is an evidence of block movements in the eastern part of the Bohemian Cretaceous Basin as early as during Cenomanian (Vachtl et al., 1968; Fajst, 1969). The beginning of the tectonics is unclear and is being connected with different tectonic phases - Subhercynian, Laramide, etc. (comp. Malkovský, 1979). From the geomorphological point of view it seems useful to take the period from the Upper Cretaceous transgression up to Eocene for the beginning of the era of gradual formation of the Bohemian Massif block-faulted topography and to mark it as the first stage of late Saxon epiplatform orogeny. The post-Cretaceous movements occurred as early as under conditions of subarial denudation and their precise dating is therefore impossible. The most pronounced geological manifestations of early Saxon orogeny are the tectonic disturbances and deformations of platform sediments and the neovolcanites. However, the earliest

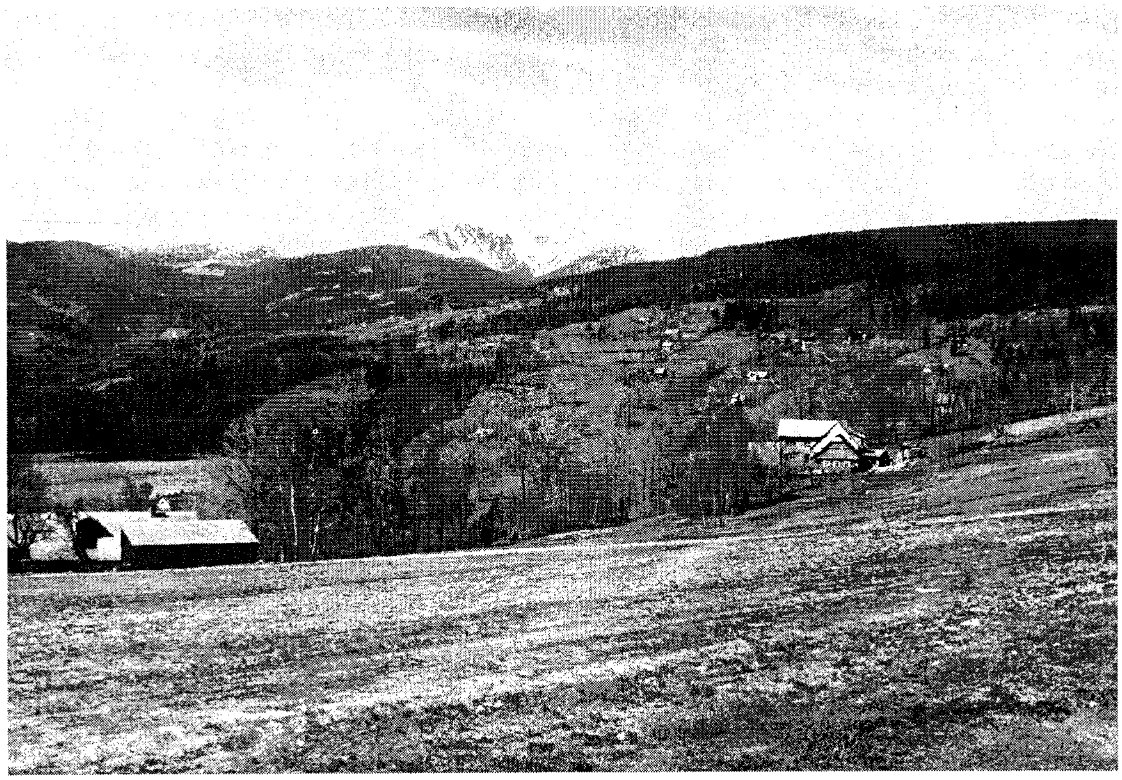

Fig. 4 Sandstone towers in the rock city of Hrubá skála Rock near Sedmihorky in the Turnovská pahorkatina - Hilly Land (the Maják Lighthouse group). Photo: B. Balatka

volcanic phase (Eocene - Oligocene, 37-17 Ma) occurred as late as after the demonstrable denudation of Upper Cretaceous sediments. In sections with the missing platform cover the geomorphological features of these movements were mostly removed by the denudation and their interpretation is not unambiguous.

The Saxon orogeny manifested in a different way and intensity in different parts of the massif, which was to a certain extent similar as in Variscan tectogenesis (the effect of above mentioned inheritage of structures). The analogy is also accepted by Malkovský (1979) by distinguishing the region of stable Moldanubicum and the region of intensive Saxonian tectogenesis. Moldanubicum misses larger remainders of the platform cover of Cretaceous and Tertiary sediments (with the exception of the South Bohemian Basins). Nevertheless, this does not necessarily mean that the Saxon tectonic movements were less intensive here.

On the one hand, Moldanubicum is the most consolidated part of the massif (which is corroborated by the absence of Caenozoic volcanism and CO_2 springs apart from the reduced extent of Meso-Caenozoic sediments). On the other hand, its elevations reach above 1400 m (near the maximum heights of the Bohemian Massif) and its contact with the Eastern Alps is very tight, which means that in Mesozoic and Caenozoic its exposure to the impact of the Alpine-Carpathian orogeny was greatest. Malkovský (1980) distinguished three subregions in the strongly differentiated area of intensive Saxon tectogenesis and the fact important from the geomorphological point of view is that each of them reaches both the marginal elevations and the Bohemian Basin. The three subregions are as follows:

a) The north-western subregion (Saxothuringicum s.s. and the western part of central Bohemicum) with the main NE-SW tectonic direction. The eastern frontier of the subregion is formed by the contact point between the Central Bohemian Hilly Land (Central Bohemian Pluton) with the Berounka River area. The relief has a distinct character of block tectonics.
b) The north-eastern subregion (Lugicum and the eastern part of Bohemicum) with NW-SE up to NNE-SSW main directions. The eastern frontier is formed by the Boskovice Furrow. The geological structure and relief of both the marginal elevations and the Bohemian Basin shows clear signs of both folding and block tectonics with the marginal elevations having morphologically more pronounced block tectonics and the folding tectonics (cuestas) being more characteristic of the Bohemian Basin.
c) The south-eastern subregion (Moravosilezicum, Brunovistulicum). The closeness of the front of Carpathian nappes resulted in a more intensive block faulting, the rise of marginal forebulge (Metacarpathian ridge), and the regeneration of Variscan dome structures.

The comparison of geological areas with different intensities of Variscan and Saxon tectogeneses and hypsometry indicates that with the exception of Bohemicum the areas are to a considerable extent identical. However, a question should be raised whether the montane parts of the Šumava Mts. also belong to the area of intensive Saxon tectogenesis, at least from the morphostructural point of view.

5. *Block structure of the Bohemian Massif*

An alternative concept of Bohemian Massif block structure appeared in the 1960s, which was later replaced by the concept of lithospheric plates. A present alternative to the Variscan zonal orogen is a model of Variscan and older terranes whose borders are approximately identical with the borders of blocks. The geological structure and the analysis of the Bohemian Massif topography (particularly the relief of marginal elevations) suggest that the massif is in its essence a complex and very heterogeneous block mosaic. The block structure is corroborated by geophysical research which provides important data about the tectonic geomorphology such as about the fault network, thickness and structure of earth crust, seismic activity, etc. Close relations were found between disjunctive tectonics and the distribution of mineral resources inclusive young mineralization (Chrt et Bolduan et al., 1968; Malkovský, 1979). On the basis of geological and geophysical characteristics it is possible to distinguish in the Bohemian Massif disturbances and blocks of various orders (Blížkovský et al., 1988). The blocks of various orders including the lowest ones can be delimitated also on the basis of the geomorphological criteria (especially on the uncovered basement). The block structure and a great significance of disjunctive tectonics in the development of the Bohemian Massif geological structure and relief are indisputable today as evidenced by a whole range of block structure models and synthetic works by Šťovíčková, 1973; Chrt and Bolduan et al., 1968; Zeman, 1978; Mísař et al., 1983; Suk et al., 1983; Malkovský, 1979, 1980). Also, the delimitation of seismotectonic blocks (Schenk, Procházková, Schenková in Bucha and Blížkovský eds., 1994) corresponds very well with the blocks delimitated on the basis on the relief analysis (Balatka et al., 1983).

Compared with the stable parts of eastern and northern Europe as well as in the comparison with the Alpine area the crust thickness in Variscan Central Europe is considerably lesser. According to Giese (in Dallmayer et al., 1995), the regular crust thickness in Central Europe (about 30 km) reflects mainly post-Variscan processes such as the Permian and Carboniferous extension and the Caenozoic rifting. However, the crust thickness in the Bohemian Massif is increased and ranges from 26 to 42 km (with the average of about 35 km) and the maximum thickness of 43 km under the central part of the Bohemian-Moravian Highland. The zone of maximum thicknesses stretches in the direction from South Bohemia eastwards to Moravia. Notable is the high average crust thickness - about 41 km under the Teplá-Barrandian block (Novotný in Vrána a Štědrá et al., 1997). The increased thickness indicates a massif subsidence in the North, West and partly also in the South (Suk et al., 1983). The increased crust thinkness are explained either by its evolution as early as in Proterozoic, or by its steady growth in the course of the later development. The latter possibility seems more realistic and can be supported by the above mentioned enormous extension of granitisation processes during Variscan orogeny. According to Procházková and Roth (1994), the present Moho topography in the Bohemian Massif was formed during the Savian and Young Styrian phases in Miocene. The geophysical research indicates a great heterogeneity of the BM crust where big changes in the composition occur in the horizontal direction, especially on the interface of blocks formed by deep faults (Zeman, 1978). The deep reflexion profiling revealed a great diversity of crustal blocks even in the vertical direction although with the increasing depth the geological structure gets rapidly simplified in the uppermost parts of the crust (Bucha, Blížkovský et al., 1994, Fig. 8.19).

The block structure of the Bohemian Massif as related to the composition and thickness of the crust was studied by Zeman (1978, 1979). He distinguished sialic blocks with the thickness of 34 to 42 km and the granitic/basaltic layer approximate ratio of 2:1, with negative gravitational and geomagnetic fields and mainly uplifting movement tendencies. With this group rank all marginal mountain ridges with the exception of the eastern part of the Bohemian-Moravian and Sudeten Mts. areas. However, it is also the southern Moldanubicum part of the Bohemian Basin that belongs here. Against them stand the simatic blocks with the crust thickness ranging between 27 and 34 km, with the approximate granitic/basaltic layer ratio of 1:1, positive gravitational and geomagnetic fields, and prevailing subsidence tendencies. The group includes Bohemicum, the Moravian block, Silesian and Brunnia (to a greater extent covered with foredeep sediments and Carpathian flysch). The changes of the crust type occur on the deep faults delineating the blocks. Two types of the crust with sharp change on the contact between crust and mantle are complemented with the third type with Moho representing a transition layer of up to 5 km in thickness, which is characteristic of the north-eastern edge of Moldanubicum (Bucha et Blížkovský ed., 1994). Details of the complex crust structure were revealed by international profiles of deep seismic profiling (Beránek et al., 1980, see also Bucha et Blížkovský eds., 1994). Height differences of the Moho surface are several times greater than the surface relief differences. The crust thickness is generally lesser under the marginal mountain ridges than under the Bohemian Basin. The problem, common to the mountain ridges of platform areas, was discussed by Škvor (1983). The research in western Bohemia (KTB Project) resolves the issue by cutting off the lithospheric roots on the basis of crust at the end of Variscan orogeny (Vrána and Štědrá eds., 1997). The roots originally continued into the upper mantle. This "tectonic"erosion was accompanied with the heavy surface erosion in the pre-Westphalian period.

Opinions about the geomorphological significance of differences between the upper brittle and lower ductile parts of crust (Battiau-Queney, 1989) which point out the rheological contrast on the basis of the lithospheric mantle appear a counterweight to plate tectonics. Creep type movements are probably occurring in the lower ductile part of the crust. The transition of the brittle crust into the ductile crust is assumed to range about the isotherm of 300/400°C. The quoted author claims that each block of the crust can have its own isostatic equilibrium, some blocks can be readily reactivated and in some the long-term development may result not in the planation but in larger height differences. There are different topographies of different ages that can exist in the landscape side by side. This concept can be very important for the Bohemian Massif with the very complex development and pronounced block structure, great differences in the crust thickness and particularly in the thickness of basaltic layer. According to Čermák et al. (1998), temperatures on the border between Moho and mantle in the Bohemian Massif range from about less than 400°C in Moldanubicum up to about 650°C under the Ohře rift and the Bohemian Cretaceous Basin. An index of brittle crust thickness can be the depth of earthquake focci. With the exception of Moldanubicum the Bohemian Massif has the prevailing earthquakes in its marginal mountain ridges, namely in the Krušné hory Mts. and in the Krkonoše Mts. This clearly shows the relation to the block structure. The thickness of the seismically active zone is from 3 to 17 km the lowest value being again appurtenant to Moldanubicum (Blížkovský et al., 1992). The contemporary geological concepts of the Bohemian Massif assign an essential importance to the tectonics of lithospheric plates, subduction, terranes, etc. The concept incorporated and modified older mobilistic theories, particularly the Variscan nappe tectonics (the Moldanubian nappe with the eastern vergency). During Variscan orogeny, western Moravia was a part of the zone of oblique collision and the contact point of several terranes. The issue of their frontiers in the eastern part of the Bohemian Massif was studied by Mísař and Dudek (1993) who distinguished five terranes here, separated from one another with a system of thrusts, vertical and horizontal faults and mylonite zones. A special position in the Bohemian Massif is that of Brunovistulicum, considered to be a possible original part of Fennosarmatia (Dudek, 1980; Suk et al. 1983; Suk, 1995). Brunovistulicum exhibits an enormously severe tectonic disintegration and inclines towards the East under the Western Carpathians which are the product of young Alpine-Carpathian orogeny with the northwestern vergencies. Thus, the Moravian part of the Bohemian Massif is a space with two approximately parallel overlapping orogenes with opposite vergencies (Stráník et al., 1993), extremely interesting not only from the viewpoint of geology but also in terms of tectonic geomorphology. The problem of terranes in the Sudeten Mts. area is now the subject to an intensive research pursued by Polish geologists (e.g. Cymerman, Piasecki, 1994).

6. Morphostructural characteristic of the Bohemian Basin

The relief of the Bohemian Massif being relatively well explored and the geological literature abundant, the following chapters will concentrate on some less known or latest pieces of knowledge about the geological structure and relief of the Bohemian Massif as related to the massif morphostructures, late epiplatform uplift or late tectonic movements in general.

The Bohemian Basin consists of three very different morphostructural areas: the Berounka River area, the Southern Bohemian area, and the Bohemian Cretaceous Basin. The order reflects the gradually decreasing age of their relief forms and their lowering altitudes. The relief prevailing in the first two areas is of erosion-denudation nature; the Bohemian Cretaceous Basin exhibits rather the erosion-accumulation relief. The basin is formed by two simatic and one sialic blocks with bedrocks from Proterozoic up to Tertiary. Some metamorphites in Moldanubicum of South Bohemia rank with the oldest basement rocks in the whole Bohemian Massif.

A dominating role in the drainage pattern of the Bohemian Basin is played by the rivers of Elbe and Vltava. Transversal valleys of the Elbe River, which follow closely after one another (across the České středohoří Mts. and the Krušné hory Mts.) separate the Bohemian Basin from the low northern foreland of the Bohemian Massif (some 100 to 150 m). The lowest point of the Czech part of the Bohemian Massif in the transversal valley of Elbe in the Krušné hory Mts. can be found at the height of 115 m. The southern edge of the Bohemina Massif is followed by the Danube flowing from the Alps, which forms magnificent breach valleys in the Austrian marginal part of the Bohemian Massif and leaves the BM forever near Krems at the altitude of 190 m.

All three areas meet near Český Brod at the crossing point of the Elbe lineament (WNW-ESE) with the Klatovy deep fault (SW-NE) and the Blanice deep fault (NNE-SSW) in the valley of Elbe and form a vague morphotectonic knot (covered with Quaternary sediments).

The Bohemian Basin has a relatively dissected topography which is also illustrated by the height difference (725 m) between the highest point (Tok, 865 m) in the Brdy Highland and the surface of the Elbe floodplain before entering the antecedent valley through the České středohoří Mts (140 m). The bottom of the Bohemian Basin and especially its edges are by 200 to 300 m higher than the foot of marginal mountain ranges. Due to the considerable thickness of Cretaceous and Permian and Carboniferous sediments the height differences of basement surface are considerably larger with the maximum thickness of Cretaceous sediments in the Bohemian Basin amounting to 964 m (a borehole near Kerhartice, altitude 330 m) and the height span of basement surface being 1500 m (Suk et al., 1991). After having added the maximum thicknesses of Permian and Carboniferous rocks (thickness 2200 m, height span of basement surface over 2600 m), the differences become even greater.

The prevailingly simatic blocks of the Bohemian Basin indicate its very complex geological structure on which very different types of relief could develop from young accumulation plains (along the lower Moldau and Elbe) up to gently undulated mountains (Brdy) with very old erosion-denudation forms. The relief on bedrocks of platform basement and the relief on the platform cover are of approximately identical acreage in the Bohemian Basin. Some parts are of the character of intrabasinal or threshold elevations. An important feature of Bohemian Basin relief development were repeated burials and exhumations, accompanied by transgressions, regressions and both general and differential uplifts and subsidences.

The area of younger post-orogenic Permian and Carboniferous basins was larger but partially overlapping with the area of older basins. According to Malkovský (1974), the Permian and Carboniferous sediments form 40% of the Bohemian Cretaceous Basin area. The Bohemian Cretaceous Basin was originally much larger than the present Bohemian Basin and its sediments can be found also in mountain ridges of northern and north-western parts of the massif. Denudation impaired the original connection of the Cretaceous basin with the Klodzko Basin. Its marginal faults turn towards the South-East at the southern end of the Králíky Graben and continue in the direction of the Hornomoravský úval (Graben). Probable is a former connection with Opole Cretaceous whose remainders in our country are known from the neighbourhood of Osoblaha (including lateritic weathering products on the Variscan basement). Uncertain -although probable- is the interconnection of the Bohemian Cretaceous Basin with South Bohemian Basins.

The Cretaceous sediments in the Bohemian Basin cover the Permian and Carboniferous basins more than the Proterozoic and Palaeozoic basins. Due to the complex structure and different basement mobility, conditions for the preservation of ancient forms in different parts of the Bohemian Massif were variable with the most favourable situation in the Bohemian Basin (namely in the Brdy Highland). The basement of Upper Proterozoic in the Teplá-Barrandian area is not known and the approximately oldest planation surface of the Bohemian Massif there is suggested by the angular discordance on the base of Lower Palaeozoic. An important stage of denudation in the final phases of Variscan orogeny is represented by planned structures under the sediments of Permian and Carboniferous basins. The Permian and Carboniferous basins of the present Bohemian Basin were less mobile than the basins in the area of Saxothuringicum. In some basins the Permian and Carboniferous sediments have deeply weathered crystalline rocks at the bottom. Correlative deposits in a greater part of the late Variscan basins suggest a typical morphology with pediments, playas and the manifestation of eolian activity in semi-arid to arid climatic-morphological areas (e.g. Holub, Skoček and Tásler, 1977; Lützner, 1988). The overriding importance from the viewpoint of assessing the size and character of the massif uplift in the period after the regression of the Upper Cretaceous Sea is that of the pre-Upper Cretaceous planation surface with sporadic places of fossilized weathering crusts and Palaeokarst forms.

6.1 The Berounka River morphostructural area

The Berounka River area in the NE-SW direction is the in terms of acreage smallest system of the Bohemian Massif in the divisions by Hromádka (1956) and Czudek (ed., 1972). Its shape is a rhomboid with parallel sides on NW and SE, delineated by deep faults or old shear zones. The western edge in the NNW-SSE direction is determined by the Mariánské lázně deep fault, the south-eastern margin then by the Klatovy deep fault. The Berounka River which approximately follows the longitudinal axis of the area has the identical direction along a great part of its course with a vague transition into the Most Basin and the Bohemian Cretaceous Basin in the NNE part. This is why it can be considered the largest intrabasinal elevation in the Bohemian Massif.

The Berounka River area as the highest part of the Bohemian Basin has a generally well understandable elevation position against the Středočeská pahorkatina Hilly Land in SE and against the Bohemian Cretacious Basin in NNE. However, it surprisingly has an elevation position also along a great part of its border with the Český les Mts. in WSW where it inclines into the Cheb-Domažlice Graben with a fault scarp on the Mariánské lázně deep fault. In the short section of this direction, the only little pronounced part is that of the frontier with the Všerubská vrchovina Highland, resulting from a relatively close relation between the Domažlice Crystalline and rocks of the Teplá-Barrandian area. Thus the only depression position of the Berounka River area is that in the North-West, opposite to the Tepelská vrchovina Highland and Doupovské hory Mts. Between the Doupovské hory Mts. and the České středohoří Mts. the

Fig. 5 The Western Krkonoše Mountains. A view from Benecko to Kotel (1435 m) in the Český hřbet Ridge. Photo: B. Balatka

area is of the elevation character on the contact line with the Žatec Basin (morphostructurally a part of the Most Basin, i.e. the Ohře rift). The unusual morphostructural position was a practical result of the young accumulative volcanic activity.

The relief of eastern and central parts of the Berounka River area is marked by its very good accommodation to resistance differences of rocks in the structure with complex folding. The area apparently passed a very complicated geomorphological development, which may be important for considerations about the Bohemian Massif relief in the period from Variscan orogeny to Upper Cretaceous transgression. The Brdy Highland is one of territories where the preservation of the oldest erosion-denudation relief forms in the Bohemian Massif can theoretically be anticipated. At the beginning, the relief descends towards the West in the Plaská pahorkatina Hilly Land (namely in the Plzeň Basin), and then ascends again in the Nort-West on the left bank of the Berounka River towards the Tepelská vrchovina Highland which geologically ranks with the Teplá-Barrandian area on the one hand, but on the other hand is morphostrucurally already an integral part of the Krušné hory Mts. elevation zone. This is given by the fact that the gentle inclination of the hilly land towards the South-East relates to the development of the eastern part of the Ohře rift.

The Brdy Highland in the vicinity of the contact line with the Středočeská pahorkatina Hilly Land is not only the highest part of the area and of the whole Bohemian Basin but there are also the oldest unmetamorphosed sediments and palaeovolcanic rocks emerging here. Basic magmatism that was particularly intensive in Upper Proterozoic and Cambrian is connected with the Proterozoic-Palaeozoic development. Proterozoic sediments that were deposited in a narrow eugeosynclinal basin (submarine volcanism), are of partly flysch character and went through an intensive Cadomian tectogenesis. They are separated from younger sediments by an angular unconformity (buried planation surface?). Cambrian sediments are rather of molasse character, suggesting an intensive denudation of the surrounding relief. The structure is further complicated by granitoid and basic bodies of which some have circular groundplans. Morphologically significant are also sporadic neovolcanites.

Major partial basins in Palaeozoic were as follows: the Příbram-Jince Basin with continental deposits of conglomerates in the Příbram asymmetric syncline; the Prague Basin, active during the whole Lower Palaeozoic (until Middle Devonian); and the Rožmitál area, delineated by faults. The basins went through a less intensive Variscan tectogenesis. In the Variscan period, the Teplá-Barrandian area subsided, perhaps due to the slipping of tectonic units from the rising Moldanubicum (Vrána and Štědrá eds., 1997). The relief exhibits great differences in the rock resistance, be them partly be subdued by metamorphosis. The in fact brachysynclinal structure with alternating anticlinoria and synclinoria (Holubec, 1990), complicated by numerous longitudinal and cross faults and thrusts, generated a basis in the Brdy Highland for the development of complex erosion-denudation relief of about Appalachian type with prepared and preserved structural ridges and knobs. Characteristic is the relief inversion as well as the complex drainage pattern. The highest part of the highland at the south-eastern edge and the general height decline towards the North-West relate to the palaeogeographical development, to the later tectonic inclination or to the drawing into the uplift of western part of the Central Bohemian pluton. One of possibilities is that the highland is cut through with the axis of the Central Bohemian threshold, in approx. E-W direction, arriving from the Středočeská pahorkatina Hilly Land. The latest studies indicate that the Teplá-Barrandian area reaches to about 30 km in the SE direction under the Central Bohemian Pluton (Vrána and Štědrá eds., 1997).

In the South-East, the highest point of Brdy (Tok, 865 m) links up with the granite relief on rocks of the Central Bohemian Pluton which already belongs to the Středočeská pahorkatina Hilly Land. The Palaeozoic sediments and granitoid rocks, in spite of being of different age, have an erosional cut at approximately same height. One of major problems in more dissected parts of the highland such as in the Křivoklát Highland and in the Hořovice Furrow concerns the distinguishing of young movements from the effects of differential erosion. In the Uppermost Palaeozoic, the earlier structure was covered with Late Variscan molasse basins: Radnice, Plzeň, Manětín, Rakovník and Kladno basins with the thickness of continental Permian and Carboniferous sediments reaching up to 1400 m. Main fault directions are NW-SE and NNE-SSW. The origination of basins was most probably connected with the later stage of gravitational collapse of thickened mantle lithosphere of the Teplá-Barrandian area on the contact with Moldanubicum, which began as early as at the turn of Devonian and Carboniferous (Zulauf et al., 1997). At that time, the Teplá-Barrandian area formed a centre of the high plateau which is being compared to the Tibetan Plateau by contemporary authors. In this case, it would be an alpine-type intermontane depression. Elznic et al. (1974) suggest the analogy of the Plzeň Basin with the Blanice and Boskovice furrows. The post-Variscan subaerial development also includes the rise of kaolins on Carboniferous arkoses in the Plzeň area, which probably partly occurred as early as during Upper Palaeozoic and continued later in Cretaceous and Tertiary (Kužvart, 1984). A great part of the highland was covered by Cretaceous sediments which are denuded today. The original sediment thickness in the northern marginal part of the area in the surroundings of Kladno and Rakovník is expected to range between 600 and 750 m (Mareš, 1969). The morphologically most conspicuous remainder of Cretaceum is a heavily tectonically disturbed mesa of Džbán (536 m). On the other hand, the distribution of Cretaceous sediments in the highest parts of the Brdy Highland and hence the age of top platforms in the highland is problematic. The later Saxon tectonics can be documented not only by the block disturbance of Cretaceous, but also by sporadic and morphologically conspicuous occurrences of neovolcanites. Significant are karst forms (partly fossil) on Palaeozoic limestones.

6.2 The Bohemian Cretaceous Basin morphostructural area

The Bohemian Cretaceous Basin ranks with West European intracratonic basins. The rests of Triasic deposits are preserved also in the Sudeten Mts. area as well as the denudation Jurassic remainders on the Lusatian fault. The occurrence of Jurassic sediments at the western edge of the Moravian Karst and that of pebbles in the Svitavy region led to the presumption of a shelf lagoon of the NW-SE direction across the whole Bohemian Massif (Eliáš in Suk et al., 1984). Cretaceous sediments form a filling of the asymmetric syneclise with the WNW-ESE axis. The origination of the basin, which is usually connected with the opening of the Atlantic Ocean or with the beginning orogeny in the Alps and Carpathians was perhaps facilitated and the position determined by a disturbance zone or a lineament, copying the Elbe shear zone (Rajlich, 1993). Towards the North-West, Cretaceous rocks penetrate across the Krušné hory Mts. into Saxony (Elbegraben) and is marked as an Elbe rift by some authors (Jowett, 1991). The direction of basin axis changes up to NNW-SSE in the eastern part of the basin in the connection with the bending of the Lusatian fault and after the crossing with the Boskovice Furrow the basin ends blind with the asymmetric Blansko Graben northwards of Brno. A continuation of the basin to the South or South-East into the region of the present Carpathians is very probably and is indicated by denudation remainders of Cretaceous rocks southwards of Blansko and in the Zábřežská vrchovina Highland near Maletín.

The thickness of Cretaceous sediments in the western part of the basin adjacent to the České středohoří Mts. is greatest with the basin being heavily disturbed by block tectonics. The most important disturbance is the Lusatian fault (Malkovský, 1977) which delineates the basin from the North and continues to Saxony (thrusting of crystalline rocks over Cretaceous sediments). The basin continuity is disturbed by neovolcanites of the České středohoří Mts. The Upper Cretaceous sediments occur also in the Most Basin the connection being indicated by the Žatec Basin. In the shallower eastern part of the Bohemian Cretaceous Basin the block movements of Cretaceous sediments were transformed into broad and flat - up to 80 km long - anticlines and synclines in the NNW-SSE direction, on which cuestas came into existence. From the morphostructural point of view, an integral part of the Bohemian Cretaceous Basin should also be the northern part of the Hornosázavská pahorkatina Hilly Land, adjacent to the Bohemian Cretaceous Basin. In its norhern part that is formed by the Kutná Hora Plateau and the Havlíčkův Brod Hilly Land, the relief gently inclines to the North towards the southern edge of the Bohemian Cretaceous Basin, in other words towards the southern foot of the Železné hory Mts. The Havlíčkův Brod Hilly Land ends in the North in the Dářko Furrow into which the Cretaceous sediments subsided in the foreland of the Železné hory Fault forming a block thrust. Extensional post-Cretaceous tectonic movements are indicated by the subsided block of Cretaceous sediments in the Moldanubicum near Škrdlovice (Prachař and Ambrož, 1971).

Conspicuous dominants in the western part of the basin are neovolcanic necks of which Ralsko (696 m) is the highest point of the basin. The necks jut above the post-basaltic planation surface, with lava flows and groups of nappes sporadically conserving the pre-basaltic surface. The Cretaceous sediments occur in very different altitudes. However, at some places they were drawn into the uplift also in marginal mountain ridges - up to the height of 723 m in the Krušné hory Mts., up to 919 m in the Central Sudeten depression in the Polish part of the basin. The base of sediments which is characteristic of the pre-Cretaceous planation surface is a good indicator of late Saxon tectonic movements amplitudes. Some parts of the basin were secondarily separated by denudation due to the post-Cretaceous uplifts. This mainly applies to the Klodzko Basin in whose southern part (the Králíky Graben) Upper-Cretaceous sediments were found of 730 m in thickness, similar to the sediments of near situated parts of the basin (Valečka, 1988). Great thicknesses of the youngest sediments (Santonian) and a partially flysch character may indicate an increasing tectonic activity towards the end of the Upper Cretaceous and a following regression. The connection of the Bohemian Cretaceous Basin with the South Bohemian Basins and the Opole Cretaceous in the northern foreland of the Jeseníky Mts. still remains an open question.

There are 8 lithofacial areas distinguished in the Bohemian Cretaceous Basin, which house different relief types. The character of lithofacies as correlate sediments is not clear similarly as their relation to source areas, the significance of synsedimentary tectonics, sea streams etc. The major source area of sandy facies, important for the development of tablelands and sandstone forms was the isle of the West Sudeten (the area of Lusatian and Krkonoše Plutons). A certain picture about the extent and rate of Cretaceous sediments denudation is provided by neovolcanite fills prepared by differential erosion, although the volcanic activity occurred relatively long after the regression of the Cretaceous sea. In the surroundings of Kladno the denudation extent is indicated by "xenoliths, today already denuded series of strata in the neovolcanites or their blocks subsided into fault fills" (Mísař et al., 1983, p. 282). In this sense, it will be necessary to further study the so called pre- and post-basaltic reliefs. Neogene surfaces were preserved on sandstones; a development of cryopediments could have occurred on less resistant clayey and marly sediments in Pleistocene. The Bohemian Cretaceous Basin is also the area of the greatest occurrence of river terraces (Balatka, 1992). Edges of the Bohemian Cretaceous Basin on the contact with the exhumed basement are either of erosional and fault character (the Lusatian thrust, the Železné hory fault) or of flexure character (Ivan, 1992a). The edges in the northern part of the basin are generally higher than the edges in the southern part. There are sandstone rock cities with structural forms and clear effects of disjunctive tectonics in the relief. The mostly flat basin topography reflects both the lithological differences (particularly those between massive sandstones and less resistant marl rocks and the differences resulting from faulting or mild deformations (the cuesta relief in the eastern part of the basin). The cuesta relief between Polička and Lanškroun forms a complex crossing of the Main European Divide (Elbe-Danube) and Miocene (Lower Badenian) marine calcareous clays emerge in its area nortwards of Svitavy at the height of 550 m.

6.3 The South Bohemian Hilly Land morphostructural area

The area includes the lower relief on Moldanubicum rocks in the western part of the existing Bohemian-Moravian System, the South Bohemian Basins and the Středočeská pahorkatina Hilly Land.

6.3.1 The South Bohemian Basins

The South Bohemian Basins are situated in the contact area between the Šumava Mts. System and the Bohemian-Moravian System, inside the horseshoe-like half-arc formed by two branches of Central Moldanubian Pluton. Their geological area (2300 km^2, Svoboda et al., 1966) is larger than the geomorphological area (2000 km^2, Czudek ed., 1972) and indicates a heavy denudation of the sedimentary fill. The basins came into existence on a morphostructural knot, right on the crossing of the Jáchymov deep fault system (NW-SE to NNW-SSE) and the Blanice Furrow deep fault (NNE-SSW) with a partial influence of EW disturbances. The faults form a dense network of the type sometimes marked as "parquette" tectonics. The crystalline bottom of the basin consists mostly metamorphosed rocks and to a lesser extent also granitoids. The České Budějovice Basin exhibits a denudation remainder of the Permian and Carboniferous fill of the Blanice Furrow (thickness of about 200 m). From the morphostructural point of view the basins form a double graben with the larger and more complex eastern Třeboň Basin and the smaller České Budějovice Basin situated in the

West. Longer basin axes are of NNW (NW)-SSE (SE) direction. The longitudinal axis of the double graben of South Bohemian Basins (NW-SE) heads approximately towards a sudden bend of the Bohemian Massif edge near the Danube River. The Třeboň Basin reaches into Austria with its south-eastern part, where it is closed again and the main Elbe-Danube Divide opens southwards of its closure. At this place, the Divide breaks to SSW-NNE, a direction characteristic of the Bohemian-Moravian Highland.

The fill of the basin consists of Upper Cretaceous and Neogene sediments and of kaolinic weathering products that were to a considerable extent redeposited. The České Budějovice Basin exhibits a much lesser extent of Upper Cretaceous sediments; however, Tertiary sediments at the basin bottom stretch towards the North-West as far as Strakonice. The Cretaceous and Neogene thicknesses reach up to 340 m and 200 m, respectively. The present situation in the stratigraphical division of the basin Tertiary fill (and the comparison with other basins) is described in Malkovský (1995). The basins are separated by a low horst of Lišov threshold with the (pre-Cretaceous?) planation surface. In addition to the block tectonics, the crystalline of the Lišov threshold exhibits also resistant rocks (gneisses, granulite). The horst structure of the Blanský les Mts. (Kleť, 1084 m) which forms the western edge of the České Budějovice Basin and belongs to the Šumava Mts. shows ring features on granulite, serpentine and amphibolite. The Třeboň Basin is passed by the Lužnice River from SSE to NNW and the České Budějovice Basin by the Vltava River from the South to the North. The two rivers meet in the initial section of the Vltava R. water gap through the Středočeská pahorkatina Hilly Land (Central Bohemian threshold). The drainage pattern of both rivers suggests a delicate adjustment to fault and fissure tectonics. The main issue, represented by the reversal of drainage from N-S to S-N in the direction from the Alpine orogene and the Alpine foredeep would call for a more detailed research and a morphostructural analysis.

6.3.2 The Středočeská pahorkatina Hilly Land

Northwards of the South Bohemian Basins there is the Středočeská pahorkatina Hilly Land with a threshold character in the relation to the Bohemian Cretaceous Basin, the feature which reflects in a frequently used term of Central Bohemian threshold. This is probably a young, flat tectonic dome with the ESE-WNW axis, crossed through by a deep Vltava R. valley of the water gap type. The Hilly Land borders are little pronounced In northern parts the exhumed pre-Cretaceous planation surface slowly sinks under the Upper Cretaceous sediments. The transition of the Hilly Land on the late Variscan granitoids of Central Bohemian Pluton into the Brdy Highland on considerably older Barrandian sediments occurs with no marked difference in the topographic degree. This is particularly striking in the Klatovy Basin that originated mainly on the apophysis of Central Bohemian Pluton as a part of Švihovská vrchovina Highland and hence a part of the Berounka River System. The transition is releaved by "floating" blocks of Barrandian rocks, Jílové zone and "islet" zones in Pluton. The frontier with the Šumava Mts. System in the South-West is also little explicit although making use of the Variscan Horažďovice fault. In the South-East, the Středočeská pahorkatina Hilly Land reaches as far as the Blanice Furrow.

The hilly land is mostly formed by the late-Variscan, petrographically complicated Central Bohemian Pluton which intruded into the Central Bohemian shear zone and "healed it" (Rajlich, 1991). Nevertheless, the intrusion is also connected with the geographically expressive Klatovy deep fault (Šťovíčková, 1973) and it can be manifested either by a narrow, over 70 km long syncline "islet" zone with weakly metamorphosed blocks of Proterozoic and Palaeozoic sediments, close to Barrandian of to the Železné hory Mts. area, or by a much narrower but petrographically more uniform Jílové fault. The metamorphosed Palaeozoic sediments of the "islet" zone suggest the originally much greater distribution of these sediments (Chlupáč, 1992). The depth of Pluton denudation in the north-eastern direction shrinks and it is also the absolute heights of relief surfaces that decrease in this direction. Predominating is the hilly land relief with "etchsurface" being probably a better corresponding term than "etchplain". Numerous, more or less isolated hills representing a certain analogy to inselbergs can be found in the western part, along the edge of the Brdy Highland. These are structural forms of more resistant metamorphosed rocks of Central Bohemian Pluton mantle such as gneisses and migmatites (Drkolná, 729 m; Neštětická hora Mt., 536 m; Pecný, 546 m, etc.). In contrast, the eastern part of the Pluton exhibits a clear majority of various granite types of which e.g. the granite of Čertovo břemeno (Devil's burden) type is distinct in the relief. Although the Central Bohemian Pluton also has a frequent typical granite relief (e.g. near Blatná and Sedlčany), any more conspicuous inselbergs of the type of high exfoliation domes are missing. Geomorphological aspects of the great variability of Pluton granitoid rocks have not been yet studied in details.

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THE STABILITY RELATIONS OF SUPPORTING SYSTEMS OF BRIDGES AND TUNNELS IN STRESS FIELDS OF GRAVITATIONAL LOOSENING ZONES (ON THE EXAMPLE OF THE IVANČICE VIADUCT, SOUTH MORAVIA)

Mojmír HRÁDEK

Abstract

Supporting systems of the Ivančice viaduct across the Jihlava River were founded in an uneven way: in crystalline bedrock in the eastern part and in clayey and sand cover of Miocene sediments, river terrace gravel sand and loess in the west. Apart from this, the interdisciplinary geo-scientific and engineering research near the Ivančice viaduct on the slopes of Jihlava River valley provided an evidence on the presence of significant fracture zones generated primarily as a result of Variscan orogenesis and restored in the course of Alpine orogenesis. The existence of deeper loosened tectonic fractures and zones of crushing and the proven deeper circulation of ground water facilitated differentiated subsidence of blocks and gave rise to a pronounced block structure of the valley with partial horsts, floating blocks and grabens. A coherence was sought between the proven block structure of the area with the horizontal and vertical deformations of supporting systems. Except for a possible action of piping in loesses and deeper sunken covers due to subsurface water circulation, the effects of block structure and rock massif loosening on bridge stability were not proven. Mathematical modelling showed that the primary cause to the unstable environment is the dissimilar way of foundation of the two bearing supports.

Shrnutí

Stabilitní poměry nosných systémů mostních a tunelových staveb ve stresových polích zón gravitačního rozvolnění (na příkladu Ivančického viaduktu, jižní Morava)

Nosné systémy Ivančického viaduktu přes řeku Jihlavu jsou nestejně založeny. Na východní straně v krystalickém podloží a na západě v miocénním jílovitém písku, říčním štěrkopísku a spraši. Kromě tohoto poznatku přinesl komplexní geovědní a inženýrský výzkum v okolí Ivančického viaduktu, na svazích údolí Jihlavy, důkazy o přítomnosti významných zlomových linií vytvořených primárně jako výsledek variské orogeneze a obnovených v průběhu orogeneze alpinské. Přítomnost hlubších, rozvolněných zlomových poruch a zón drcení a prokázaná hlubší cirkulace podzemní vody vytvořily podmínky pro diferencovaný pokles ker a vznik výrazné kerné stavby údolí Jihlavy u Ivančic s dílčími hrástěmi, plovoucími bloky a příkopy vyplněnými miocénními sedimenty. Byly také hledány souvislosti mezi prokázanou kernou stavbou území a horizontálními a vertikálními deformacemi nosných systémů. Kromě možného působení sufoze ve spraších a hlouběji zakleslých pokryvech vlivem cirkulace podzemních vod se nepodařilo vliv kerné stavby a rozvolnění skalního masivu na stabilitu mostu prokázat. Matematické modelování ukázalo, že již samotný nestejný způsob založení obou nosných opěr vytváří nestabilní prostředí.

Key words: convergent platform margin, neotectonics and gravitational tectonics, loosening of rocks, bridge supporting systems foundation, disturbance of stability, Czech Republic

Note

Project manager Dr. M. Hrádek, CSc. was assisted at his research by teams from the Institute of Geonics, Czech Academy of Sciences with doc. Ing. P. Konečný, CSc., Dr. J. Malík, CSc. and Dr. Z. Kaláb, CSc., from the Institute of Geological Engineering (High School of Mining and Technical University Ostrava) where the team consisting of Prof. Ing. K. Müller, DrSc., doc. Ing. R. Grygar, CSc., doc. Ing. L. Hofrichterová, CSc., Ing. A. Poláček, CSc. and Ing. J. Jelínek worked under the leadership of doc. Ing. J. Müllerová, CSc., from the Institute of Wood and Steel Structures (Faculty of Civil Engineering, VUT Brno) led by Prof. J. Melcher, DrSc., Design and Drawing Office Ing. A. Pechal, CSc. from Brno and other experts.

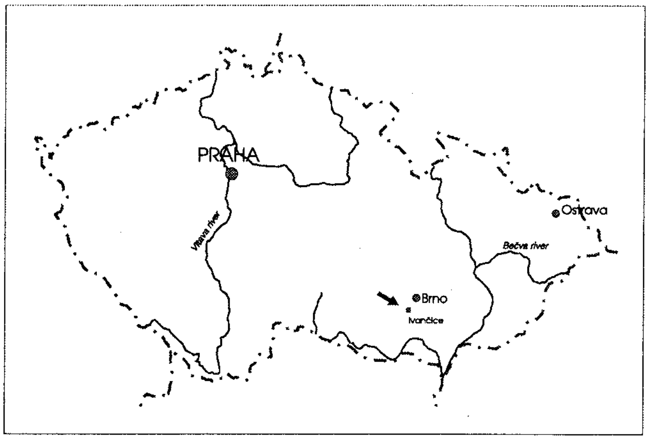

Fig. 1 The situation of the Ivančice viaduct in the Czech Republic.

1. Introduction

The Project of "The stability relations of supporting systems of bridges and tunnels in stress fields of gravitational loosening zones" was supported by the Grant Agency of Czech Republic (No. 103/95/1536) and implemented in 1995-1997. It concerned the issue of stability of bridges founded within the rock environment of the tectonically loosened rock massif in valleys situated on the convergent SE margin of the Bohemian Massif, near its contact with the subsided area of the Carpathian Foredeep. As a model area was chosen the railway bridge across the Jihlava River near Ivančice - the so called Ivančice viaduct (IVV) and its surroundings which is situated in the centre of the mentioned area.

The main workplace was the Institute of Geonics, Academy of Sciences of the Czech Republic, in whose Brno Branch Office an evaluation of the final report (Hrádek - Müllerová - Melcher, 1997) was made on 15 January 1998. The acquired knowledge is important for the study of tectonically loosened rock massif in valley environment both from the viewpoint of bridge foundation and from the viewpoint of general geomorphological and geological development of convergent platform margin.

Since the features of rock massif loosening can be polymorphous and the ways of their identification and surmounting of their effects at the foundation of structures very heterogeneous, the project employed interdisciplinary approaches with participating specialists from nearly all earth science branches (geomorphology, engineering and structural geology, applied geophysics, hydrogeology and geotechnique) and from disciplines of building and construction (geodesy, photogrammetry, design and construction of bridges).

2. Project objectives

The project objectives consisted in defining the zones of gravitational loosening in the southern part of the Brno Massif produced by tectonic deformations, in the assessment of their wider importance and in studying the coherences between their existence and the disturbed stability of supporting systems of bridges and deformation of their structures. No stability disturbances were found in tunnels which are situated farther from the valley. The very beginning of the project also offered a possibility to assess possible neotectonic and gravitational tectonic effects on the rise of bridge stability disturbances.

3. Research of stability situation in supporting systems of the Ivančice viaduct as related to the zones of gravitational loosening in its surroundings

It is the railway bridge across the Jihlava River near Ivančice that has been spoken of as the Ivančice viaduct (IVV) since 1925. Today, there are two bridges at this place after chronic technical defects of the old bridge built in 1870 led to the erection of a new one after more than a hundred years, which was put into operation in 1978. This bridge is of single-track bridge construction consisting of a six-field bridge beam dwelling on plate steel supports with frame structure. The supports are made of concrete, massive with parallel wings. They differ in terms of their foundation on both sides. On the eastern side with fixed bearings the support is founded in the rock crystalline basement with no problems. In contrast, the situation on the western side is more complicated. In the 30 m thick loess sedimentary cover, fluvial gravel sands of higher terrace and water-bearing Miocene sands the support dwells on 20 m bored piles seated into the Miocene sands. On this side the bearings between the structure and the support are movable, allowing the expansion of +/-200 mm. After 8 years of operation, the expansion joint reserve between the steel structure and the support on the western side of the new bridge began to show a gradual shrinking and at the same time the western support began to sink and tip. Measurements made in 1995 indicated a subsidence of the southern support by 58 mm. Maximum horizontal deformations in one of measuring boreholes reached 46 mm near the surface and up to 63 mm in deeper sections in 1991, which led to a consideration about the hypothetical existence of a shear zone at the depth of about 20 m. Safeguard measures of the lower structure were commenced, which consisted in the erection of a pile wall with anchorage and a surcharging wall and monitoring of inclinometric and geodetic measurements. The grant project research included the assessment of their efficiency.

Fig. 2 The Ivančice viaduct across the Jihlava River valley. The western support is founded on piles in Miocene water-bearing sands, the northern support is fixed on the opposite side of the valley in crystalline massif. The tectonic Bránická kotlina (basin) with a broad floodplain and subsided Miocene sediments to be seen to the right of the bridge, to the left the structure of the old Ivančice viaduct. In the left background in front of the forest and summer houses there is a rocky slope bench bounded by a fault at the foot of the higher slope. Here the Jihlava River left a high river terrace. Photo M. Hrádek.

The research brought an evidence on the existence of loosened, both narrow and even several hundred meter wide fracture zones of various directions in the surroundings of the bridge, with the manifestation of cataclasis, intensive crushing, inclined to rock fall, block toppling and the rise of rock slides, and with tensional gravitational opening of fissure systems, which gives rise to tiny gravitational dilatant (tension) gashes and fault saddles on the surface.

Steep dipping faults 70-80° towards the valley centre and backtilted fractures dipping oblique from the valley centre against the slopes, separating partial blocks of horsts was found.

The morphostructural research confirmed the block tectonic structure of the valley, consisting of horsts and blocks "floating" in the loosened zones. These partial horsts are on both valley sides separated with hanging grabens. The course of block separating grabens is in general semicircular and in detail complicatedly fractional with dominating NW-SE faults; the partial horsts interlock with their nose-shaped projections. Individual horsts and graben form a complicated step-like graben, apparently at the place of up-doming of original surface.

It was not successfully proven whether the floating blocks on the slope of the Jihlava River penetrate subvertically by sinking into the deeply loosened zones of Sudetic direction or move along listric faults, or even along the detachment fault due to lateral spreading. It seems, however, that close space in valley is limited for activity of lateral spreading.

The Miocene sediments with covers of Quaternary formations (loesses, fluvial sediments) lying on the unevenly into the valley sinking blocks (in grabens) produce an unstable environment for the foundation of bridge and tunnel structures.

Proven was also the aquiferation of deeper tectonic zones which create conditions for groundwater circula-

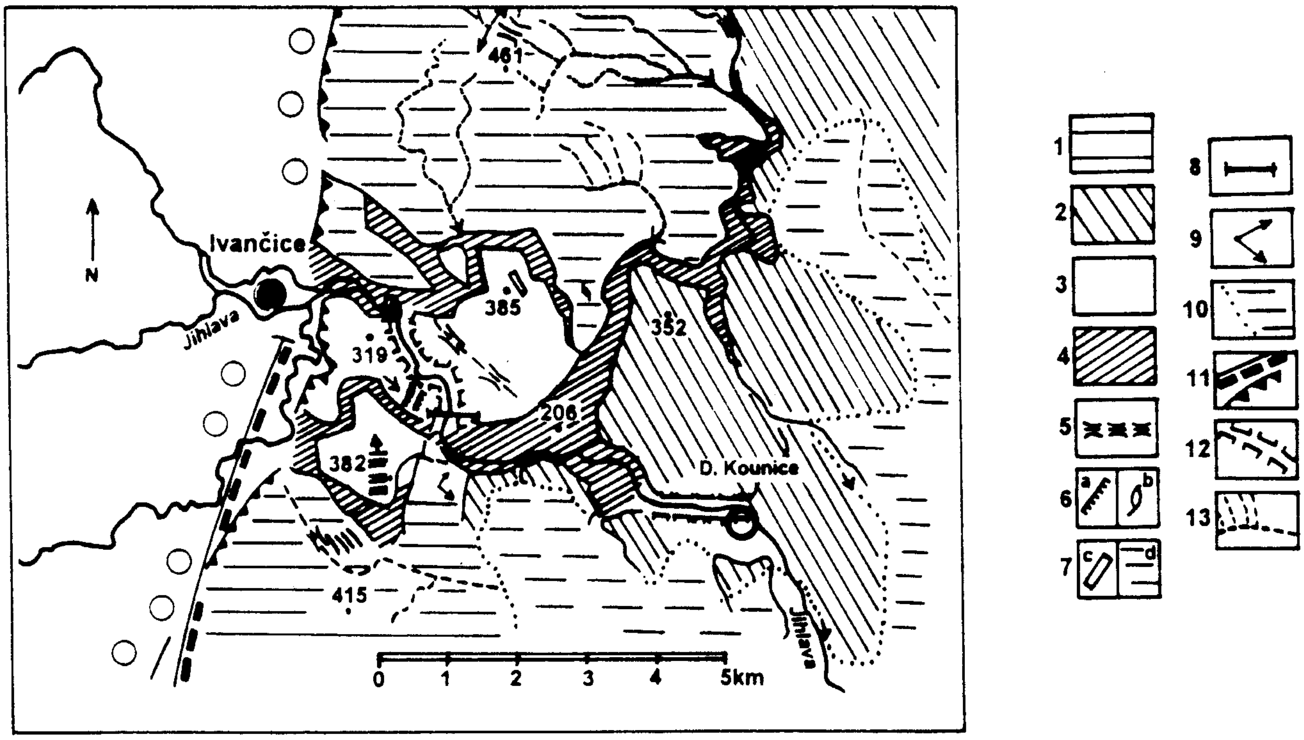

Fig. 3 The scheme of block structure and gravitational tectonics in the Jihlava River valley near Ivančice at the passage through the Bobravská vrchovina (Highlands) horst. Explanation: 1. The Carpathian Forebulge of Bobravská vrchovina (Highlands) with features of asymmetric horst or half-dome. 2. Tilted blocks dipping along antithetic faults. 3. Subsided blocks (horsts) in the zone of the Jihlava River valley, separated by hanging grabens from the margin of the forebulge. 4. Grabens and half/grabens separating the individual horsts and tilted blocks. 5. Fault passes (saddles). 6., 7. Landforms originated in the stress fields of gravitational spreading located in the inclined surfaces of moddle slopes a) downhill-facing scarps, b) tension gashes, c) slope benches (back or down-slope tilted), d) multiple crested ridges (not sagging) on the top of horst ridges. 8. The Ivančice viaduct with stability disturbance of bridge supports. 9. Prevailing directions of extensional stress. 10. Contact of tilted blocks with the Miocene sediments of the Carpathian Foredeep. 11. Front of the Carpathian Forebulge. 12. Valleys based on tension cracks.

tion, reaching also the surface covering formations and creating conditions for piping, settlement and subsidence of bridge supports as well as bodies of railway fills, reminding undermined areas; the deep loosening of fracture zones was confirmed by radiometrically measured emanations and radon springs.

The disturbance of IVV stability which manifested in the gradual shrinking of reserve in the expansion joint was verified both by inclinometrical and by geodetical and photogrammetrical measurements.

The assessment of inclinometric measurements in boreholes situated in the vicinity of the IVV western support indicated the occurrence of measurable horizontal deformations in the ground body of the bridge embankment and a complex movement of the support; vector of movements and its size were measured in 1990-1995; the geodetic measurements brought evidence of vertical sinking.

The method of foundation of the western support of the IVV in less consolidated soils was modelled mathematically. It shows that the excentric load given by the shape of its construction leads to a tendency to induce on the bridge-facing side of the mentioned support the rise of a potential stress zone, responsible for the unbalanced conditions.

4. Conclusions

The southern part of Brno granitoid massif has the features of xenomorphous horst (the so called "bobravská hrást'" horst) and forms a pronounced tectonic structure with multiform manifestations of tectonic disturbance and loosening. The reason of tectonic deformations is that it was taking up an exposed regionally geological position at the contact of the Bohemian Massif with orogenic zones in the course of geological development; Bohemian Massif was a part of Prekambrian fundament, the so called brunovistulicum and was to be found in the foreland of both Variscan and Alpinian-Carpathian orogene; thus the Brno Massif with its crystalline mantle ranks with the typical polymeta-

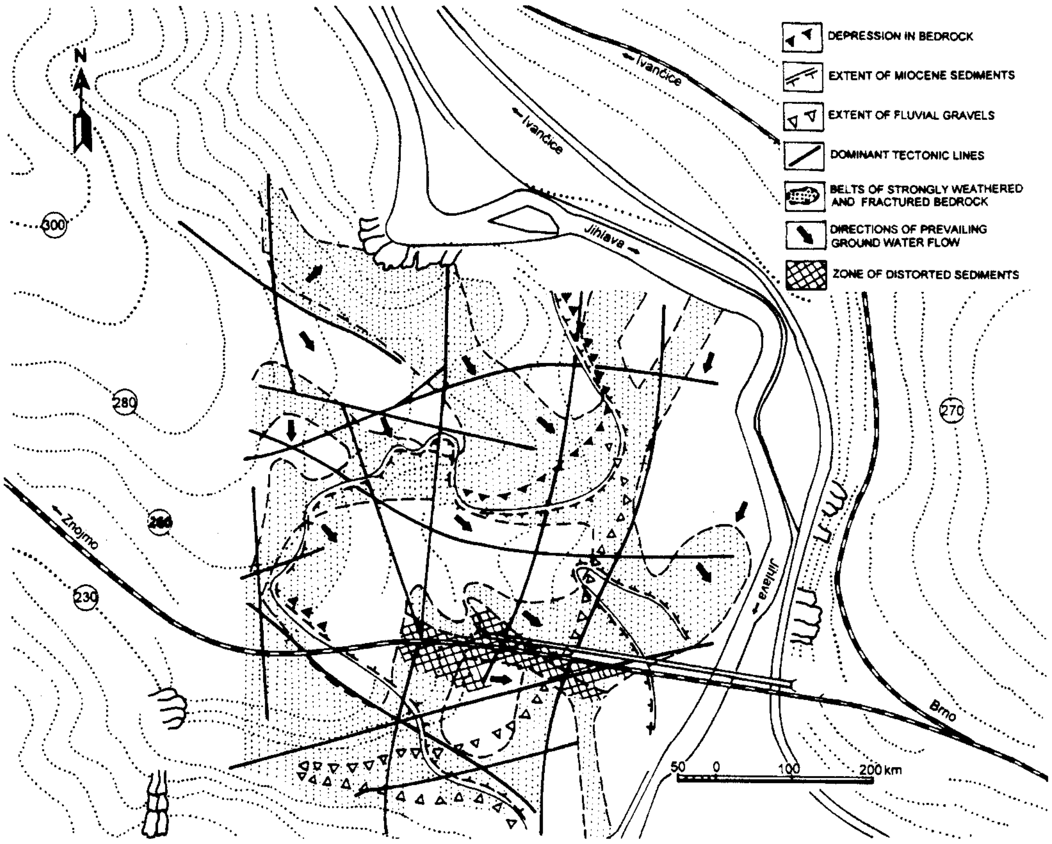

Fig. 4 The situation of underlying rock disturbance in the nearest surroundings of the Ivančice viaduct according to geophysical measurements (Hruška et al., 1994).

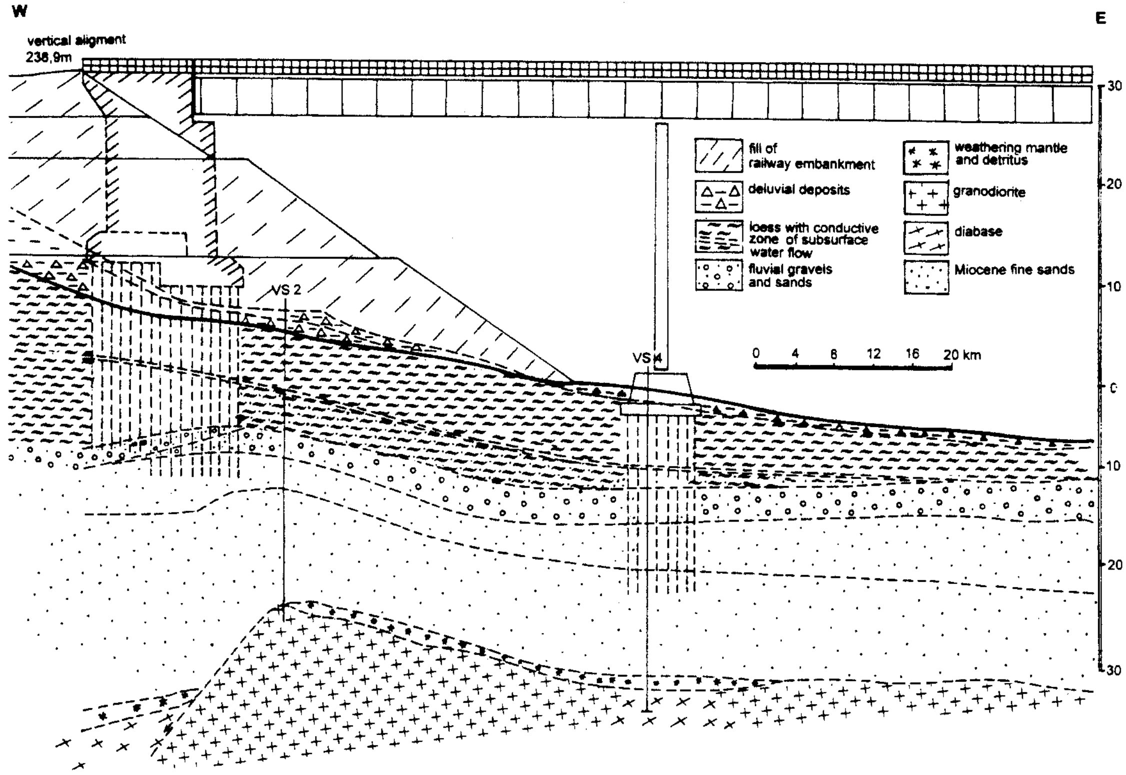

Fig. 5 Construction of the western abutment and the first pillar of the Ivančice viaduct, and the way of concrete piles foundation in sedimentary rock substratum. On the basis of the implemented geophysical measurements the steep front in the granodiorite bedrock is interpreted as a tectonic contact of two differently subsided blocks.

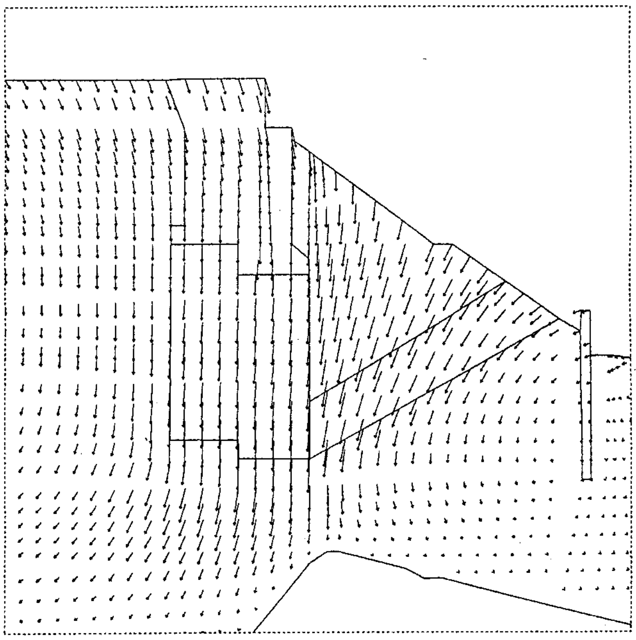

Fig. 6a An example of mathematical modelling of deformation field with consideration of bridge support operation and its loading and with constructed pill wall (Konečný - Malík, 1997 in final report).

morphous and polydeformation areas; towards the end of Miocene the Brno Massif was a part of flexural bent of the Bohemian Massif, so called forebulge.

There is no doubt that the Jihlava River valley is founded on an important fault system of NW-SE direction (the so called Ivančice-Trboušany fault), splitting the "bobravská hrást" horst into the southern and northern blocks; from the viewpoint of structure the more northwards situated valley of the Bobrava River is very similar to that of Jihlava, thus being a confirmation to the existence of a uniform structural plan of wider area of interest.

A typical feature of the rocks in the surroundings of the IVV is its brittle tectonic disturbance which results in rock massif loosening and impaired coherence; the internal structure of fracture zones was revealed by geophysical research (width, inclination, filling) whilst the surficial properties of these zones were the subject of geomorphological research (various types of gashes); there were found narrow as well as (up to several hundred meters) broad tectonic zones in the surroundings of the IVV, and steep-dipping fracture zones featuring the zones of gravitational loosening of various directions, with sericite and limonite coatings and mangan oxides.

In the southern part of the Brno Massif the main fault lines found are of NNE-SSW (faults of the Boskovice furrow), NW-SE and WNW-ESE (Sudetic faults), NNW-SSE and ENE-WSW directions, which form a block structure as faults of late Variscan orogenic stage reactivated by Alpine folding. They were also employed in time of neotectonic and gravitational tectonic movements after the colision of the Bohemian Massif with the Alpine orogenic front towards the end of the Tertiary period in Miocene; in the course of uplift of the bobravská hrásť horst and after the syntectonic gravitational collapse the graben-like structure of the Jihlava River valley (Ivančický příkop graben) originated, which was delimitated by steeply falling marginal faults (70-80°) forming a fault wedge in the 6 km wide zone of tectonic suture at the contact of two blocks.

The graben of this structure represents a unique phenomenon of the Bohemian Massif margin, with tiny fault gaps on horst tops and their partial steps which indicate post-tectonic gravitational creeping and tensional stress.

It was demonstrated on actual geological conditions of the IVV basement where a crossing of at least two important fracture zones cames, that the IVV western support was built up in the SE projection of structurally lower block of Réna in the southern flank of the Jihlava River tectonic graben, limited by faults of Sudetic (NW-SE) direction. This block forms an isolated ("floating") internal segment of the fault wedge.

The research did not bring any evidence of the direct effect of present tectonical, gravitational and seismic movements on the stability disturbance of the IVV supporting bridge system; very probable are however hydrodynamic regime changes in the aquifer zone of granitoid parent rock of Brno Massif with features of non-compact confined ground-water body in fracture and fault zones of deeper loosening and crushing and in pores of Miocene basal clastics; regarding the tectonic

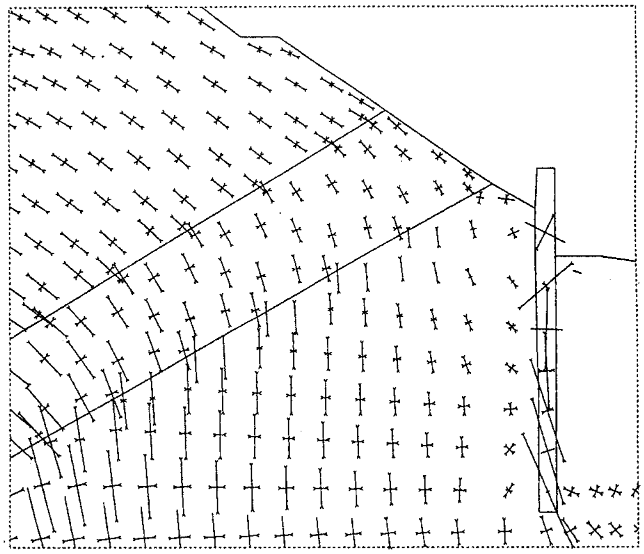

Fig. 6b A deformation field at alternative positioning of bolts anchored in the support lower structure (Konečný - Malík, 1997 in final report).

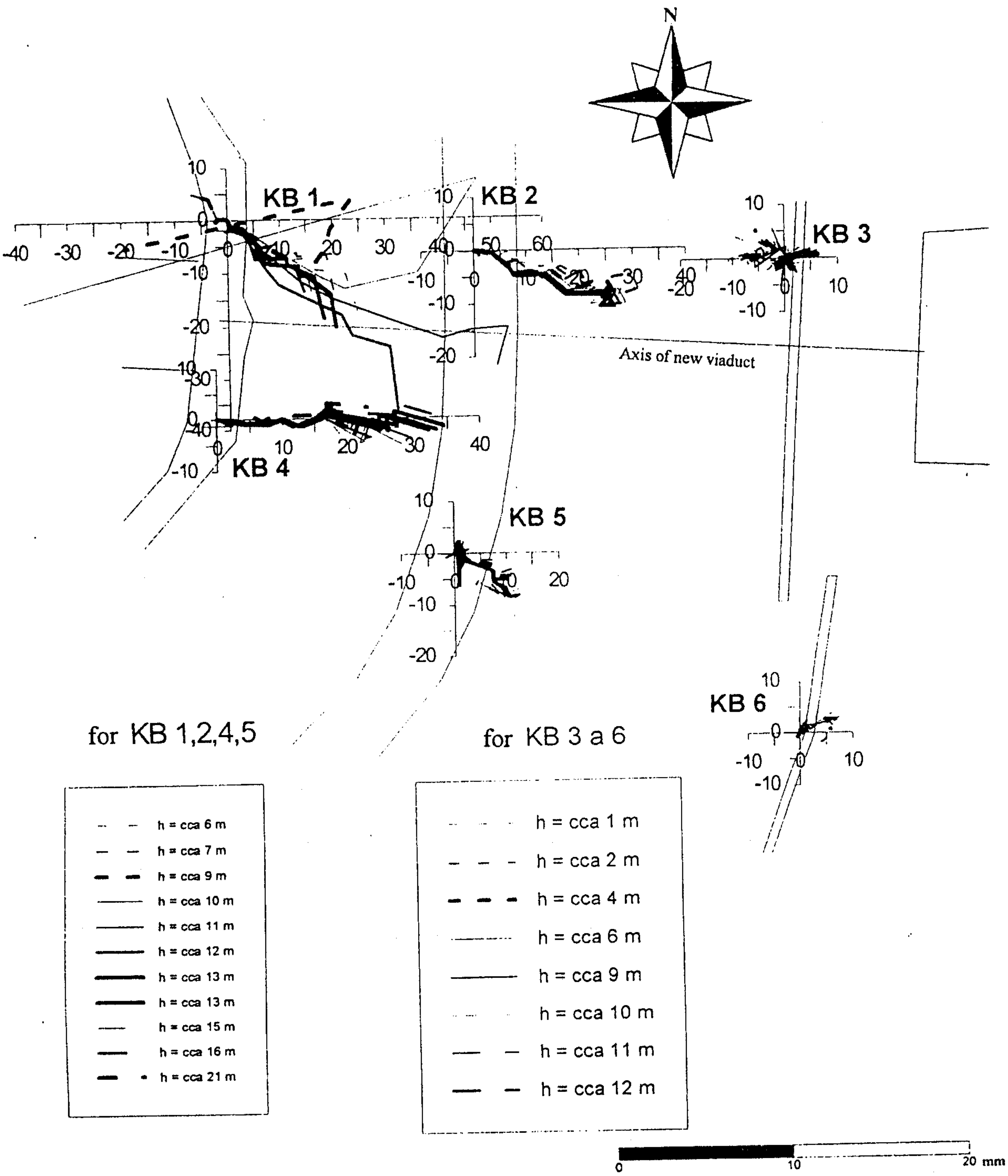

Fig. 7 The course of general horizontal displacement at some depths of inclinometrical boreholes KB 1 to KB 6 in the neighbouring of western bridge support during the measurements (Hofrichterová, 1997 in final report).

culation with drainage effects that can be expected in the neighbouring fracture systems. Presumed is also a hidden drainage by means of surface cover formations, Miocene sediments, gravel sands of river terraces and loesses. The influence of the regime on the development of piping appears to be a probably most decisive destabilizing agent of IVV supporting systems.

The characteristic engineering geological features of the area include the occurrence of tectonically sunken Neogene sediments which may be unstable in terms of their volume in the environment of magmatic bedrocks and can markedly influence shear strength. The fine-grained sandy Neogene sediments can change their properties in contact with water and liquidize due to the hydraulic gradient, or even incline to cav-

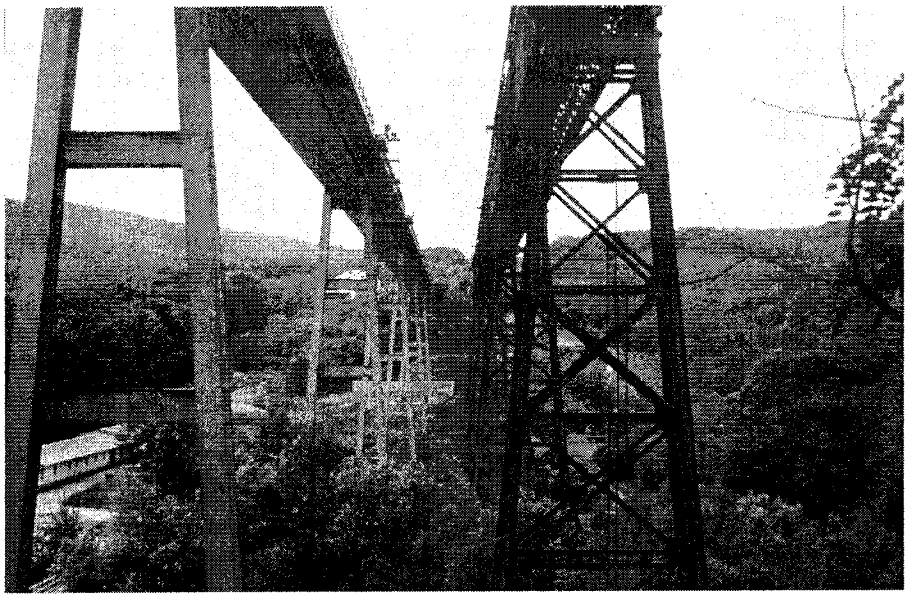

Fig. 8 The railway bridge across the Jihlava River valley is called the Ivančice Viaduct. At present there are two bridges. The old bridge was constructed in 1870 and the new one after more than a hundred years, in 1978. The necessity of construction of a new bridge demonstrates some difficulties with stability of supporting systems of the older one and close proximity of both structures with disturbed stability shows questionableness of this site for foundation of structures in general. Photo M. Hrádek.

ing and piping phenomena similarly as in the IVV basement. Due to the same reason, attention should also be paid to loesses as foundation soils of the Ivančice region.

A major weak point of the IVV construction can be considered the fact that all piles of the western support and pillars were not installed into the bedrock but with regard to their maximum length of 20 m partially into sediments - gravel sands or basal Miocene sands.

Evaluated were inclinometric measurements made in 1990-1995 in 6 boreholes deep 13 to 28 m situated in the embankment body near the western support. The irregular measurements found mainly horizontal down-slope oriented deformations (to SE up to E) in the majority of boreholes, and only one borehole (in surcharging bench) exhibited up the slope. The deformations were found both near the surface and close to the collar of well and also in the depth. The horizontal deformations in the depth were generally considered the manifestations of shear zones. The maximum deformation next to the support (KB 1) over the period of about 15 months was 63 mm with the max. daily displacement of 0.105 mm. Some boreholes (KB 1 and KB 5) do not show any decrease in growth rate of total horizontal displacement, the remaining ones do. It is assumed therefore that the horizontal deformations can further occur in the future.

The conduction of horizontal deformation zones was proven with help of geophysical survey, indicating the routes of underground water from the slope towards the valley floor as zones of subsurface wash-out (piping). From this point of view, the cause of western bridge support deformation seems to be the sinking of the ground body (of railway fill) into vacant spaces left after the leaching of washed out fine-grained particles.

Geodetic alignment of the bridge made after the implementation of measures to ensure the stability of the lower structure in 1995 showed a subsidence at the western Hrušovany support by 57 to 58 mm. Other measurements carried out by a hybrid method employing the technology of terrestrial geodesy and special photogrammetrical methods indicated that the position of the measured section of the structure does not change in position, height or rotation.

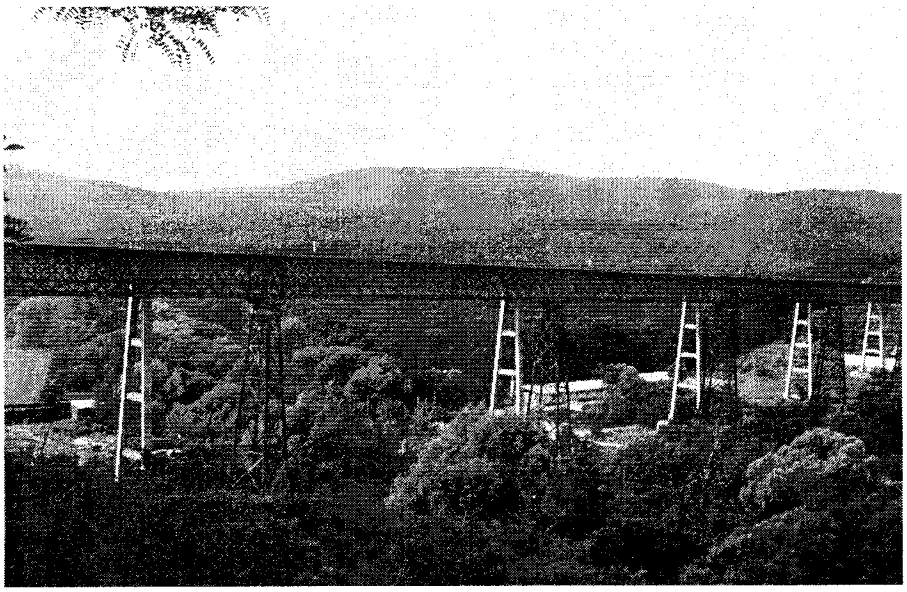

Fig. 9 Ivančice Viaduct on the background of the Krumlovský les Forest horst with strong neotectonic modelation. A hanging graben separates two partial horsts in the upper left center and shaded steep fronts end up with smaller blocks. Photo M. Hrádek.

With regard to the disturbed stability of the lower structure due to actual sitting of the underlying sediment the effects could have shown in the bridge structure as sinking, displacement and tilting; the proposals for concrete construction measures for these cases were already mentioned.

A gradually increasing efficiency of IVV stabilizing elements was proven, represented by the wall of drilled piles with anchoring into Miocene sands, the built up surcharging wall at the foot of the railway fill between the first pillar and the western support, and other field treatment of the ground body.

Regarding the found out subsidence of the western support in IVV by 58 mm in 1995 various methods of how to ensure the bridge stability were considered for the case that the situation would repeat. Statistic calculations indicated that according to the railway-track class in force a surcharge of the load-carrying structure by the sinking supports cannot put the carrying capacity of the main beam into danger. It showed that a necessary equipment of bridges in the environment of loosened rock massif must also be a possibility of bearings rectification. A technical procedure was worked out for the rectification of the main beam expansion bearing.

The mathematical and geotechnical modelling made by the method of final elements was to explain the causes of instability inception and to learn mechanisms occuring in the ground body after the implemented stabilization measures. As justified appeared a presumption of stress fields in the "ground body - bridge support - pillar" system, generated in the consequence of excentric asymmetrical loading of the western support and its lower structure by forces acting in the supporting bearing of the bridge structure being the main source of deformations. The excentric load and the chosen method of foundation of the western support on the bored piles in the soils of relatively poor strength result in the generation of a potential stress zone on the bridge-facing side, responsible for the rise of unbalanced conditions and consequently for the redistribution of stress and displacement. The mathematical modelling also showed the anchoring system installation leading to the improvement of the situation and to the gradual stabilization of the support.

One of major results of the project is the knowledge that even in seemingly stable rock massifs such as the Brno Massif, which however exhibit a strong tectonic loosening due to the repeated brittle disturbance, an increased attention should be paid to the complex research in earth-sciences at the foundation of the structures; in this way, funds spent for the later expensive additional research can be saved.

There were more than 20 papers worked out during the solution of project.

References *of papers worked out and/or published during 1995-1998:*

GRYGAR, R. - HOFRICHTEROVÁ, L. - JELÍNEK, J. - MÜLLEROVÁ, J. - POLÁČEK, A. - MÜLLER, K. (1996): Morphotectonics and geophysical investigation in surrounding of Ivančice Viaduct. In: Kaláb, Z. ed.: Data Analysis in Seismology and Engineering Geophysics. Proceedings (Volume II). Inst. Geonics AS CR Ostrava, p. 212-224.

GRYGAR, R. - JELÍNEK, J. - MÜLLEROVÁ, J. - MÜLLER, K. - POLÁČEK, A. - HOFRICHTEROVÁ, L. - HRÁDEK, M. (1997): Konfrontace morfotektonické a strukturně-tektonické analýzy křehkého porušení brněnského masivu v širším okolí Ivančic. Sb. II. semináře Čes. tekt. sk., p. 19-21, ČGS a IGI VŠB-TU Ostrava.

HRÁDEK, M. (1994): Seismic interpretation of the Ivančice railway bridge abutment instability causes and its comparison with results of geomorphological investigation and geotechnical surveys. In Kaláb, Z. ed.: Engineering seismology (Proceedings of conference). Inst. Geonics AS CR Ostrava, p. 44-48.

HRÁDEK, M. ed. (1995): Natural Hazards in the Czech Republic. Studia geographica 98, Inst. Geonics, AS CR Brno, 162 pp.

HRÁDEK, M. (1995): Introduction into the Project "Stability Relations of Supporting Systems of Bridges and Tunnels in Stress Fields of Zones of Gravitational Spreading". Studia geographica 98, Inst. Geonics AS CR Brno, p. 138-161.

HRÁDEK, M. (1995): Tektonické a gravitační tvary v údolí Jihlavy na jihovýchodním okraji Českého masivu. Geologické výzkumy na Moravě a ve Slezsku, ČGÚ a Sekce geol. věd PřF MU Brno, Brno, p. 111-112.

HRÁDEK, M. (1995): Valleys of the eastern margin of the Bohemian Massif: brief outline of their origin, age and natural hazards. Acta Montana, Ústav Struktury a Mechaniky Hornin AS CR Praha, ser. A, No. 8, p. 29-41.

HRÁDEK, M. (1995): Úloha geomorfologie při řešení projektu: Stabilitní poměry nosných systémů mostních a tunelových staveb ve stresových polích zón gravitačního rozvolnění. In.: Sborník referátů mezinár. věd. konference, sekce 3-Geologie, VŠB-TU Ostrava, Ostrava, p. 96-99.

HRÁDEK, M. (1996): Gravity mass flows and rock-avalanches in the Miocene deposits at the Moravské a Nové Bránice surroundings (in Czech with English summary). Geol. výzkumy na Moravě a ve Slezsku v roce 1995. Český Geol. Ústav a Přír. Fak. MU Brno, p. 59-61.

HRÁDEK, M. (1996): Origin of valleys at the eastern margin of the Bohemian Massif and their natural hazards. In: Lóczy, D. and Bassa, L. eds.: Geomorphology and changing environment in Europe. IAG European Geomorphological Conference, Budapest, p. 52.

HRÁDEK, M. (1996): Investigation of zones of gravitational loosening on the convergent southeastern margin of the Bohemian Massif (in Czech with English summary). In: Kaláb, Z. ed.: Data Analysis in Seismology and Engineering Geophysics. Proceedings (Volume II), Inst. Geonics AS CR, Ostrava, p. 225-231.

HRÁDEK, M. (1997): Morfotektonika epikratonního křídla kolizních předhlubní na příkladu jihovýchodního okraje Českého masivu. Sb. II. semináře Čes. tekt. sk., ČGS a IGI VŠB-TU Ostrava, p. 29-31.

HRÁDEK, M. (1997): Zones of gravitational loosening of the Bohemian Massiv. Supplementi di Geografia Fisica e Dinamica Quaternaria, Suppl. III-1997, T. 1, Comitato Glaciologico Italiano, Torino, p. 209.

HRÁDEK, M. (1998): Main features of morphotectonic development of a platform in the period between tectogeneses exemplified by the southern margin of the Bohemian Massif. Geolines, 6, Inst. Geol. AS CR, p. 27-28.

HRÁDEK, M. - KOLEJKA, J. - ŠVEHLÍK, R. (1997): Czechia and Slovakia. In: Embleton, C. C. eds.: Geomorphological Hazards of Europe. Elsevier, Amsterdam, p. 61-90.

HRÁDEK, M. - MÜLLEROVÁ, J. - MELCHER, J. (1997): Stabilitní poměry nosných systémů mostních a tunelových staveb ve stresových polích zón gravitačního rozvolnění. Závěrečná zpráva projektu Grant Agency CR 103/95/1536. MS, Inst. Geonics, AS CR, branch Brno.

HRUŠKA, J. et al. (1994): Zpráva o geofyzikálním měření na lokalitě Ivančický viadukt. III. etapa. Geofyzika, a.s., Brno.

HRUŠKA, J. - SYNEK, V. (1998): Zpráva o geofyzikálním měření na lokalitě Moravské Bránice III - gravitační tektonika. MS, Geofyzika Brno.

KALÁB, Z. ed. (1996): Data Analysis in Seismology and Engineering Geophysics. Proceedings (Volume II), in Czech with English summary. Inst. Geonics, AS CR, Ostrava, 261 pp.

MÜLLER, K. - POLÁČEK, A. - MÜLLEROVÁ, J. (1996): Radiometric manifestation of weak zones in rock massif (in Czech with English summary). In: Kaláb, Z. ed.: Analýza dat v seismologii a inženýrské geofyzice, Inst. Geonics AS CR Ostrava, p. 248-254.

POSPÍŠIL, Z. et al. (1997): Závěrečná zpráva o provedení hydrogeologických prací v prostoru Ivančického viaduktu a jímacího území Moravské Bránice. MS, Ekohydro, Brno.

SYNEK, V. (1996): Zpráva o geofyzikálním měření na lokalitě Tetčice. MS, Geofyzika Brno.

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GLOBALIZATION OF RETAIL NETWORK BY LARGE CORPORATIONS IN THE CITY OF BRNO AND ITS SURROUNDINGS

Barbora KOLIBOVÁ

Abstract

The paper deals with a new phenomenon of our socio-economic life, i.e. the penetration of supranational trading companies onto the internal Czech market in the period of transformation. The article is an introductory consideration of the situation in Brno and its hinterland.

Shrnutí

Globalizace maloobchodní sítě velkými firmami v Brně a jeho zázemí

Obsahem příspěvku je nový fenomén našeho společného ekonomického života - pronikání nadnárodních obchodních společností na vnitřní trh České republiky v období transformace. Tento článek je úvodním zamyšlením, jaká je situace oblasti v městě Brně a jeho zázemí.

Key words: globalization, transformation, supermarket, style of living, consumption, Brno, Czech Republic

1. Introduction

One of problems that are currently tackled by the Institute of Geonics, Academy of Sciences of the Czech Republic in Brno within the scope of an institutional programme is the study of processes and changes resulting from the transformation of our society after 1990. The contribution can be considered an introductory research directed to changes occurring due to the globalization of retail network.

Globalization has recently been one of most frequently used terms. However, its unambiguous and generally valid definition has not been found yet. It is often described as a process that eliminates frontiers of national economies by the possibility of moving large financial volumes in real time and on a global scale. Catalyzer of this qualitative shift from "internationalization" of economy to the "globalization" can be considered advanced information technologies.

The globalization of retail network by the large corporations represents a new phenomenon of our socio-economic life.

The issue is just at the very beginning of its existence and will be further subjected to deeper analyses. Its scope being considerably wide, it can be investigated from several viewpoints or attitudes. Another point of view of this problem or the new socio-economic phenomenon is that of professionals, i.e. economists, geographers, sociologists (unbiased view) and another one is that of local municipal councils, self-governments and town councils (which concerns larger towns and their hinterlands). Yet another group of interested persons consists of representatives from firms penetrating the structure of retail network in this country.

The phenomenon must be perceived and understood in the wide array of coherences and studied from many aspects and points of view.

This paper will discuss the issue from the viewpoint of temporal and spatial aspects.

2. Temporal aspect

Several years ago, the trade network in the Czech Republic, stigmatized by the legacy of Socialist period, could be classified as insufficient both from the viewpoint of quantitative and qualitative parameters. The first half of the 90s witnessed a considerable improvement of purchasing conditions, nevertheless, it was only the striking drive of supranational chains with strong capitals that brought revolutionary changes in the situation of retail offer during the second half of the 90s. The Czech internal market was penetrated by many foreign corporations such as Dutch EURONOVA (daughter company of ROYAL AHOLD), DELVITA (Belgium), TESCO (Great Britain), JULIUS MEINL (Austria), PENNY MARKET (Germany), etc. One of winning Czech companies was INTERKONTAKT. All cities in this country have their specific networks with different giant corporations winning the market in the Capital of Prague and its surroundings, in Ostrava or in Brno. For some of them it was a successful comeback: for example JULIUS MEINL was introduced in the then Czechoslovak Republic in the period between the two wars.

Foreign giants that had to cease their activities and leave Brno were only PRONTO and K-MARKT.

New large-scale supermarkets rise often in non-central localities, on exposed traffic joints. Their philosophy stakes on a presumption that Czech consumers will gradually prefer the so called week shopping. And the presumption is corroborated by the research of purchasing behaviour of the population. The latest results of a "Supermarket 98" study worked out by INCOMA Prague and GfK Prague indicated that the tendency to do shopping in the large-scale shopping centres and supermarkets has been further deepened. It is only 45 % of households today for which the main place for buying food products is a small self-service shop (70 % at the beginning of the 90s, more than 50 % in 1997).

In contrast, the market position of "modern" selling types such as supermarkets, hypermarkets, discount shopping centres was markedly reinforced (40 % in 1999, 32 % in 1998). The percentage of small-scale counter shops on the market is steadily decreasing.

More than a half of households use their cars for buying food: of these 35 % very often or sometimes. The preference of supermarkets and hypermarkets increases with the size of the seat, with the achieved education level, and with the income level of households (viz Tab. 1).

Tab. 1 Hypermarkets in the Czech Republic, 1995-1999

1995	0
1996	2
1997	7
1998	25
1999	40 (estimate)

Source: INCOMA Prague (1998).

The above mentioned new types of shops - supermarkets, hypermarkets and discounts - differ in terms of their sales area size, employees, assortments, types of sale (e.g. discount - right from boxes), annual turnover and economic indices as well as in terms of other services and facilities such as parking, restaurants, refreshments, fast food, petrol stations, etc.

Supermarkets are considered shops with the sales area over 400 square meters. To name several ones in Brno, let us mention Julius MEINL, MANA, DELVITA, which appeared on the Czech market as early as in the first half of the 90s.

Discounts are considered to be large-scale shops focused on price-oriented consumers, low prices being balanced by the limited range of products offered and by the lower purchasing standard.

Hypermarkets are large-scale shopping centres over 5000 square meters, smaller versions over 2 500 sq. meters with more than a half of non-food assortment. To a certain extent, these hypermarkets stand in for the former stores. In the second half of the 90s, the hypermarkets that came into existence were GLOBUS on the northern limits of Brno, TESCO, HYPERNOVA in the southern part of the city, and INTERSPAR southwards of the downtown in the original built-up area.

Press releases of trading companies indicate that the majority of supranational corporations endeavour for offering mainly Czech-made food products (80 % to 95 %).

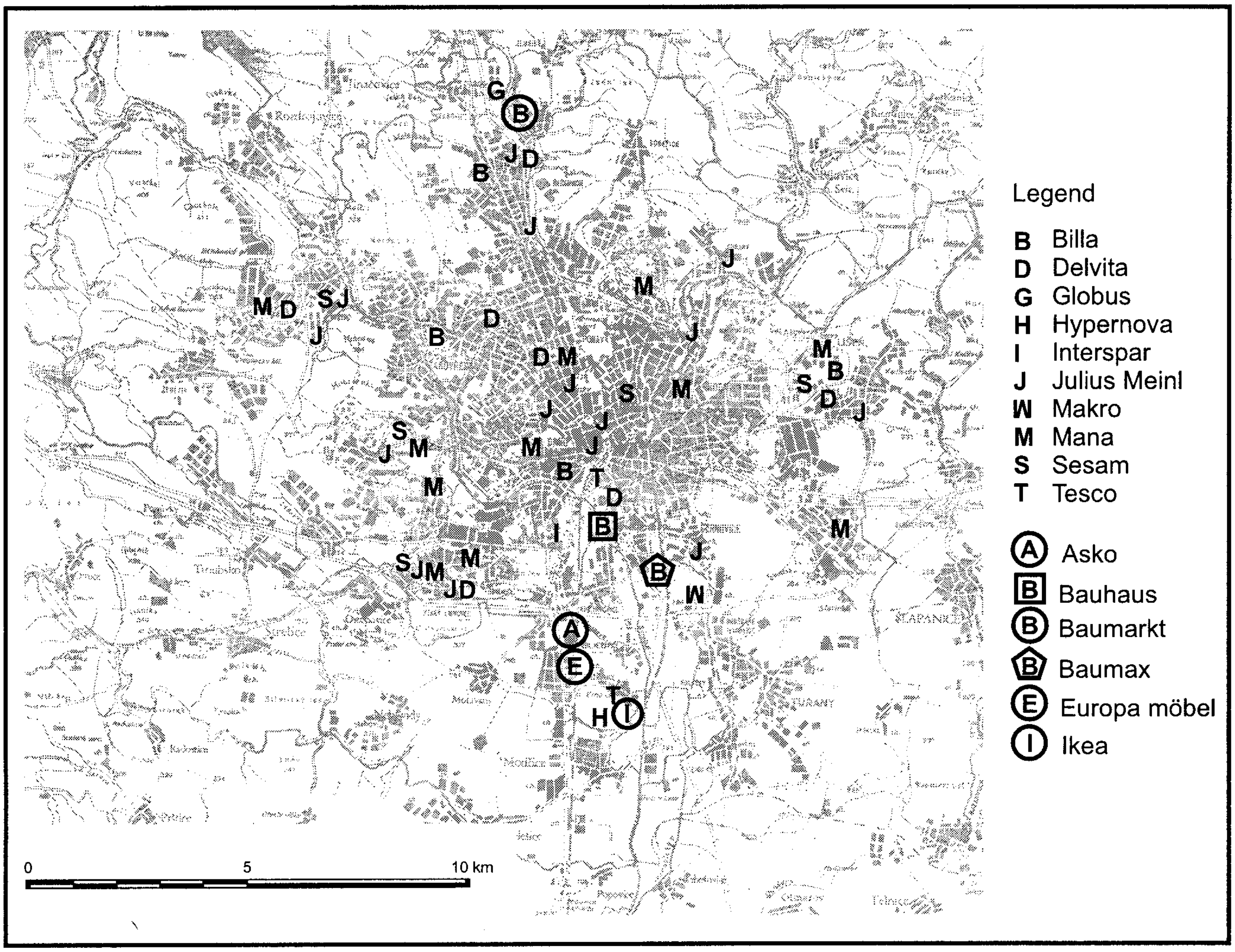
In addition to the above types there are also new large-scale specialized non-food shopping centres in Brno such as Ikea, EUROPA MÖBEL, ASKO for furniture, BAUHAUS, BAUMARKT, BAUMAX for household utensils, etc.

3. Spatial aspect

Should we ask about methods of how these supranational giants get onto our internal retail market, the answer is easy: with the lagging legislation in this country the only thing to do is to make an entry in the business register, to buy a suitable site and to launch the business. This is the place where local authorities can either issue the building permit in the given area or not.

CR Ministry of Industry and Trade published a methodological handbook for municipalities with the title "Development and optimization of retail network dimensions in the territory" (January, 1998). According to this document all municipalities can determine and calculate their existing possibilities and needs for retail facilities in the given region. PRIOR to issuing a construction permit for a large-scale store or a shopping centre, the municipality should carry out mapping of the existing trading network in the given area of interest. The survey usually includes the classification of shops into groups by their size, assortment and location. The municipality should have records on all retail outlets, their operators, type, assortment, square area, condition of the facility and parking possibilities. It is also important to know the connection to public transport, annual turnover, annual rentals, structure of purchasing customers (local or hinterland) as well as the influence of season on the turnover. It is then possible, on the basis of such an analysis, to define the extent and structure of retail facilities in individual towns and villages.

Unlike in the Czech Republic, planning authorities in the countries of European Union have at their disposal a system of competences and tools that makes it possible for them to efficiently intervene into the development of retail network, to take into account requirements of towns and villages as an important factor.



Map: Location and lay-out of retail shopping facilities of individual trading corporations in the city of Brno. Sketch: A. Petrová.

The functioning of such a trading network as a whole is more seriously felt in the cities. Traffic problems in the communication network whose transport capacity cannot keep pace with the growing facilities and growing numbers of cars and population mobility in general can become rather pressing and many a time traffic jams can negatively affect the attractiveness of these "out-of-town" centres.

Many small trading companies in town centres had to close down which reflected in the deadening of some traditional shopping sites. In order to stay competitive smaller retailers will have to gather their strengths in associated networks, to cooperate with the large trading chains and to offer customer-specialized services.

An efficient form and a good helping hand on the way to the customer on the part of firms operatings in the retail network is the distribution of leaflets and adverts. It is very difficult to acquire information about the efficacy of adverts and leaflets from public relations representatives who are not prepared to share the strategic data due to the severe competition among the individual supranational corporations.

The factor of gravitation and attendance in the individual centres can be investigated for example by means of the sociological method of direct observation, which is going to be most probably employed in the future field research at the collection of data. However, the method is quite demanding in terms of time and space.

As illustrated in the enclosed map and taking into account the combination of two mentioned aspects of time and space we find out that the development in localization and expanding of supranational retail corporations in the territory of Brno is saturated in the north-south direction while the eastern and western sections of the city (with preponderant neighbourhoods of prefabricated blocks of flats) have insufficient retail network facilities. The fact is well-known to the department of area-planning and the situation that is a consequence of the European trend where the retail giants are being built at motor-way feeders, ie. at places with lower-priced building sites will be resolved in the future.

Corporations that first entered our territory in the first half of the 90s were JULIUS MEINL, MANA, DELVITA and BILLA. These are companies ranking in the category of "supermarkets" with the sales area over 400 square meters. This trading network typically makes use of former PRAMEN shops and this is the reason why its facilities can mostly be found inside the city built-up area.

The introduction of larger hypermarkets dates back to the second half of the 90s. This type of retail facilities can rather be found on the city limits, in non-central localities, outside the housing areas and at the motor-way feeders. They are therefore used by the population from a broader surroundings of adjacent country-side seats.

The most successful corporation in the territory of Brno seems to be EURONOVA, a.s. which a daughter company of supranational concern ROYAL AHOLD (Netherlands). To the date of 30 June 1998 the corporation owned a total of 27 MANA, SEZAM and Prima shopping centres in the region. EURONOVA is followed by REWE (Germany) that took over the BILLA shops. The last foreign company building a network of supermarkets and operating in our region is DELVITA (Belgium). Of 60 supermarkets operated by the above mentioned foreign corporations 43 are in Brno and only 17 in other towns of the region.

4. Conclusion

The author must state that the present economic situation in the Czech Republic shows signs of impairment - the growth of unemployment and the increasing economic uncertainty. Yet, even in this period of hard times the supranational chains try to ever more penetrate the retail network in this country. It will be therefore interesting to monitor the situation and make a comparison after some time.

Consequences of developing large-scale retail centres:

- ebb-tide of purchasing power from integrated parts of the city;
- falling sales in traditional localities;
- diminishing job opportunities in domestic stores and shops;
- closing-down of shops in traditional localities (and the related dilapidation of buildings);
- subordinary role of downtown for population supplies.

An integral part of these consequences can be considered changes in the behaviour of customers. The trend relates to the metamorphoses of living style and connects with a new attitude to the philosophy of consumption.

References

HOLOUBKOVÁ, Z. (1998): Koncentrace maloobchodu v České republice v režii zahraničních řetězců. Právo, 1. 12. 1998.

INTERNET: web sites of individual supra-national companies.

Rozvoj a optimalizace dimenzí maloobchodních sítí v území. Ministerstvo průmyslu a obchodu České republiky, January 1998, 46 pp.

NĚMEC, P. (1998): Globalizace má dostat přesnější pravidla. Hospodářské noviny, 1. 10. 1998.

PINKA, J. (1998): Lidé dávají podle obchodníků přednost českým potravinám. Právo, 1. 12. 1998.

PROFIL - VIZE - SWOT: Brněnský kraj. Regionální koordinační skupina Brněnského kraje. Brno, January 1999, 110 pp.

VAISHAR, A. et al. (1995): Case study: Brno. Moravian Geographical Reports, 3, No. 1-2, p. 4-29.

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Reviewer

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TRANSFORMATION OF INDUSTRIAL PRODUCTION IN THE DISTRICT OF BRNO-PROVINCE

Josef KUNC

Abstract

The situation of industrial production in the district of Brno-Province appears relatively stable after the transformation and privatization of companies. In the course of the 90s, some inefficient works were either closed or their production markedly restricted, and in contrast, several hundred of mainly small-scale industrial shops came into existence. It was these smaller establishments that reported rather positive economic results in the last years. The entry of foreign capital into the district and its companies also appears relatively positive. Other possibilities to further develop the industrial potential of the district can be sought in a favourable location near Brno - in the possibility of using fast and good transport connection or to profit from the planned gradual forcing of industrial facilities out of Brno behind administrative city limits.

Shrnutí

Transformace průmyslové výroby v okrese Brno-venkov

Stav průmyslové výroby v okrese Brno-venkov se po transformaci a současně probíhající privatizaci podniků jeví jako poměrně stabilní. V průběhu devadesátých let byly zastaveny nebo výrazně omezeny některé neefektivní provozy, naopak vzniklo několik stovek převážně menších průmyslových provozoven. Právě tyto menší podniky vykazovaly v minulých letech spíše kladné hospodářské výsledky. Také vstup zahraničního kapitálu do podniků okresu se jeví jako poměrně pozitivní. Další možnosti rozvoje průmyslového potenciálu okresu je možno hledat v jeho výhodné poloze k městu Brnu, v možnosti využívat rychlé a dnes již kvalitní dopravní spojení či těžit z předpokládaného postupného vytlačování průmyslových podniků z centra Brna za jeho administrativní hranice.

Key words: industry, transformation, Brno-Province district, Czech Republic

1. Introduction

The territory of Brno-Province has always had and still has very strong integration links with the city of Brno. Similarly, the links of large industrial works in Brno with industrial facilities behind the administrative city limits used to be lively and many of these enterprises used to have their subsidiaries or production plants in the closest Brno surroundings. Demands for space and location often meant a shift of the company behind the city limits while it was only the headquarters that remained in the town itself. In this context, the industrial production of Brno-Province should be logically analyzed in its historical and present development as a component of one whole with the core represented by the city of Brno. Yet, the article will only analyze the industry in the Brno surroundings administratively marked as the district of Brno-Province, one of the most important reasons being the fact that when assessing the territories of Brno-City and Brno-Province districts as one "undivisible" unit, it would be very difficult to show clearly all merits acquired by the province district compared to Brno over the last ten years. It is particularly the successful privatization of industrial companies in the district and the entry of strong foreign capital that are pointed out in this work.

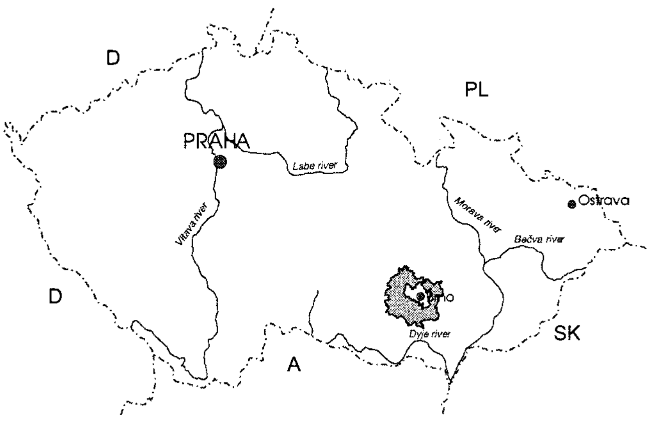

Fig. 1 Area under study

2. Industrial development of the district until 1990

The industrial history of today's Brno-Province district whose ring forms a marginal zone of the Brno conurbation dates back to the middle of the 18th century. Similarly as in Brno, it was connected with textile manufacturies and small food-producing facilities (flour mills) - mainly in Tišnov and Ivančice.

An important impuls to the development of industrial production in the 19th century was the boom of coal mining near Rosice, which was further supported by the construction of local railway track between Zastávka and Zbýšov. Iron works and rolling mills (Zastávka) came into existence as a logical consequence of coal mining. The local food production such as sugar refineries, breweries, malting houses, distilleries, flour mills (Modřice, Židlochovice, Hrušovany) spread in the southern part of today's district from the middle of the 19th century and the first textile works appeared in Šlapanice, Tišnov and Veverská Bitýška (see Bartoš, I. et al., 1986).

The 20th century represented an onset of engineering and metal-working production with larger industrial facilities established in Tišnov, Zastávka, Ivančice and Modřice. First lime works started their production in Čebín and Mokrá during the 20s. In 1926, the company for brick-making machines at Drásov was purchased by Brown-Boveri Switzerland, which founded a new enterprise specialized in electrotechnical production (MEZ national enterprise after 1948).

The building of industrial base continued after 1945. A subsidiary of Zbrojovka Brno was built up in Kuřim as early as in the course of World War II (1942), in which machine tools started to be made in 1946 and the company was renamed to TOS in 1950. New textile factories were founded in Tišnov (Modeta Jihlava, national enterprise for knitted fabrics) and Ivančice (Retex, national enterprise) after the War. The abandoned coal mining objects at Oslavany housed a subsidiary of První brněnská strojírna Brno, and the facilities of former brewery at Hrušovany u Brna became a shoe-making company Závody Gustava Klimenta Třebíč towards the end of the 50s. New large cement works were built at Mokrá in the 60s and in the same period of time Works of J. Juran, national enterprise, Heavy Engineering Works Brno came into existence in Zastávka u Brna. The newest larger industrial facilities built in the territory of the district before 1989 are manufacturers of building materials: Pórobeton Hrušovany u Brna and Brick works Cihelny G. Klimenta Brno at Šlapanice.

Towards the end of 1989, the majority of people in industries in the district of Brno-Province worked in engineering, fuels and energy, and textile and clothing industries, as indicated in Tab. 1. The employment percentage fully covers with the country average in the industries. The first mentioned two industries had the participation in total employment rate by ca. 4.5 % (2.5 %) higher.

In contrast, the index of specialization in Tab. 1 suggests a pronounced specialization of industrial production in the district. As compared to the CR average, the district of Brno-Province had a much greater representation in terms of building materials production (8.7 % employees in the district and only 2.6 % of Czech average) and leather industry (7.2 % in the district and 3.2 % of Czech average). However, while the industry of building materials was represented by more than 15 companies and organizations, the higher percentage of leather industry is represented by just one shoe-making company at Hrušovany u Brna with its subsidiary in Pozořice. On the other hand, the percentage of metal-working and other industries in the district is distinctly

Tab. 1 Workers in industries of national economy to the date of 31 December 1989

Industry	Brno-Province	Brno-Province	Czech Republic	Specialization index
	Workers (absolute)	Percentage	Percentage	Percentage Brno-Province/ Percentage in CR
Fuels and energy	2719	11.2	12.4	90.3
Metallurgy of iron and non-ferrous metals	0	0.0	6.9	-
Metal-working	671	2.8	5.3	52.8
Engineering	7947	32.8	28.4	115.5
Elektrotechnical	868	3.6	6.6	54.5
Chemical and rubber-making	1190	4.9	5.6	87.5
Building materials	2117	8.7	2.6	334.6
Wood-processing and furniture	630	2.6	3.6	72.2
Textiles and clothes	3089	12.7	10.0	127.0
Leather	1742	7.2	3.2	225.0
Paper and printing	637	2.6	2.2	118.2
Food	1720	7.1	6.9	102.9
Other	667	2.8	6.3	44.4
TOTAL	24248	100.0	100.0	-

Source: The balance of labour force resources in CSFR to 31 December 1989, FSI Prague 1990, own calculations.

lower with metallurgy of iron and non-ferrous metals according to the labour-force balance in the Brno-Province district not being represented at all towards the end of the 80s. Nevertheless, a note should be made at this place that the Federal Bureau of Statistics probably made a mistake at ranking Kovolit Modřice with its subsidiary at Česká with the engineering industry instead of metallurgical production.

The number of industrial workers by the balance of labour force recources was a bit distorted due to overestimated commutation from Brno-Province to neighbouring districts. In addition, the 1991 census which was realistic enough to describe the situation prior the transformation of economy indicated that there were over 35 thousand economically active (earning) persons employed in industries (ie. 44.1 % of economically active population in the district), which indicates that the number of permanent residents in the district of Brno-Province, employed in industries was considerably higher. The records speak of nearly 15.5 thousand workers commuting to work in industrial companies of neighbouring districts while there were only 5.1 thousand workers commuting to workplaces located in the district. The pronounced difference is due to a considerable number of commuters to Brno (40 % of all economically active industrial workers resident in the district of Brno-Province). The commutation to other districts was negligible in the comparison with that to Brno but it still affected job availability for the population of marginal areas of the district (similarly also in Kučera, 1996).

At the end of the 80s, there were about 25 thousand persons working in local industrial facilities in the district, 22 thousand were employed by central-controlled industrial facilities, more than 1.3 thousand by industrial facilities controlled by manufacturing cooperatives, and some 1.7 thousand persons were employed in communal production. The industrial production in the district was concentrated mainly in large- and medium-sized companies. Nearly two thirds of all workers were employed in firms with more than 500 employees, and over 90 % of them worked in companies with more than 100 employees (Galvasová, I. et al., 1996). Tab. 2 presents a list of most important industrial companies in the district at the end of 1989.

Nearly a fifth of industrial jobs in the district were there thanks to TOS Kuřim and more than two thousand workers were employed in Modřice and Ivančice. The percentage of industrial jobs in total jobs available was very high in Kuřim (75 %) and also in smaller industrial villages such as Drásov, Hrušovany u Brna, Mokrá-Horákov, and Zbýšov (over 75 %), which proves the former clear industrial specialization of the named villages. On the other hand, the percentage was far lesser in Ivančice, Rosice and Tišnov, which means a greater diversification of sectors of national economy and a significant representation of tertiary sector.

3. Transformation of industrial production in the district after 1990

Basic features of industrial transformation changes in the district of Brno-Province as well as in the whole Czech Republic was slimming of companies, disintegration of large concerns or national enterprises, and independence of newly established entities. Very often the companies were forced to change their traditional production programmes or geographical locations of their exports. A very important phenomenon was the change of property rights with the majority of companies being transferred into private ownerships - both domestic and foreign.

The greatest shrinkage in workers was after 1990 recorded by TOS Kuřim, RUD Zbýšov and Botex Hrušovany u Brna, ie. by the companies with the highest numbers of workers towards the end of the 80s (compare Tab. 2 and Tab. 3). Poor economic results of in the past the far largest employer in the district TOS Kuřim including the unsuccessful entry of successful

Tab. 2 Largest industrial enterprises in the district of Brno-Province by the number of employees to the date of 31 December 1989

Order	Enterprise	Seat	Employees
1	TST, k.p., TOS Kuřim	Kuřim	4572
2	Rosické uhelné doly, k.p.	Zbýšov	1925
3	Závody GK Třebíč, Závod 5 Obuv (Shoe-Making Works)	Hrušovany u Brna	1882
4	CEVA, k.p. Brno, Závod 1 Cement Works Mokrá	Mokrá-Horákov	1179
5	Kovolit k.p. Modřice	Modřice	1082
6	RETEX	Ivančice	724
7	Mosilana Brno, Závod 05-Alexovice	Ivančice	722
8	Rico	Veverská Bitýška	704
9	Avia Prague, kompletační závod Ivančice	Ivančice	652
10	MEZ, k.p. Brno, závod 2 Modřice	Drásov	649

Source: Economic indices for facilities of central-controlled industry in the Czech Republic to the date of 31 December 1989 - Data base of Czech Bureau of Statistics, 1990.

Tab. 3 Largest industrial enterprises by the number of employees in the district of Brno-Province in 1998

Order	Company	Seat	Employees
1	TOS Kuřim – OS, s.r.o.	Kuřim	1130
2	Českomoravský cement, a.s. Závod Mokrá	Mokrá-Horákov	890
3	AMP Czech, s.r.o.	Kuřim	800
4	Lanatex, s.r.o.	Ivančice	640
5	Kovolit, a.s.	Modřice	600
6	Hartmann-Rico, a.s.	Veverská Bitýška	540
7	Slévárna Kuřim, a.s. (Foundry)	Kuřim	500
8	Siemens Elektromotory, a.s. Závod Drásov	Drásov	320
9	Romika Industries, a.s.	Hrušovany u Brna	310
10	Tero Rosice, a.s.	Rosice	300

Source: Important enterprises of the Czech Republic 1998, Prague 1998. Survey made by the Department of Geography in cooperation with Labour Exchange Brno-Province, Brno, 1997.

machine tool manufacturer ZPS Zlín brought the Kuřim enterprise (mother company) to bankruptcy. Total liabilities to creditors amount to 1.3 bil. CZK. Better results are recently reported by daughter company TOS Kuřim-OS, s.r.o. which employs more than 1000 workers as the only industrial company in the district. Today, the traditional manufacturer of machine tools exports to foreign countries approximately two thirds of its production. The dominant Czech customer is Škoda Auto Mladá Boleslav whose 1997 purchases of machine tools amounted to 230 mil. CZK and annual production volume was 630 mil. CZK. Economic results of the company for the first nine months of 1998 indicate that the company's turnover is going to surmount 750 mil. CZK. The half of TOS stock is owned by FOBS Leasing Brno, which further controls the foundry Slévárna Kuřim, a.s. and another daughter company Kuličkové šrouby Kuřim, s.r.o.

The heavy restriction or even stoppage of inefficient manufacture affected two formerly important fuel and energy facilities - Rosické Coal Mines in Zbýšov and Power Plant in Oslavany together with some other plants of food industry (sugar refineries) at Židlochovice and Sokolnice. In the case of Zbýšov and Oslavany, the two formerly important power generating centres, there cannot be any doubt that the fall of significance for the industrial production in the district is greatest ever experienced. In contrast, the town of Kuřim has kept its dominant position in this respect in spite of problems related to the disintegration of TOS. This was possible thanks to the entry of strong foreign capital (see further on). Other formerly important industrial towns and villages maintain their position thanks to foreign developers.

In 1998, the ten largest companies in the district employed about 6 thousand persons in contrast to more than 14 thousand in 1989, which is 42.8 % of the original employment. However, since the total drop of industrial employment before the end of 1997 was hardly 5 thousand, the trend towards disintegration of concerns and the rise of several tens of smaller companies cannot be overlooked similarly as the new orientation of the district to medium-sized and small companies.

Present industrial data do not make it possible to compare the industrial structure with the balance of labour force resources of 1989. The author can therefore make only a qualified estimate. Of present industries comparable with the industries existing in 1989 the greatest production decrease was recorded in power engineering, leather industry, textiles and clothes, and food industry. The original significance has been held by engineering and the industry of building materials. The importance of metal-working industry and particularly that of electrotechnical industry increased with the latter becoming a carrier industry in the district.

The industrial enterprising in the district can be best characterized by "the number of enterprising entities in industry with 1 and more employees per 10 thousand inhabitants". In the case of Brno-Province, there were 799 of these entities to the date of 31 December 1998, which means a value of 50.7 of industrial entity per 10 thousand inhabitants (CR 54.2). Although the district does not even reach the country average, it ranks with this index with the better half in a set of 77 CR districts (1.4 % industrial entities in CR means an average of 107.8 % for the set of 77 districts).

Towards the end of 1998, there were 40 enterprising entities with 1 and more employees and foreign capital registered in the district. Using a similar index as above the level of enterprising can in this respect be expressed by a value of 2.5 of industrial entity with foreign capital per 10 thousand inhabitants. And again, the district of Brno-Province does not reach the Czech average (2.9) but within the framework of 77 Czech districts it approaches the middle and even ranks with the highest values in Moravia.

The average monthly wage of one industrial worker in the district towards the end of 1997 amounted to nearly 10 700 CZK. Although this value made the district of Brno-Province hold a position in the first third of all CR districts by average industrial wage (19^{th} place), the district ratio to average country industrial wage did not reach 100 % (99.5 %). The reason consists in the high income of one industrial worker in districts with dynamic and prosperous corporations (Mladá Boleslav, Pilsen) as well as in districts with "traditionally" high salaries (Ostrava-City, Karviná, Most). On the other hand, the lower section of the list of districts with average monthly wages per one industrial worker does not show any pronounced differences in wages.

A comparison of workers in major sectors of national economy during eight years of transformation is presented in Tab. 4.

been included in the first wave (Cementárny a vápenky-CVM Mokrá, Retex Ivančice and YTONG Hrušovany).

The greatest amounts of shares in the first wave were offered by CVM Mokrá, Kovolit Modřice and TOS Kuřim. Kovolit Modřice and Retex Ivančice were privatized exclusively by the coupon privatization method in which 97 % of basic capitals of both companies were sold (the remaining 3 % falling to Restitution Investment Fund by law). CVM Mokrá and Pórobeton Hrušovany were the companies most attracting developers and foreign investors with their shares. In the first privatization wave the average price of a share exceeded 1000 CZK

Tab. 4 Workers by major sectors of national economy (NE) in Brno Province (BP) and in Czech Republic (CR) to the date of 31 December 1997

Sector	Workers to 31 Dec. 1989		Specialization index	Workers to 31 Dec. 1997		Specialization index
	BP (%)	CR (%)		BP (%)	CR (%)	
Primary	11 621 (21.2)	685 271 (13.1)	161.8	4 085 (7.9)	293 512 (5.9)	133.9
Secondary	27 012 (49.3)	2 479 024 (47.3)	104.2	24 495 (47.1)	2 030 478 (40.6)	116
Of this industry	24 248 (44.0)	2 114 882 (40.4)	108.9	19 339 (37.2)	1 593 778 (31.9)	116.6
Tertiary	16 148 (29.5)	2 072 613 (39.6)	74.5	23 412 (45.0)	2 673 146 (53.5)	84.1
NE TOTAL	54 781 (100.0)	5 236 908 (100.0)	-	51 992 (100.0)	4 997 136 (100.0)	-

Source: Balance of labour force resources in CSFR to 31 Dec. 1989, FSI Prague, 1990. Employment in the civil sector of national economy by administrative regions and districts for 1997, Czech Bureau of Statistics Prague, 1998.

As suggested by the above Tab., the greatest absolute and relative fall in workers was recorded by the primary sector, ie. by 7.5 thousand persons (decrease in its total employment share by 13.3 %). The shrinkage in industry was about 5 thousand persons during the last eight years, which meant the drop in its total employment share by nearly 7 %. In the comparison with the Czech Republic the decrease is lower by 1.7 percentual point. On the other hand, the significance of tertiary sector increased and the sector had already 45 % share in total employment of the Brno-Province district in 1997 (increase by 15.5 %), yet it was still far from getting near the country average of 53.5 %. Also, the specialization index indicates that the basic sectors of national economy in the district reduce their variation range and their shares in total employment become gradually equal.

3.1 Coupon privatization

Of possible privatization methods it was that of coupon privatization, mostly used at privatizing industrial entities in the district of Brno-Province. The first wave of privatization in 1991 was attended by 7 industrial companies of 1.1 bil. CZK total book value. The second wave included 8 companies of which three have already

in all corporations with the exception of TOS Kuřim, which means that those interested in the purchase could buy for a value higher than nominal (similarly also in Szczyrba, 1994).

The second wave of privatization was generally attended by companies smaller than those participating in the first wave. The greatest amount of shares was offered by RUD Zbýšov. Fruta Modřice and Mikrop Čebín intended to privatize nearly the whole basic capital. The greatest interest was again in the shares of CVM Mokrá whose price per piece exceeded 2000 CZK, similarly as in the first wave. In contrast, the lowest-priced stock was that of RUD Zbýšov (137 CZK) which reflected the unfavourable economic and financial situation associated with the stoppage of coal mining and the company's general restructuring. All shares of industrial companies in the district offered in the 2nd wave of privatization were sold with the exception of some CVM Mokrá stock (due to extensive demand).

Other industrial enterprises not included in coupon privatization were privatized mainly by direct sales to Czech subjects with some of works or establishments being returned to their original owners within the restitutions (Kučera, 1996). To mention some of larger com-

Tab. 5 The list of companies with foreign participation in the district of Brno-Province by the number of employees to the half of year 1998

Order	Company	Seat	Specialization	Foreign partner	Employees
1	Českomoravský cement, a.s.	Mokrá	Cement and building materials	Germany	890
2	AMP Czech, s.r.o.	Kuřim	Assembly of connectors and cables for autom.ind.	U.S.A.	700
3	HARTMANN-RICO, a.s.	Veverská Bitýška	Hygienic and medical articles	Germany	500
4	SIEMENS Elektromotory, s.r.o.	Drásov	Eletric motors, el. Machines and instruments	Germany	320
5	Romiko Industries, a.s.	Hrušovany u Brna	shoe-making	Switzerland	310
6	JULI Motorenwerke, k.s.	Moravany	Electric motors	Germany	300
7	Krytina Šlapanice, a.s.	Šlapanice	Bricks and brick products	Austria	170
8	NEUMEYER CZ, s.r.o.	Oslavany	cold metal moulding	Germany	150
9	Schmalhofer, s.r.o.	Rosice	air-conditioning systems	Germany	150
10	YTONG, a.s.	Hrušovany u Brna	Building units	Germany	140

Source: Department of Geography, Masaryk University Brno, Labour Exchange Brno-Province, 1998.

panies with 500 and more employees, it would be EKOTEX Ivančice, s.r.o. - a spin-off from Retex state enterprise, privatized by direct sales in 1992. IVACAR Service Ivančice, s.r.o. was founded in the same year by selling the Ivančice subsidiary of Avia Prague. A year later, a public tender gave rise to Lanatex Alexovice, s.r.o. which singled out of the Ivančice establishment of Mosilana Brno. The last of larger works was Metalpres Zastávka, s.r.o., separated from the original company FORM Brno as early as in 1990 but privatized in direct sales as late as in 1995. At the end of the same year, the more than a half stock package of TOS Kuřim was acquired by Závody přesného strojírenství Zlín in the repeated direct sale, and the privatization of industrial companies in the district of Brno-Province was practically completed with the exception of two more important companies, ie. Technoart Újezd u Brna and Brněnské papírny Předklášteří.

3.2 Foreign capital

Foreign capital played an important role in the privatization of big industrial companies in the district, trying to win at least the majority of shares if not the whole stock. The largest companies with foreign participation are listed in Tab. 5.

In this way, the foreign investors succeeded in winning three prominent manufacturers of building materials in the district. The Belgian-American corporation Cimenteries CBR owned the majority of CVM Mokrá stock, partly acquired by privatization and partly by bonds of new shares. CBR sold its shares to Heidelberger Zement (Germany) - a company which joined the cement works at Mokrá to Cement Bohemia Prague into one whole under the name of Českomoravský cement Praha, a.s., residing in Beroun. In addition to the manufacturing plant at Mokrá-Horákov the company owns the cement works in Brno-Maloměřice and the lime works in Čebín. The German construction holding YTONG A.G. bought in privatization the majority stock of Pórobeton Hrušovany and renamed the company to YTONG, a.s. The new company with about 140 workers in the half of 1998 is very well doing and became the top producer of silicate building units. The Austrian company Ziegelwerke Gleinstätten acquired a clear stock majority in brickworks Cihelny Šlapanice, a.s. and the name of the company was changed into the present Ziegelwerke Gleinstätten - Krytina Šlapanice, a.s. The company employs about 170 workers.

The entire property of Rico, a.s. Veverská Bitýška (including the subsidiaries in Most, Havlíčkův Brod and Chvalkovice) became controlled by Hartmann, Germany at the end of 1993 through the direct sale. Today's name of the company is Hartmann-Rico, a.s. In 1994, Siemens Germany purchased the complete stock of MEZ Drásov and included the company together with other establishments of the former national enterprise MEZ Brno in Frenštát pod Radhoštěm and in Mohelnice into a new company limited Siemens Elektromotory, s.r.o. with about 320 workers. Botex Hrušovany extinguished in the course of 1998 and gave place to Romiko Industries, specialized in shoe-making similarly as the previous owner and possessed by the Swiss capital.

Other important foreign investors are again companies with the German capital: JULI Motorenwerke, k.s. with the manufacture of electromotors and 300 workers, NEUMEYER CZ, s.r.o. which is specialized in cold moulding of metals and has 150 employees, and Schmalhofer, s.r.o. Rosice with the manufacture of air-conditioning systems. The latest large foreign investment is the construction of an assembly hall on the green meadow in Kuřim by American AMP. The company resides is Harrisburg, Pennsylvania and employs 42 thousand workers in its 180 plants located in 40 countries. The works in Kuřim offered 800 jobs and the line of production are connectors and their assembly, cables and bunched cables and harnesses for motor car industry. Also, AMP Czech, s.r.o. provided extra jobs for redundant workers from the near TOS Kuřim.

It is possible to make a general statement that the entry of foreign capital is accompanied not only by investments into new technologies facilitating an essential restructuring of industrial companies, but also by possibilities of increasing exports mainly to western markets.

4. Conclusion

Similarly as in the whole Czech Republic, the transformation process in the district of Brno-Province resulted in the decreased industrial production and industrial jobs with inefficient and unproductive plants being either closed or their operation markedly restricted. A part of redundant workers was absorbed by the strong labour market in the city of Brno which forms an integral part with the labour market of Brno-Province. Another part of released workers shifted their activities into other sections of national economy, particularly into building industry and tertiary sector, or started private businesses. This is why the district has never showed any significant increase of unemployment.

In the course of the 90s, there were several hundred of mainly small-scale industrial shops coming into existence, particularly specialized in engineering and metal-working production, but also in wood-processing, furniture-making and food industries. It can be said in general that it is exactly these smaller companies in the district whose management brings good results at the present time. The large corporations with markedly positive economic results are CVM Mokrá and YTONG Hrušovany u Brna, both in the possessions of German firms. The entry of foreign capital and the orientation of this capital to medium-sized companies shows relatively positive results on the local labour market. A very important impuls to improve industrial production in the district was the construction of a new assembly hall by the American electrotechnical company AMP in Kuřim where more than 800 jobs became available in two years and the company represents one of the most dynamically developing industries in the district thanks to its production programme.

Other possibilities for further development of industrial potential in Brno-Province can be seen in the favourable location of the district in the immediate surroundings of Brno as the second largest centre in the Czech Republic. The industrial companies can make use of very good and fast road and railway connection with the core of the region. The gradual forcing of industrial facilities out of the centre of Brno behind the administrative city limits may play another important role in the further development of local industries.

References

BARTOŠ, J. et al. (1986): Historický místopis Moravy a Slezska v letech 1848-1960. Profil Ostrava, 286 pp.

GALVASOVÁ, I. et al. (1996): Návrh strategie hospodářského a sociálního rozvoje okresu Brno-venkov. Výsledná syntéza poznatků. GaREP Brno, 101 pp.

GaREP, s.r.o. Brno and LOW & spol. s.r.o. Brno (1998): Hlavní směry hospodářského a sociálního rozvoje brněnského kraje s důrazem na přeshraniční spolupráci s Dolním Rakouskem. Závěrečná zpráva o řešení projektu. Brno, 75 pp.

KUČERA, T. (1996): Geografická analýza transformace průmyslové výroby v okresu Brno-venkov v první polovině devadesátých let. Diplomová práce - kat. geografie, PřF MU Brno, 76 pp.

HAMPL, M. et al. (1996): Geografická organizace společnosti a transformační procesy v České republice. Přírodovědecká fakulta Univerzity Karlovy. Praha, 395 pp.

SZCZYRBA, Z. (1994): Geografická analýza výsledků první vlny kupónové privatizace v České republice. Diplomová práce - kat. geografie, PřF MU Brno, 61 pp.

Bilance zdrojů pracovních sil v ČSFR k 31. 12. 1989, FSÚ, Praha, 1990.

Sčítání lidu, domů a bytů 1991. Pramenné dílo. ČSÚ Praha, 1995, 219 pp.

Sčítání lidu, domů a bytů 1991. Dojížďka a vyjížďka do zaměstnání a škol. Česká republika, Jihomoravský kraj. ČSÚ Praha, 1993, 102 pp.

Významné podniky České republiky 1998. Hoppendstedt Bonnier Information Praha, 1998, 1129 pp.

Zaměstnanost v civilním sektoru národního hospodářství podle krajů a okresů ČR za rok 1997. ČSÚ Praha, 1998, 87 pp.

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NEGATIVE INFLUENCES OF COAL EXTRACTION IN THE MINING AREAS OF THE KARVINÁ REGION

Jan HAVRLANT

Abstract

The Czech mining industry has undergone a pronounced transformation and damping down. In the year 1996, quality black coal is only mined in the Karviná part of the Ostrava basin and in one colliery in the Frýdek-Místek part of the basin. The employed caving technology of underground extraction, however, caused a number of ecological and economic problems in the Karviná region. The question of future coal mining and consequent negative effects on the local countryside are connected with numerous factors. A more extensive application of new laws concerning the protection of environment, prices of imported coal and other factors come to the fore in the economy of coal mining.

Shrnutí

Negativní vlivy důlní činnosti v dobývacích prostorech Karvinska

České hornictví prodělalo v 90. letech výraznou transformaci a útlum. Po roce 1995 je kvalitní černé uhlí exploatováno pouze ve čtyřech důlních podnicích v karvinské části Ostravské pánve a v jediném podniku ve frýdecko-místecké části pánve v rozsahu necelých 14 mil. tun ročně. Používaná technologie hlubinného dobývání na řízený zával, ukládání problémových odpadů z úpraven uhlí a hlušin v krajině však způsobily zvláště na Karvinsku řadu ekologických a ekonomických potíží. Otázka budoucnosti těžby uhlí a následných negativních vlivů dolování ve zdejší krajině je spojena s řadou aspektů. Do ekonomiky dobývání vstupuje v současnosti do popředí širší uplatňování nových zákonů o ochraně životního prostředí, nový Horní zákon, faktory nižších cen dováženého polského uhlí ad.

Key words: black coal extraction, negative influences, Ostrava basin, Czech Republic

1. Introduction

The Ostrava basin, in which the Ostrava-Karviná Mining District (further only OKR) is situated, has the prime position in extraction of high quality black coal for more than 160 years. In the former Czechoslovakia during the period of 60-80s this region produced 90 % of the country´s total output of black coal. 75 % of the total production used to be obtained in the Karviná part of OKR and nowadays, after extensive transformation changes in the Czech mining industry, coal extraction here is provided in 12 collieries, which are integrated into 4 huge mining plants, and provide even more than 90 % of the total output in the Czech Republic. Remaining 1/10 of the total black coal production falls on the Frýdek-Místek part of the basin, where the Paskov plant is still in operation. In the last ten years the total production decreased approximately by half, which means that the current output is 14 million tons per years.

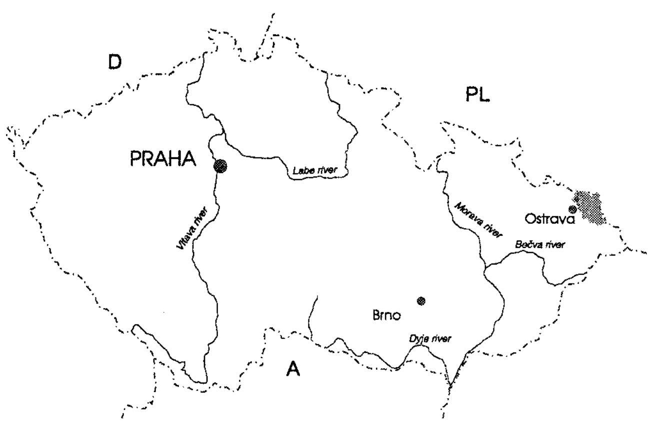

Fig. 1 Area under study

The Karviná part occupies about 1/3 of the former OKR area (305 km^2). However, after the transformation changes and damping down at the beginning of the 90s, this area represents the only viable mining locality in the Czech Republic. Currently, the coal is mined in the saddle seams of the Karviná part of the basin at the depth of 500-800 m below the surface. Thickness of the seams is more than 1 m. The deepest effectively exploited 40^{th} seam (Prokop) is located at the depth of 900-1000 m and its thickness in some parts reaches to 10-14 metres.

On the other hand this area represents a rather devastated landscape due to coal extraction connected with intensive negative consequences caused by undermining and dumping of wastes in the natural environment.

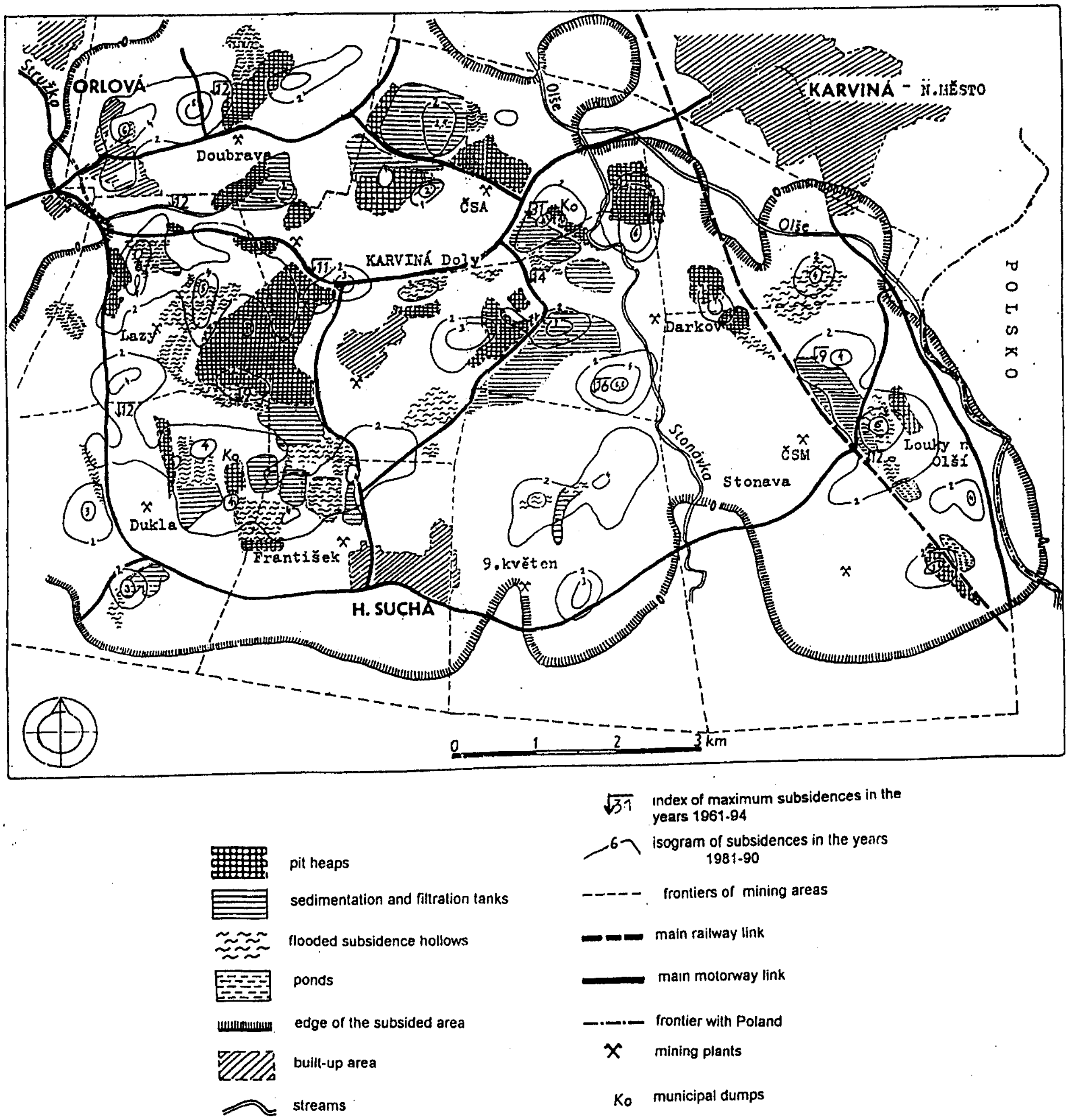

Fig. 2 Mining Wastes and Terrain Subsidences in the Karviná Region

2. Negative influences of coal extraction

Mining is connected with the huge production of waste rock. A half to 75 %, and even 1 ton of waste rock fell to 1 ton of coal extracted during a new development. In the past decades the OKR mines carted out approximately 15-24 million tons of waste rock to the surface and dumped them near the collieries. In the 90s after damping down, the production of waste rock fell below 7 million tons per year (OKD, 1995).

In this way, 38 dumps have gradually been heaped up in the Karviná region and cover nowadays the area of 550 hectars. Most of the waste rock is stored in 11 central dumping grounds with the capacity of several million cubic metres. The largest of them is situated in Karviná-Doly (169 ha), other dumps are located in Doubrava, Orlová, on the boundary between Petřvald and Ostrava and in the frontier area of Louky nad Olší. Some of the dumps have alredy been reclaimed, others are being prepared for recultivation and for integration into the cultural landscape. Henceforth, in the mining space of the Karviná region further 18 dumping grounds totalling to 300 ha were heaped. This leads to a serious damage of the natural environment in a very negative way, especially due to the considerable amount of dust, pollution, aesthetic deterioration of the landscape and decrease of lands available. New classic dumps are not heaped there anymore. During the last years mainly extensive localities devasted by underground extraction, muddy and flooded mining subsidence basins and areas prepared for decontamination and reclamation are being filled up with waste rock. Considering the fast changes and pace of sanitary-reclamation works, the number and extent of equalizing dumps can not be specified. These filled localities are only of the temporary character and in the industrialized area they represent a relatively less disturbing phenomenon.

Much more problematic wastes from the preparation plants and flying dust from the local power stations are stored near the coal mines. These are carried away together with slurry and flotation waste rock through the system of pipes into the industrial sedimentation tanks and into the devastated areas in flooded subsidence basins. In the Karviná region these areas represent the continuing extensive devastation of natural environment, especially after having been filled up with the wastes mentioned, which form large anthropogenic areas. The dumping grounds are sources of excessive air pollution as well as surface and underground water contamination. At the beginning of the 80s, 19 areas were employed as the sedimentation tanks, in 1995 it was already 45 areas totalling more than 550 hectars, including dammed and artificial setting tanks located within the plants and on the dumping grounds. The total area of industrial tanks increased in the last 15 years by 1/5 (460 ha in 1980). The whole networks of tanks, which are situated in the mining space (MS) of coal pits, were filled up and their total area nowadays is 160 ha at the Darkov Mine in Karviná, 120 ha at the ČSA Mine, 120 ha of MS in Lazy-Orlová or 115 ha of the ČSM Mine in Stonava. The largest individual tanks came into existence at the ČSA Mine, Karviná (112, 76, 54 ha) and in Louky nad Olší (113, 66, 53 ha). According to the forecast (Terplán, 1991) these extremely problematic localities are believed to take up the total area of 1200-1500 ha at the end of the 90s. Their decontamination and reclamation will be possible only after coal extraction there is finished.

However the subsidences and the consequent total devastation of the landscape is the most serious problem in the Karviná region. Whilst in the 70s the surface subsidences still took up almost a half of the OKR area, nowadays a nearly total area of the Karviná region is affected by them.

Only the northernmost part and southern edges of the Karviná MS have remain out of influences caused by undermining. More than 115 km^2 (OKD, 1991) were affected by the surface subsidences. This resulted in the formation of deep depressions which in the course of 10 years deepened by 5-7 m and gradually saturation and muddiness of these subsidence basins and consequent total devastation of the landscape. The subsidence of the area resulted in the waterlogged soil, gleization and flooding of available lands as well as in the gradual extinction of vegetation including large forests.

As a result of subsidences in the Karviná region during the last 40 years, the run-off conditions, hydrologic network and surface and underground water regime changed completely, esp. in the area of Karviná-Darkov, -Doly, -Louky, Stonava, Suchá, Orlová and Doubrava. Today the waterlogged and flooded areas occupy the total area of about 880 ha, which is approximately 13 % of land found in the subsidence effect and altogether almost 8 % of the total area of the Karviná MS. The majority of the 20 flooded depressions is used for dumping coal wastes coming from the coal washery and therefore their water is considerably polluted. There are also tension cracks, stepwise fractures and inclination (as much as 30 %) that appeared on the edges of the subsidence basins. Changes in the overall configuration of the relief resulted in an extensive deformation and destruction of all surface buildings, communication and engineering networks including. The enormous damage resulted in demolitions of the whole affected residential areas in Karviná, Doubrava, Orlová and recently also in Darkov, Louky nad Olší and others. At the present, the landscape devastated due to the subsidences occupies approximately 3/4 of the mining space (MS).

Sanation and recultivation of these areas, building up of new surface buildings and residential areas is an extremely costly business. Nevertheless, this reality did not reflect in the economy of mining plants in the past years in spite of the fact that the used caving method supported by the former regime consequently caused the disaster. At the beginning of the 60s, about 1/5 of exhausted coal seams was filled up, whilst in the 70s it was less than 1/10 of seams. In the 80s, the mining plants did not fill up even the necessary minimum (approximately 5 % volume of land fill) and in the course of the last years, the majority of mines stopped filling the extracted seams. Therefore, after removing the mine, there is cracking, heading and breaking dovn of roofs into the exhausted space in the overlying beds. The evidence of the existence of caving is a subsided basin whose total area is larger than that caused by caving into the seams underground. Reasons for mentioned coal extraction technology were and still are limited to an immediate economic effect. The filling of exhausted seams means for collieries an instantaneous increase of energy, transport and at the same time a decrease of output and productivity, which leads to a rise of expenses on the production of coal (approximately by 1/3). A higher price of coal would make this traditional raw material unmarketable. On the other hand, the method of caving extraction caused the damage of bil-

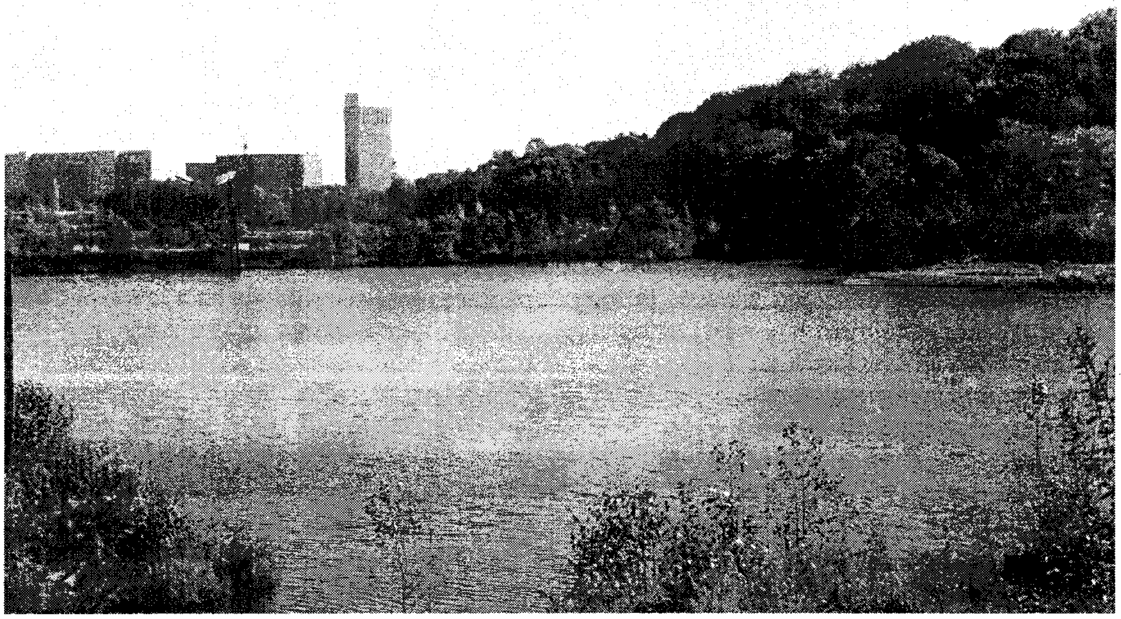

Fig. 3 Flooded subsidence hollows in the Karvina-Darkov mining space, which are over 100 ha in area and 15-31 m in depth, are utilizable for the sedimentation of coal sludge. Photo Jan Havrlant, 1998.

lion CZK. Owing to the subsidences, other expences on sanitary-reclamation and reconstruction works increased extremely. Land filling is very important as it would mean that both the primary consequences of coal extraction such as surface subsidences and dumping would occur to a lesser degree, and the secondary consequences associated with considerable ecological and economic losses would decrease. The total number of subsidences in the Karviná region and their course from the beginning of coal extraction on is impossible to find out as up to 1960 they were not systematically observed. The intensive changes of surface were recorded especially in Karviná-Doly situated in the old part of Karviná in the ČSA MS, where the locality of the former railway station subsided by more than 30 m in the period from the end of the 60s to 1995. In the south-western part of the Jindřich Colliery the surface sank to as low as 11 m and in the north of the ČSA Mine by 8 metres during the last 30 years.

In the neighbouring MS of the Darkov Colliery, which was opened at the beginning of the 80s, the subsidences have been in progress up to the present day as well as in the older part of MS of the 1. Máj Mine situated to the south-west of the Mír Colliery in the Stonava cadastrar area, and since 1961, this locality has subsided by more than 15 m, of which 6.5 m during the last 10 years. In the period 1961-1990, a subsidence basin located in the part called Solca which is neighbouring with MS of the ČSA Mine, deepened by 14 metres. The new Darkov Mine extended coal extraction to the east as far as Karviná-Darkov and in the direction of the Stonávka river where 6.5 m subsidences caused disastrous changes in the flow-off situation and flooding of large areas, similarly to the neighbouring MS already mentioned. The southern edge of MS of the Darkov Mine belonging to the 9. květen Colliery has a slightly lower subsidance; a subsidance basin in the Křivý Důl deepened by 4.5 m during the last 10 years.

Since the 70s, the eastern part of OKR-MS of the ČSM Mine in Stonava has become another considerably devastated area. An extensive subsidence basin of more than 12 m, which subsided by as much as 6 m in the course of the last 10 years, is located at the highway overpass crossing the main railway line used for international connections. The landscape devastation spread also to the preserved areas of former ponds in Louky nad Olší where subsidence basin sank by 5-8 metres. Similarly, the area north of the ČSM Mine subsided by 8.5 metres in the location of sedimentation tanks. The subsidences extended to the east as far as the frontier stream of the Olše River whose bed subsided in the division between Louky and Darkov and therefore its part got into counter-declinity. Fast local surface changes caused problems with drainage and gnarling of rails the fast train line due to compressive and tensile stresses. Costly reconstructions of roads, superstructure, relaying engineering network, new embankments, damming of reservoirs and streams and the necessary evacuation of local inhabitants and demolitions of destroyed housing resources are permanently in progress.

The most serious problems in the northern part of the Karviná region in the MS of the ČSA Mine around Doubrava Colliery are those of undermining. Subsidences situated in the localities north of the pit in the old part of Orlová and southwest of the mine near the boundary with the MS of the Lazy Mine in Orlová reached the depth of 10-12 m in the period 1961-1990 and especially during the last 10 years the basins deepened by as much as 3-6 metres.

In the neighbouring MS Orlová-Lazy, as mentioned above, more subsidence basins are to be found of which the most problematic ones are situated in the northern part of MS near the main highway Ostrava - Karviná near the railway line in Orlová at the place of today's setting tanks, and in the southwestern part of MS of the Darkov Mine - close to Barbora Colliery in Karviná Doly, where subsidences reached maximum values of 7-9 m since 1961. In the last 10 years, even a 6 m deep subsidence was recorded in the former locality north of the coal mine.

In MS Lazy which is situated southwards of the Dukla Colliery, a 12 m deep subsidence basin was formed on the boundary with the Orlová part. Southwest and also northwest of the Dukla Mine a few more subsidence basins of 7-8 m in depth came into existence.

4-metre subsidences were measured in the neighbouring František MS in the course of the last 10 years.

In the western part of the Karviná region near the boundary with the Ostrava part of the basin, subsidences as well as their consequences are of less intensity and extent. During 1961-1993, some 3 to 6-metre subsidences of the surface were recorded in the Petřvald MS of the Fučík Mine and in this respect they are similar to the earlier subsidences in the Ostrava part of OKR.

3. Conclusion

Despite the considerable current reserves of high quality black coal in the Karviná part, prognoses concerning any further development of extraction of this raw material and its ecological and socio-economic consequences can hardly be made. They are connected with a number of new factors that come to the fore in the economy of coal mining. Taking into consideration the fact, that according to the new Mining Law and other laws concerning the protection of environment also expenses on the liquidation of damage in the landscape, payments of sanitary and reclamation works and reconstructions of the surface buildings are to be reflected in the price of coal as well. At the same time regarding the competition of cheaper imported Polish coal, a further decrease in the production can be assumed, esp. in the Frýdek-Místek part of OKR and in the elder collieries in the Karviná region. A further structural transformation of this originally mining region and presumably also slow down of the effect of negative mining effect caused by the extraction in the natural environment will relate to what has been mentioned above. In the case that the current trend in the caving method of extraction will be continued, the surface subsidences of similar intensity will go on and all the reconstruction works will be come just necessary and very costly maintenance of the landscape which would otherwise have to face a total devastation. The question of the future of coal mining in this frontier region calls for a complex ecological and socio-economic analysis of mining works and their consequences. The solution of ecological issues has to include final reclamation and overall regeneration of this industrialized area.

References

HAVRLANT, J. (1977): Negativní vlivy důlní činnosti na krajinu na příkladu dolů ČSA, Máj a AZ v karvinské části OKR, Diplom. práce, PřF UK, Praha, 144 pp.

HAVRLANT, M. (1979): Antropogenní formy reliéfu a životní prostředí v Ostravské průmyslové oblasti, Spisy PF 41, Pedagogická fakulta, Ostrava, 153 pp.

Terplán (1991): Ostravská sídelní regionální aglomerace, Územní plán velkého územního celku, Praha

Ostravsko-karvinské doly, a.s. (1995): Podkladové materiály a mapy skutečných poklesů v DP důlních závodů, důlní podniky v Karviné a Orlové.

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FIVE YEARS OF THE BRNO BRANCH OF INSTITUTE OF GEONICS AT THE ACADEMY OF SCIENCES OF THE CZECH REPUBLIC

Antonín VAISHAR - Oldřich MIKULÍK

1. Foundation of the Branch Office

The Institute of Geonics at the Academy of Sciences of the Czech Republic was constituted in 1993 in the course of transformation of the former Czechoslovak Academy of Sciences. Its headquarters in Ostrava came into existence in the place of the former Mining Institute of the Czechoslovak Academy of Sciences, whilst the Brno Branch Office links up with activities of some departments from the abolished Geographical Institute of the Czechoslovak Academy of Sciences. Since 1st July, 1998 the Institute is an organisation subsidised by government, funded partially from a direct contribution from the state budget, partially from other sources of which the most important ones are those provided by a range of grant agencies for targeted projects, other sources being also receipts from technical expertise and studies carried out on the basis of commercial contracts. The position of the Branch within the Institute is relatively autonomous which follows out of its technical profile and dislocation. The seat of the Branch Office is in Drobného street 28, in the Brno quarter of Černá Pole.

2. Institutional programme

The centre of gravity for activities of the Branch is an institutional programme whose purpose is to integrate all existing activities in one direction, to generalise results of individual partial programmes of grant or other types, and to ensure the continuity of scientific work.

The first institutional programme REGIONAL EVALUATION OF THE ENVIRONMENT UNDER CONDITIONS OF ECONOMIC AND SOCIAL TRANSFORMATION was based on the conception of the former centre for regional research of environment at the Geographical Institute, Czechoslovak Academy of Sciences and included the following projects:

- Environment Development in Regions of Various Types
- Geosystems in the Czech Republic from Environmental Viewpoint
- Environmental Studies in Urban Agglomerations and Settlement Systems
- Regional Differentiation of the Quality of Life
- Remote Sensing Methods for Landscape Use and Environmental Management
- Regional Information System and Environmental Cartography
- Regional Fundaments of Eco-Development (project of international cooperation).

The probably most important project in the first period of programme existence was that of the Atlas of the Czech Republic, worked out for the CR Grant Agency in cooperation with a number of universities, which was not realized.

Since 1996, the programme is included in the key direction of the Czech Academy of Sciences under the name "REGIONAL EVALUATION OF ENVIRONMENT IN THE CONDITIONS OF CZECH REPUBLIC UNDER TRANSFORMATION". The programme solution has three basic groups of problems: Research of environment in urban geosystems; Research of environment in rural geosystems, and Evaluation of impact of large technical works on environment. These are also the boundaries for proposals of grant projects and technical expertise. In terms of regions, attention was primarily paid to the transformation of landscape and society in the districts of Znojmo, Břeclav and Hodonín, later on also to the town of Brno and marginal regions of South Moravia.

In 1998, the conception of institutional direction was up-dated with the project named THE STRUCTURE AND DEVELOPMENT OF REGIONS FROM ENVIRONMENTAL POINT OF VIEW where the subject of study will be regional analyses and analyses of geographical problems in areas of various sizes mainly in Moravia in the conditions of acting consequences of transforming economic and social mechanisms and the beginning of operation of large regional administrative units. The attention will further be paid to urbanized regions including large conurbations such as in Brno or Ostrava, rural (particularly marginal) regions, regions of large-scale nature protection, regions of natural disasters and regions of either existing or planned technical works so that it is possible to assess the dynamics of development in the whole system of settlement also in some specific natural geosystems, particularly with regard to economic and social prosperity and possibilities of sustainable life. A comparison analysis of small and medium-size Moravian towns is under methodological preparation.

3. Grant projects

At the very beginning, the grant projects transferred from the Geographical Institute were finalized. These were the following tasks of CR Grant Agency, Grant Agency of CR Academy of Sciences, and CR Ministry of Environment:

- Anthropogenic Impact on the Course and Character of Karst Water
- Anthropogenic Transformation of Relief and Possibilities of its Assessment
- Prognoses of Underground Water in Relation to Geographical Conditions
- Evaluation of Elements of the Karst Environment and Its Positive Influence on Infant Organism
- Possibilities of Detection of Climatic Changes in Historical Period
- Complex Geomorphological Analysis of the National Park Podyjí
- Danger to Some Towns, Villages and Important Technical Works in the Czech Republic Caused by Natural Hazards
- Development of Slopes in Periglacial Period.

The speleological studies resulted in publishing the proceedings STUDIA CARSOLOGICA 6, while the other projects continued with further research. An output from the grant projects bound to natural hazards and climatic changes was the publication Natural Hazards in the Czech Republic within the series of STUDIA GEOGRAPHICA.

Grants acquired during the time of the Branch existence were based on the adopted scientific conception of the Branch and gradually included the following projects:

- TRANSFORMATION OF THE BORDER LANDSCAPE IN SOUTH MORAVIA.
  The manuscript study includes physico-geographical, socio-geographical and historico-geographical analyses of the model region of South Moravia, an analysis of some problems of natural environment, an analysis of the relation between the large-scale protection of the landscape and its prosperity, an analysis of some social and economic problems (agriculture, recreation, border location, functional structure of district towns, entrepreneurial potential of the population).
- THE CULTURAL AND ECONOMIC CONDITIONS OF DECISION-MAKING FOR SUSTAINABLE CITY.
  The research study was coordinated by the Polytechnic in Turin and was carried out in the Cupertino with the Geographical Institute of Hungarian Academy of Sciences in Budapest and with the Geographical Institute in Ljubljana. The project dealt with an analysis of traffic and transport issues, retail business trade and public greenery. Its results were published in Moravian Geographical Reports.
- THE FLUCTUATION OF CLIMATE IN THE PRE-INSTRUMENTAL PERIOD OF THE CZECH REPUBLIC: MONITORING OF HISTORICAL ENVIRONMENTAL CHANGES.
  The attention was directed primarily at the search and analysis of original sources and documents to carry our a reconstruction of weather and climate in the territory of the Czech Republic in the 16th and 17th centuries during the period of which the beginning of so called Short Glacial Epoch was to show up in the great deal of the European territory.

One of major disclosures was the exploitation of hitherto unutilized hand-written diaries with meteorological data. Results are valuable also for countries neighbouring with the Czech Republic. With regard to the topical character of the issue it is also the historical floods that appear in the limelight.

- CARRIER SYSTEM STABILITY OF BRIDGE AND TUNNEL STRUCTURES IN STRESS FIELDS OF ZONES OF GRAVITATIONAL LOOSENING.
The research which was carried out jointly with experts from Technical University Ostrava, High School of Mining and from other workplaces resulted in the following geomorphological conclusion: Numerous tectonic and gravitational formations largely of tensile expansion were generated in the stress fields of zones of gravitational loosening, which even included a vertical (shear) component at some places. The resulting process which led to the present morphology of the valley can be called gravitational spreading directed to fill the valley. The vertical component of normal faults may be facilitated by basal attitude of the rock massif at the level of valley floors that are heavily disturbed by debris, which may contribute to the step-like block sinking. The phenomenon is also typical of the valley of the Bobrava River.
- GEOMORPHOLOGICAL DEVELOPMENT OF THE RELIEF IN THE NATIONAL PARK OF PODYJÍ AND AT THE BROADER SOUTHEASTERN EDGE OF THE BOHEMIAN MASSIF.
The research aimed at mapping the basic characteristics of the relief of the foreland on the marginal scarp of the Bohemian Massif in the Jaroslavická Upland on a scale of 1:50 000. Studied were links between the geological structure and formations as well as the tectonic issue. New pieces of knowledge were gained about Tertiary sediments in the northern back-land of the National Park, about the distribution of remaining fluvial sediments in the deep river valley of Dyje and about the nature of tectonic disturbance to the underlying rock. The localities of Ledová sluj, Králův stolec and Býčí skála were investigated by using the method of georadar. A geomorphological inventory of some relief formations in the National Park of Podyjí was worked out within the environmental programme of the CR Ministry of Environment parallel to this grant.
- IDENTIFICATION AND ASSESSMENT OF OLD DUMPS IN THE SPACE OF BRNO-SOUTHWEST BY MEANS OF INTERPRETING AERIAL AND SATELLITE PHOTOGRAPHS.
235 sites were identified in the territory of the SE quadrant of Brno in cooperation with the Karl-Franzens University in Graz, Austria, of which 90 exhibited signs of possible contamination that was later confirmed during the detailed investigation in the majority of them. The mentioned sites were then classified into five classes of danger on the basis of methodology of ETI-models. The most problematic first and second classes include 54 sites. The project resulted in a digital cadaster of sites with old waste loads, whose customer became municipal authorities of the City of Brno.
- NEW PROSPERITY FOR RURAL REGIONS.
The project dealth with problems of marginal mainly border regions in Moravia and Slovenia. The course of transformation and its consequences were studied in seven model regions together with all associated borderland problems and environmental aspects. The research employed methods of behavioral geography. The following problems were identified and documented: deepening marginality, worsening labour market situation, structural demographic degradation, absence of suitable developmental programmes etc. Utilization of human resources is considered a decisive factor for the solution of the issue a necessary pre-requisite being the regional policy.

In addition to the above projects the Branch participated in the grant of the Mendel University of Agriculture and Forestry in Brno CHARACTERISTICS OF UNITS OF GEOBIOCOENOLOGICAL TYPOLOGY IN THE CZECH REPUBLIC.

4. Expert opinions

Since the very beginning of its existence the Branch deals with projects ordered by various governmental and private institutions and organizations. The activity was originally a form of Cupertino with the practice and a possibility to test the research procedures in reality. However, later on it became an economic necessity. Let us mention some of the most significant works of the character:

- a series of regional studies in the Protected Landscape Area of Žďárské vrchy (Hills) for the CR Ministry of Economy,
- physico-geographical characteristics of territories of water reservoirs in Letovice, Boskovice and Těrlice for HYDROEKO Agency,
- some physico-geographical aspects for the revitalization of Dyje River floodplain for the same Agency,
- a study into impacts of extraction and processing of stone in the Leskoun quarry on the landscape and environment for the District Council of Znojmo,
- a biogeographical assessment of plans to modify the water stream of Leska for National Amelioration Administration,
- a series of assessments of the area Skalka near Perštejn of interest for České energetické závody (ČEZ a.s.),
- groundworks to EIA for the conception of decontamination of sludge beds near Rožná for DIAMO o.z. GEAM Dolní Rožínka,
- a socio-economic study of Danube Pollution Reduction Programme project for UN Global Environmental Facility,
- historical development of anastomosing river system as the main protection phenomenon in the Protected Landscape Area of Litovelské Pomoraví for the CR Ministry of Environment,
- and many other projects.

5. Editorial activities

Since the very beginning of its existence the Branch issues twice a year a periodical MORAVIAN GEOGRAPHICAL REPORTS. The aim was to maintain the exchange of literature with abroad, to contribute to the identification of the Branch under its new name and under a new organizational scheme, to encourage publishing activities of experts from the Branch as well as of other Czech and foreign specialists engaged in the regional issue of Moravia and associated problems, and to gain a tool of technical discussion. The original project of the periodical anticipated a close cooperation with Moravian universities whose workplaces are represented in the editorial board.

In the course of the first six years there were altogether 12 numbers with the total extent of about 650 pages. Gradually, the periodical became a prestigeous technical magazine also for authors from neighbouring countries. In 1998, the board of editors was joined by some foreign members. Apart from this, the Branch issued a number of non-periodical works. In addition to the already mentioned results of grant projects, these included proceedings from conferences and seminars organized by the Branch. The majority of these publications are in English.

6. International conferences

In five years of its existence the Branch organized four international conferences with proceedings. These conferences were attended by nearly 50 foreign geographers from seventeen (mainly European) countries.

- HEALTH, ENVIRONMENT AND DEVELOPMENT. The conference of IGU Commission (Brno, September 1994).
- GEOGRAPHY AND URBAN ENVIRONMENT. The first Moravian geographical conference CONGEO '95 (Brno, September 1995).
- RURAL GEOGRAPHY AND ENVIRONMENT. The second Moravian geographical conference CONGEO '97 (Valtice, September 1997).
- The 2nd Czecho-Slovak Academic Seminar in Geography (Brno, November 1997).
- The third CONGEO'99 is in the process of preparation. The conference with the topic of REGIONAL PROSPERITY AND SUSTAINABILITY will be held at Slavkov near Brno (Austerlitz) in September 1999. A new impulse is the idea of organizing international field workshops with physico-geographical topics in even years.

7. Conditions

The Branch has at its disposal facilities and lands which provide a relatively very good working environment whose proper management and maintenance presents considerable costs. The headquarters are located close to the town centre. The Branch has in its possessions also a facility in Veslařská Street with the deposit part of library and archives, and a field base Salmovka in the cadastral area of Blansko-Těchov. The workplace is sufficiently equipped and the telecommunications facilities are of world standard.

The set up of a team that would be capable of fulfilling tasks following out of the workplace concept and topical requirements of practice is considered a major objective. To form such a team is a question of long time and it can be said that this was the task the Brno Branch struggled with during the entire period of five years. The absence of medium-aged stratum of workers (30 to 45 years) more or less continues. Fortunately, there are about ten new young university graduates of whom some hopefully stay for a permanent job. The present scientific and technical staff of the Branch is as follows (to the date of 1 July 1999):

Petra HEERENOVÁ – librarian

Mgr. Pavlína HLAVINKOVÁ – physical geography, waste management

RNDr. Sylvie HOFÍRKOVÁ – physical geography

RNDr. Mojmír HRÁDEK, CSc. – geomorphology

RNDr. Antonín IVAN, CSc. – geomorphology

Mgr. Eva KALLABOVÁ – social geography

Mgr. Hana KELLNEROVÁ – social geography

RNDr. Karel KIRCHNER, CSc. – geomorphology

PhDr. Barbora KOLIBOVÁ – sociology

Ing. Jan LACINA, CSc. – biogeography

Mgr. Zdeněk MÁČKA – physical geography

RNDr. Oldřich MIKULÍK, CSc. – social geography

RNDr. Jan MUNZAR, CSc. – climatology, historical geography

RNDr. Stanislav ONDRÁČEK – hydrology

RNDr. Evžen QUITT, CSc. – climatology

Mgr. Andrea PETROVÁ – GIS, remote sensing

Ing. Radek POKORNÝ – computer and communication technology

Mgr. Alžběta STRACHOVÁ – sociology

Mgr. Jitka ŠKRABALOVÁ – environmental geography

Mgr. Bohumír TRÁVNÍČEK – social geography

RNDr. Antonín VAISHAR, CSc. – social geography

RNDr. Jana ZAPLETALOVÁ, CSc. – geography of transport and recreation

THE 3rd SLOVAKO-CZECH ACADEMIC SEMINAR IN GEOGRAPHY

Oldřich MIKULÍK - Peter MARIOT

The 3rd Slovako-Czech Academic Seminar in Geography was held in the Geographical Institute of Slovak Academy of Sciences in Bratislava on 8 December 1998 as a successful follow-up of the cooperation between two academic workplaces which decided in 1996 to continue in the previous long-term cooperation. The present contacts do not yet include joint programmes but rather focus on the exchange of information, experience from research projects resolved by the two workplaces, and the extension of contacts among young experts. Topics of the last three years discussed the issues of similarities and dissimilarities in the development of the Slovak Republic and Czech Republic after their split (1996), similarities and dissimilarities in the development of towns in both countries (1997), and the third seminar concentrated on specific features of transformation process in the hinterland of large cities (1998). There are proceedings available from each of the seminars.

The Bratislava workshop had 12 papers prepared of which six contributions of Czech participants from the Institute of Geonics, Academy of Sciences of the Czech Republic in Brno were presented during the morning session.

In his introducing paper A. Vaishar characterized the region of Kunštát na Moravě as an internal periphery of the Czech Republic. After a brief characteristic of the region and set-up goals of the project he made a general assessment of external links of the region, social consequences of transformation and opportunities of local municipalities to find their prosperity. At the present time, neither the town of Kunštát nor the neighbouring centres of Lysice and Olešnice are capable of full integration of their region and of providing to the region the full range of services of urban character. There are various visions about the region's future. Kunštát would like to capitalize on its cultural and historical values, Olešnice plans to develop manufacturing functions, and Lysice intends to capitalize on the travel industry from Brno in the connection with the local chateau and its surroundings as well as to support medium-sized businesses.

The paper presented by J. Zapletalová discussed possibilities of developing recreational activities in the Kunštát area. The region is distinguished by its high aesthetic and natural values and can be classified as an area of all-year use with dominant summer recreation. It is situated on the margin of the sphere of influence of Brno as the regional centre whose population comes here for recreation in their cottages and summer houses.

E. Kallabová and J. Škrabalová informed about the present situation of the Kunštát area as it is viewed by the local population on the basis of a public survey made in the region. The assessed parameters included the stability of families in the region, the position and prospects of the area on the labour market, the situation of municipalities in the region, the attitude towards nature and environment protection programmes, the evaluation of answers delivered by grand-parents, and the differentiation of results by respondents' education. Life problems and pessimistic judgements reflect the situation which combines the region's remoteness and the concrete state policy which in marginal regions still misses any comprehensive conception in many a sphere.

The contribution presented by J. Kunc included an evaluation of the present situation in the industrial production of Brno-Province district after the transformation as relatively stabilized. Inefficient and unprofitable manufactures were stopped or markedly restricted their production. Several hundred of mainly small-scale industrial shops came into existence in the course of the 90s, particularly so in engineering and metal-working industries. Further possibilities for developing the industrial potential of Brno-Province district can be seen in its favourable location within the immediate surroundings of Brno.

B. Kolibová discussed the globalization of retail network by large corporations in Brno and its surroundings, characterizing her contribution as an introductory survey of innovation processes that gradually change not only ourselves, but also our style of living and our environment. In what way and with what consequences – this will be the subject of further research.

The paper of O. Mikulík was the last one in the block of Czech contributions devoted to the research of one of model areas characterized as marginal – the region of Kunštát. This paper was a summary of hitherto knowledge from the economic transformation of the region with graphical plotting of changes and the status of industrial manufactures, agricultural facilities and private businesses in municipalities of the region.

The second part of the session – papers presented by Slovak colleagues – was opened by P. Podolák and his contribution in which the author pointed out the necessity of paying more attention to the evaluation of the process of population reproduction at a lower level of administrative territorial division and mentioned the importance of its taking into consideration at assessing the regional differentiation of demographic structures. The measurements were made in 114 municipalities of six regions in the hinterland of Bratislava. There cannot be any doubt that the analysis made at the level of municipalities contributes to the better knowledge of processes under study and their chains of causations in the spatial context.

A. Michálek summarized the major problems of some towns and their hinterlands on the basis of a new administrative territorial division which is a considerable intervention into the spatial organization of Slovak society. The measure will impact many dimensions of social development and developmental possibilities – particularly so in newly established socio-territorial units including both physical and functional relations between individual seats. The author claims that a minimum of 15 administrative districts out of the newly established forty do not perform their functions and are not efficient at utilizing the potential of the area, which will mst probably result in zero economic and social effects.

D. Kollár analyzed in his paper the innovation activities and the development of employment in industrial companies of Bratislava conurbation. The research included all companies with more than 24 employees in former administrative regions of Bratislava and Trnava. The positive or negative development of employment rate in the individual industrial companies is to a considerable extent copying the innovative behaviour of these companies, thus clarifying the background of economic results.

V. Ira evaluated the research made in the surroundings of Bratislava from a viewpoint of some aspects of transformation process with regard to the pre-requisites of sustainable development. He pointed out the necessity of paying much more attention to the development of social and environmental elements in the town hinterlands, stressing the long-term protection of their positive qualities.

The contribution of F. Podhorský discussed the intensity of suburban transport in the hinterlands of largest Slovak towns. The author worked out a typification model for some towns on the basis of intensity of bus and train connections and the number of suburban transport connections, which consists of four categories as follows: towns with the opened-, partially limited-, limited-, and considerably limited hinterlands. The suburban transport is considered important within the general transport intensity.

P. Mariot closed the Seminar with a contribution in which present trends of transformation were evaluated in the recreational surroundings of Slovak towns. The greatest attention was paid to indices that contributed to the transformation with their positive influence, and to indices whose effect resulted in negative changes in the surroundings of largest Slovak cities – Bratislava and Košice.

Discussions to all presented papers and the final exchange of opinions confirmed once again the usefulness of workshops for both parties. At the same time, the workshops documented the contributing character of monothematic seminars whose topics, although worked out only to a lesser extent so far, are very pressing. The theme of the 4th Czecho-Slovak Seminar in Geography to be held in Brno in Autumn 1999 will follow the hitherto lines.

Publications available

RURAL GEOGRAPHY AND ENVIRONMENT (168 pp.). Proceedings contains 25 papers of authors from 18 countries, read in the CONGEO '97 Conference. (price CZK 190,-)

PODOBNOSTI A ROZDÍLY VÝVOJE MĚST ČR A SR PO ROCE 1990 (95 pp.). Proceedings contains 12 papers, read in the 2nd Czech-Slovak Academic Conference in Geography (price CZK 115,-)

IDENTIFICATION AND EVALUATION OF THE FORMER WASTE DUMPS IN THE BRNO-EAST AREA (132 pp.). Results of the grant elaborated in co-operation with Karl Franzens University Graz (price CZK 125,-)

SPECIFIKA TRANSFORMAČNÍHO PROCESU V ZÁZEMÍ VELKÝCH MĚST (76 pp.). Proceedings contains 10 papers, read in the 3rd Slovak-Czech Academic Conference in Geography (price CZK 125,-)

MĚSTO BRNO V ŠIRŠÍCH SOUVISLOSTECH (100 pp.). Proceedings containing 9 papers dealing with the development of the city of Brno and its main functions within the process of globalisation. (price CZK 125,-)

REGIONAL PROSPERITY AND SUSTAINABILITY (250 pp,). Proceedings contains 22 papers of authors from 11 countries, read in the CONGEO '99 Conference. (Price CZK 350,-)

It is possible to order by mail: Institute of Geonics, Brno, PO Box 23, 613 00 Brno

fax: 420(0)5 578031, e-mail: heerenova@geonika.cz

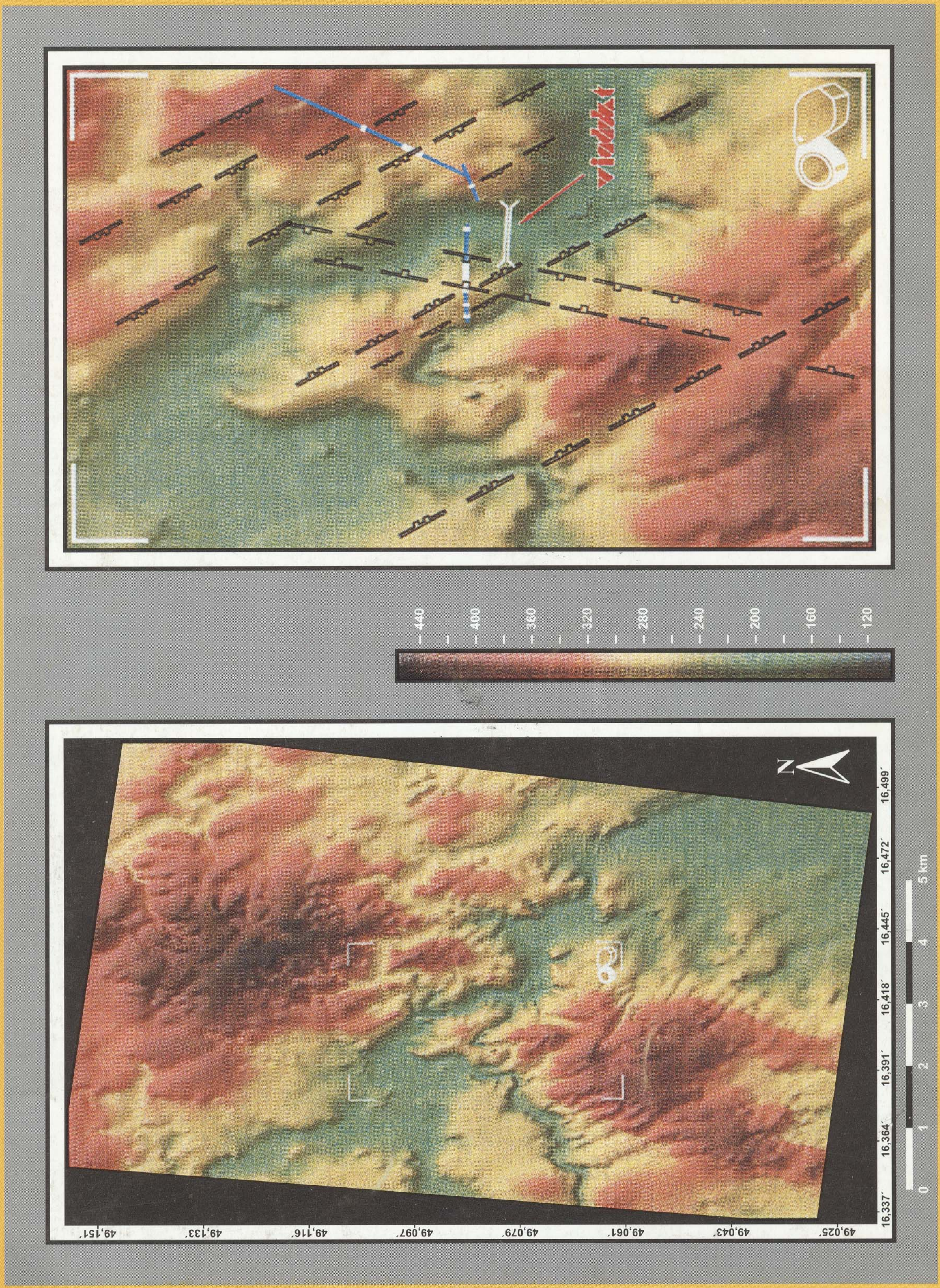
The southern part of the Český les Forest Haltravský hřbet Ridge with the flat topography of the Chodská pahorkatina Hilly Land in forefield.

Photo: B. Balatka

The NE part of the Tertiary Sokolov Basin near Ostrov, enclosed by the Doupovské hory Mts. and the highest part of the Krušné hory Mts. near Klínovec.

Photo: B. Balatka

Illustration to A. Ivan's paper



Digital terrain model (DTM) of Ivančice viaduct area and a detail with interpretation of main tectonic zones. The western support of the viaduct is localized in the crossing of tectonic lines. Blue marking illustrates the P line of electric resistance profile; white marking illustrates sections with fractural disturbances, interpreted on the basis of geophysical measurements (VES-Vertical Electrical Sounding). After Grygar et al. (1996).

Illustration to M. Hrádek's paper