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SELECTED ANALYSES OF THE MORPHOSTRUCTURE OF THE NE PART OF THE RYCHLEBSKÉ HORY MTS. (CZECH REPUBLIC)

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ABSTRACT
The Rychlebské hory Mts. are situated in the northeastern spur of the Bohemian Massif. The morphologically distinct Marginal Sudetic Fault, which borders the Sudetic mountain range both on the Polish and Czech sides, runs through the studied area in the direction NW - SE, dividing the Sokolský hřbet Ridge, the centre of the area of interest, from other parts of the Rychlebské hory Mts. Morphostructural analysis within the studied area, as a part of ongoing morphotectonic research, comprising analyses of joint and fault system, drainage pattern, and morpholineaments, was performed in order to determine the correlation between the structural conditions and landforms. The direction NW - SE, parallel to the Marginal Sudetic Fault, represents very significant direction in the entire studied area. The other distinct structural directions are NE - SW and N - S. The faults and joints of these directions have influenced development of landforms in the area, as it is clearly seen from the arrangement of morpholineaments.

KEYWORDS: morphotectonics, joint analysis, fault analysis, Marginal Sudetic Fault, Fore-Sudetic block (Bohemian Massif)

INTRODUCTION

"Morphostructure" (by western geomorphologists referred to as "morphotectonic unit") involves a structural geological base of relief including rocks, i.e. lithologically controlled landforms, and influences of an older tectonics (joints, folding). Landscape is created on this base by means of neotectonics and exogenic processes. Therefore, morphostructural analysis as a group of methodical procedures is aimed to uncover a direct or an indirect connection between current landforms on the Earth surface and the geological structure of the Earth interior (see Demek, 1987).

Analyses of joint and fault systems, drainage pattern, and morpholineaments have been performed in the area under study, which is situated in the NE part of the Rychlebské hory Mts. in the northern part of the Czech Republic. Morphotectonic analysis of the adjacent areas was performed e. g. by Kopecký, 1986, Ivan, 1997, Badura et al., 2003.

The submitted morphostructural analysis composes a part of a morphotectonic research being performed in the studied area. The goal of this research is to uncover a genesis of the landscape and to reconstruct a neotectonic development of the area in question as well as to assess a possible recent tectonic activity.

Monitoring of the recent tectonic activity is carried out by means of direct measurements on the fault planes by the deformometer TM-71. These crack gauges TM – 71 are situated on the structures in underground spaces of two karst caves. It allows to eliminate the influences of superficial slope processes as well as atmospheric effects (Stemberk and Štěpančíková, 2003).

Data refering to investigation of current geodynamic processes in the adjacent area such as geodetical, geophysical (gravimetric) data, and GPS measurements support the research as well. Geodetic survey and gravimetric observations, having recorded oscillating movements in the Fore - Sudetic block, are carried out mainly on the Polish side of the Sudetic Foreland (Blachowski and Cacoń, 2003, Cacoń et al., 2003). Measuring in the network of GPS is perfomed both on the Polish and Czech side of the Fore – Sudetic block and also the Sudetic mountain range (Schenk et al., 2002, Cacoń et al., 2003).

GEOLOGICAL AND MORPHOLOGICAL SETTING

The area in question is situated in the northern part of the Moravo – Silesian belt in the northeastern spur of the Bohemian Massif (Fig. 1). The centre of the area is represented by the Sokolský hřbet Ridge (the highest peak Studniční vrch Mt. 992 m a. s. l.), which is a geomorphological subunit of the Rychlebské hory Mts. and the adjacent part of the Žulovská pahorkatina Hilly Land.

Marginal Sudetic Fault (MSF), one of the most clearly marked tectonic zones in Central Europe and well evidenced by fault slopes bordering the Sudetic ranges towards the Fore-Sudetic block, runs through the Rychlebské hory Mts. in the direction NW – SE (Oberc and Dyjor, 1969). The course of the fault and other parallel faults in the zone is also pronounced by mineral springs and Neogene and Quaternary vulcanites (Buday et al., 1995) (Fig. 2). The Fore-Sudetic block near the MSF is tectonically divided into several individual grabens filled by Tertiary sediments (see e. g. Frejková, 1968, Cwojdżiński and Jodłowski, 1978).

Geology of the area of interest comprises the Variscan Žulová granite pluton, which represents an apical part of a vast granitic body indicated by an extended gravity low (Cháb and Žáček, 1994), and its Devonian metamorphic cover including predominantly a belt of gneisses, amphibolites, quartzites, and crystalline limestones. The Žulová granite pluton covers the entire studied part of the Žulovská pahorkatina Hilly Land and the north-western marginal slope of the Sokolský hřbet Ridge whereas the other part of the Ridge is formed by the metamorphic cover (Fig. 1).

The MSF divides the southwestern geomorphological subunits of the Rychlebské hory Mts. from the subunit Sokolský hřbet Ridge, which belongs already to the Fore – Sudetic block. The wedge-shaped Sokolský hřbet Ridge as a horst declines stepwise to the NE along the faults of sudetic direction (NW – SE) similarly to the whole Rychlebské hory Mts. (Ivan, 1997).

The Sokolský hřbet Ridge is terminated by distinct marginal slopes. The marginal slope in the SW is undoubtedly connected with the MSF and the slopes in the NW and SE are also probably associated with faults (Fig. 3). Nevertheless, none of these anticipated faults in the NW nor SE are recorded on geological maps, with the exception of some geological sketches (e. g. Cháb and Žáček, 1994) on which a fault runs through the valley of the Bělá River.

Although it is very difficult to prove geologically a presence of a fault, particularly on the NW margin of the Sokolský hřbet Ridge, owing to uniform bedrock (only granitoids), its existence is probable, since the marginal slope up to 600 m high goes down towards the Žulovská pahorkatina Hilly Land comparatively steeply. Furthermore, the Hilly Land represents a slightly lowered basal weathering plain of the Pre-Upper Miocene planation surface (so called etchplain – see Goudie ed., 1991) with several remnants of kaolin-rich saprolites, remodeled by a Pleistocene glacier and including numerous inselbergs of which arrangements are predisposed by faults (Ivan, 1983) (see Fig. 3). Besides the facts mentioned above, it should be emphasized once again that the planation surface of the Hilly Land lies up to 400 - 500 m lower than the Sokolský hřbet Ridge so one can assume a presence of a fault by which the Ridge was uplifted (Figs. 3 and 4).

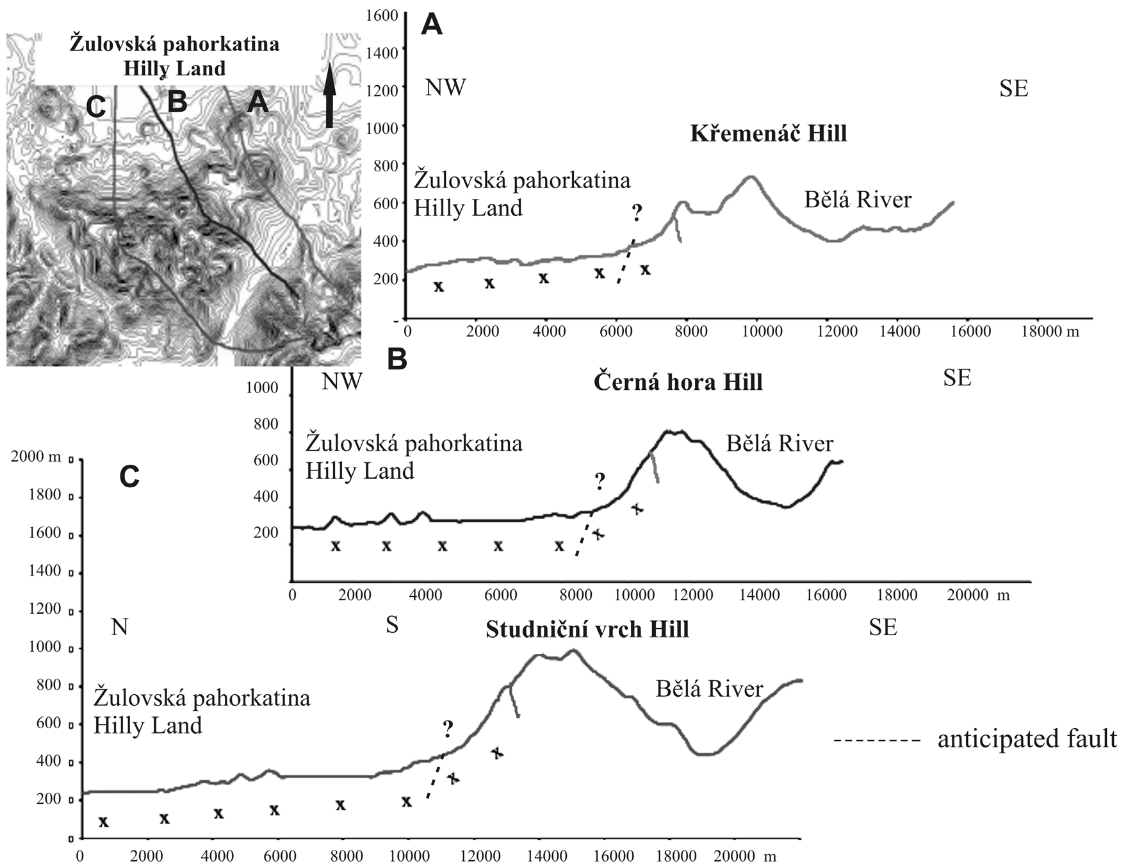

Fig. 4 Cross profiles of the Sokolský hřbet Ridge and the Žulovská pahorkatina Hilly Land

The presumable fault origin of the marginal slope towards the Žulovská pahorkatina Hilly Land was discussed already by the authors such as Götzinger (1925) and Anders (1939) in Ivan (1972). Collecting of evidence (geomorphological or geophysical) for the existence of the fault will be a subject of further research.

FAULT ANALYSIS

The fault analysis has been performed on the base of various types of maps and groundworks such as geological, geophysical or geomorphological ones.

The most prominent tectonic structure in the studied area is undoubtedly the MSF striking NW - SE, which steeply slopes beneath the Žulová granite pluton to the NE (dip 70° - 80° near Vápenná village) (Harazim in Grünnerová, 1972) (fig. 2). The MSF has been active since Prevariscan period and variable vertical movements of the block mass along the MSF have occured from Permian to Recent (e.g. Cloos, 1922 in Skácel, 1989, Zapletal, 1950, Skácel, 1989). During the Alpine cycle the MSF was reactivated, the fault scarp bordering the Sudetic mountain ranges was created, and a rapid subsidence of the Fore-Sudetic Block was acompanied by filling out by Cenozoic sediments (Oberc, 1967, Oberc and Dyjor, 1969, Skácel, 1989 etc.).

There are almost exclusively faults of the sudetic direction (NW – SE) recorded on the gelogical maps of the studied area (Žáček red., 1995, Cháb, 1990, Grünnerová et al., 1972). Only a few of the recorded faults are of different direction (NE - SW), particularly in the SE part of the Sokolský hřbet Ridge. Although the faults of the secondary directions NE – SW and some diagonal ones were not recorded geologically, they are displayed in the morphology markedly as well (see bellow the chapter “morpholineaments”).

JOINT ANALYSIS

The measurements of joint strikes have been carried out both on natural rock-outcrops and on walls of granite and crystalline limestone quarries.

The main directions of the fracturing in the Žulová granite pluton reflect the stress under conditions of cooling of the pluton. The primary joint system is of two chief directions: cross joints (Q) NE – SW (20° – 30°) and longitudinal joints (S) NW - SE (120° – 130°) (Fig. 5).

The longitudinal joints, parallel with the MSF, were affected by crushing in exposed parts so distinct cataclastic zones were created. Some of these cataclastic zones are up to 20 – 30 m wide and are followed by very intense weathering towards the depth and width (Harazim in Grünnerová 1972). Cross joints are of the direction 20° – 30° which is followed also by pegmatitic and aplitic dykes.

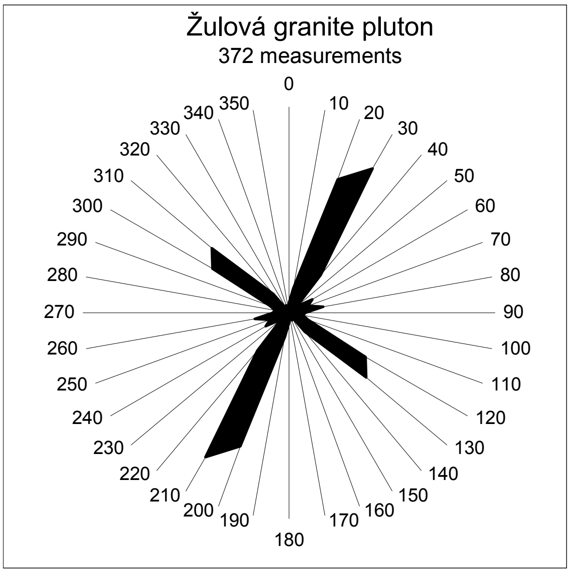

Fig. 5 Frequency of joint orientation in the Žulová granite pluton.

The metamorphic cover in the studied area comprises also two predominant directions of joint system. The sudetic direction (110° – 120°) is displayed very noticeably. The second significant direction is, however, N – S (350° – 10°) (Fig. 6).

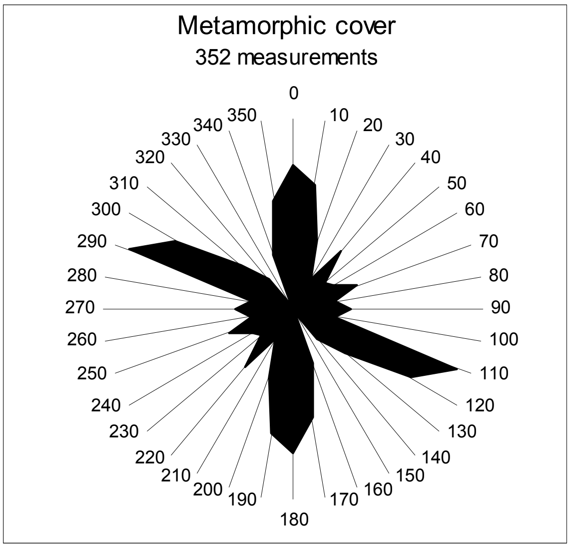

Fig. 6 Frequency of joint orientation in the metamorphic cover of the Žulová granite pluton.

The joint diagrams were also performed within the frame of the metamorphic cover by an individual type of rock. According to Marek (1990), combining statistical measurements completed within different lithological complexes is not proper, since rocks reflect structural and tectonic influences differently depending on their mechanical properties.

Nevertheless, it was found that the measurements within the Sokolský hřbet Ridge differed regardless the lithology, based on individual blocks which were delimited by the faults predominatly of sudetic direction. The joint diagrams within the frame of the blocks show several times bigger mutual similarity than within the frame of rock type differentiation, which may be due to individual development of the blocks.

As we can see, the sudetic direction 110° - 130° as a main system dislocates both the Žulová granite pluton and the metamorphic cover, as well as all blocks within the metamorphic cover, which may suggest the younger age of the dislocations of this direction.

DRAINAGE NETWORK ANALYSIS

Drainage pattern investigation is an important part of a morphostructural analysis, since one assumes that rivers respond to changing morphostructural and morphoclimatic conditions susceptibly.

The area in question is drained north-east to the Klodska Nysa River. The streams of a higher order (according to Strahler´s stream ordering (1952) in Goudie ed., 1991) create predominantly a dendritic drainage pattern. Some of their parts are of a rectangular pattern due to following the joint and fault network.

Despite declining of the Sokolský hřbet Ridge to the NE prevailing direction of the drainage is towards the NW, which suggests an original inclination of the Ridge to the NW (see Fig. 3).

Nearly all water streams with the exception of the Lubina Brook, which has created a very deep V-shaped valley, have shallow or almost undeveloped valleys on the steep parts of the marginal slopes of the Sokolský hřbet Ridge, which suggests young age of these segments. The longitudinal profiles of the streams running towards the Žulovská pahorkatina Hilly Land display a knickpoint around 400 m a.s.l. slightly above the foothill of the marginal slope of the Ridge (Fig. 7). A possible connection between these knickpoints and the trace of the anticipated fault bordering the Sokolský hřbet Ridge towards the Žulovská pahorkatina Hilly Land will be a subject of further research.

MORPHOLINEAMENTS

Morpholineaments as linear elements of the relief have been interpreted on the base of 1 : 10 000 topographic maps, digital elevation model processed by an ArcView 3.2. software from 1 : 25 000 topographical maps, and geological maps and groundworks.

The morpholineaments in the area under study are expressed in the morphology mainly as a foot or a trace of rectilinear slopes, and as landforms related to the drainage network (thalwegs etc.). Most of the morpholineaments are bounded either to the fault or joint pattern, and the weakened zones in the area, though not all of the faults are recorded on the geological maps.

Orientation of the morpholineaments in the studied area is of two predominant perpendicular directions: NW – SE (120° - 150°) and NE – SW (40° - 70°) (Fig. 8). These directions reflect the main system of primary joints occuring in the granitoids in the studied area, and the fault system affecting the metamorphic cover of the Žulová granite pluton covering the eastern part of the Sokolský hřbet Ridge.

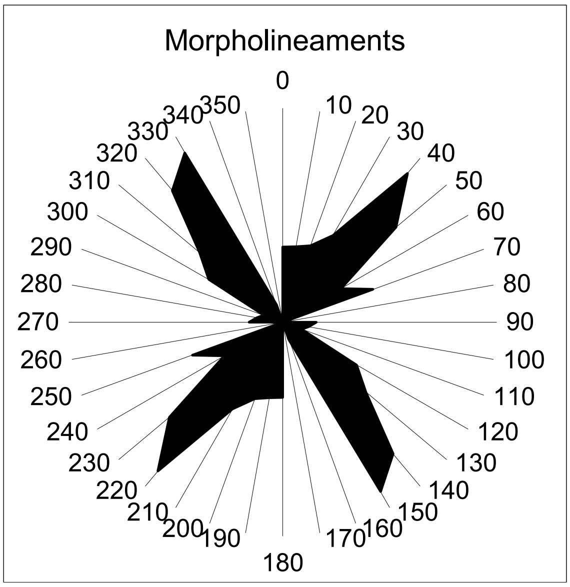

Fig. 8 Orientation of morpholineaments in the studied area. Length of the rectilinear segments is taken into account.

The morpholineaments in the sudetic direction (NW – SE) are mostly longer and more pronounced in the relief than the morpholineaments of other directions. For example (see Fig. 3), the valley of the Uhlířské údolí Brook follows the fault of sudetic direction which passes through the saddle between the Křemenáč and Bílé kameny Hills and is expressed also by the valley of the Žlebník Brook situated already on the other side of the Sokolský hřbet Ridge behind the saddle. The upper course of the Vidnávka River valley is even predisposed by the Sudetic Marginal Fault as well as the south-western marginal slope of the Ridge and the entire northern marginal fault slope of the Rychlebské hory Mts. The rectilinear trace of the right slope of the Křemenáč Brook valley and the right slope of the Černý potok Brook valley continuing on the same line are other examples of morpholineaments of the sudetic direction as well as a limitation of the inselberg Boží hora Mt.

In contrast, morpholineaments of more or less perpendicular direction NE – SW are displayed in the relief at shorter distances, nevertheless, they are more frequent. Some segments of the Skorošický potok, Černý potok, and the Červený potok Brooks are the cases (Fig. 3). The Vidnávka River follows an anticipated fault of this direction between the villages of Žulová and Kobylá as well (see the geological map in Grünnerová et al., 1973). Another distinct morpholineament of the direction NE – SW is the foothill of the rectilinear marginal slope of the Sokolský hřbet Ridge in the SE.

These two directions NW – SE and NE – SW manifest themselves even by perpendicular corridors of two carst caves Na Špičáku and Na Pomezí.

CONCLUSION

The Sokolský hřbet Ridge represents a horst-like morphostructure noticeably limited towards its vicinity by distinct marginal slopes probably of tectonic origin. Verification of the origin of the marginal slopes will be a subject of further research.

Interior segmentation and arrangement of the horst of the Sokolský hřbet Ridge as well as landforms in the adjacent Žulovská pahorkatina Hilly Land (e.g. inselbergs, drainage network) reflect structural and tectonic setting prevailing in the territory of interest, which is given by the primary joint system and tectonic structures of the directions NW – SE and NE – SW. History of the Marginal Sudetic Fault particularly its reactivation during the Neogene played the role as well.

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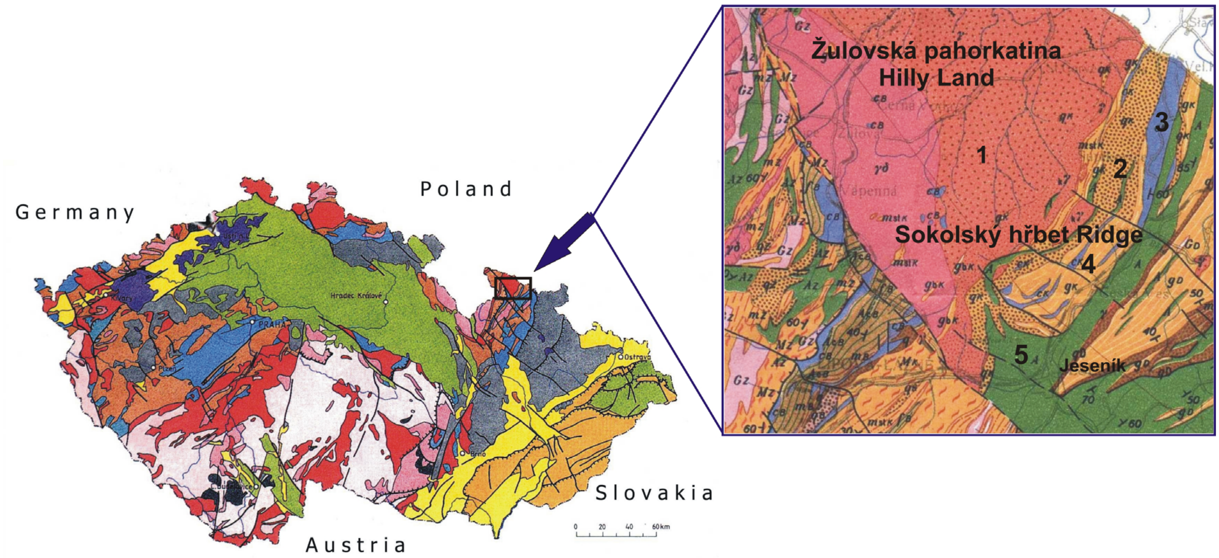

Fig. 1 Position of the studied area in the Czech Republic and geological setting. 1 - granitoids, 2 - quartzites, 3 - crystalline limestones, 4 - gneisses, 5 - amphibolites.

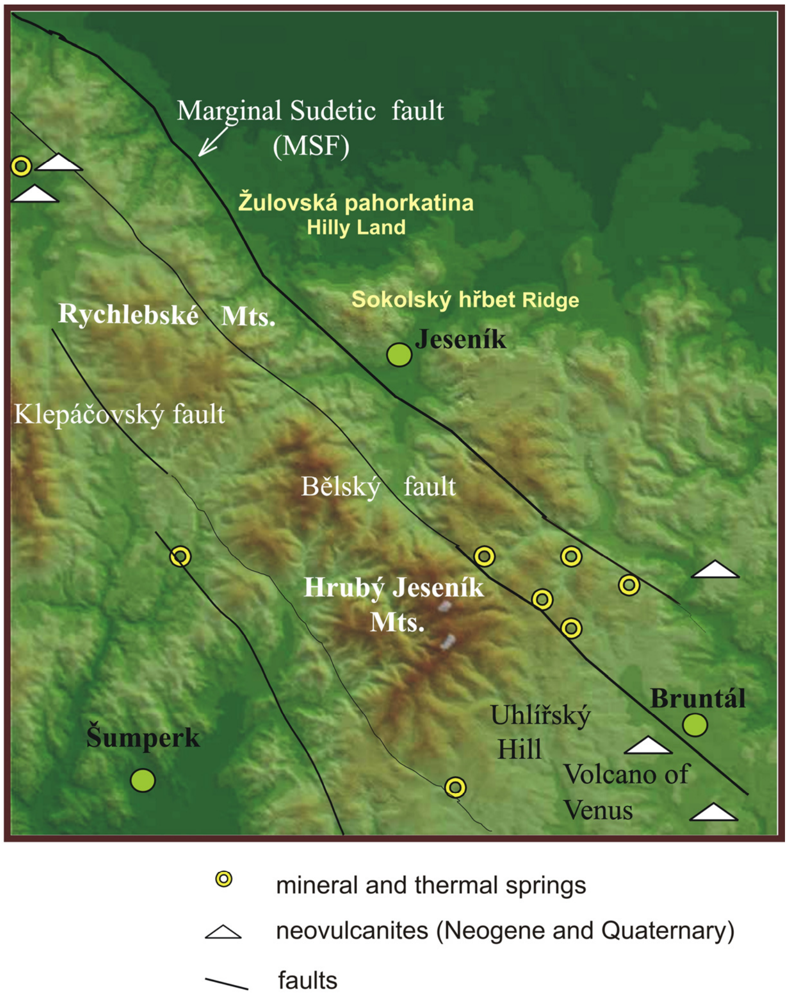

Fig. 2 Display of active tectonics in the relief of the surroundig area.

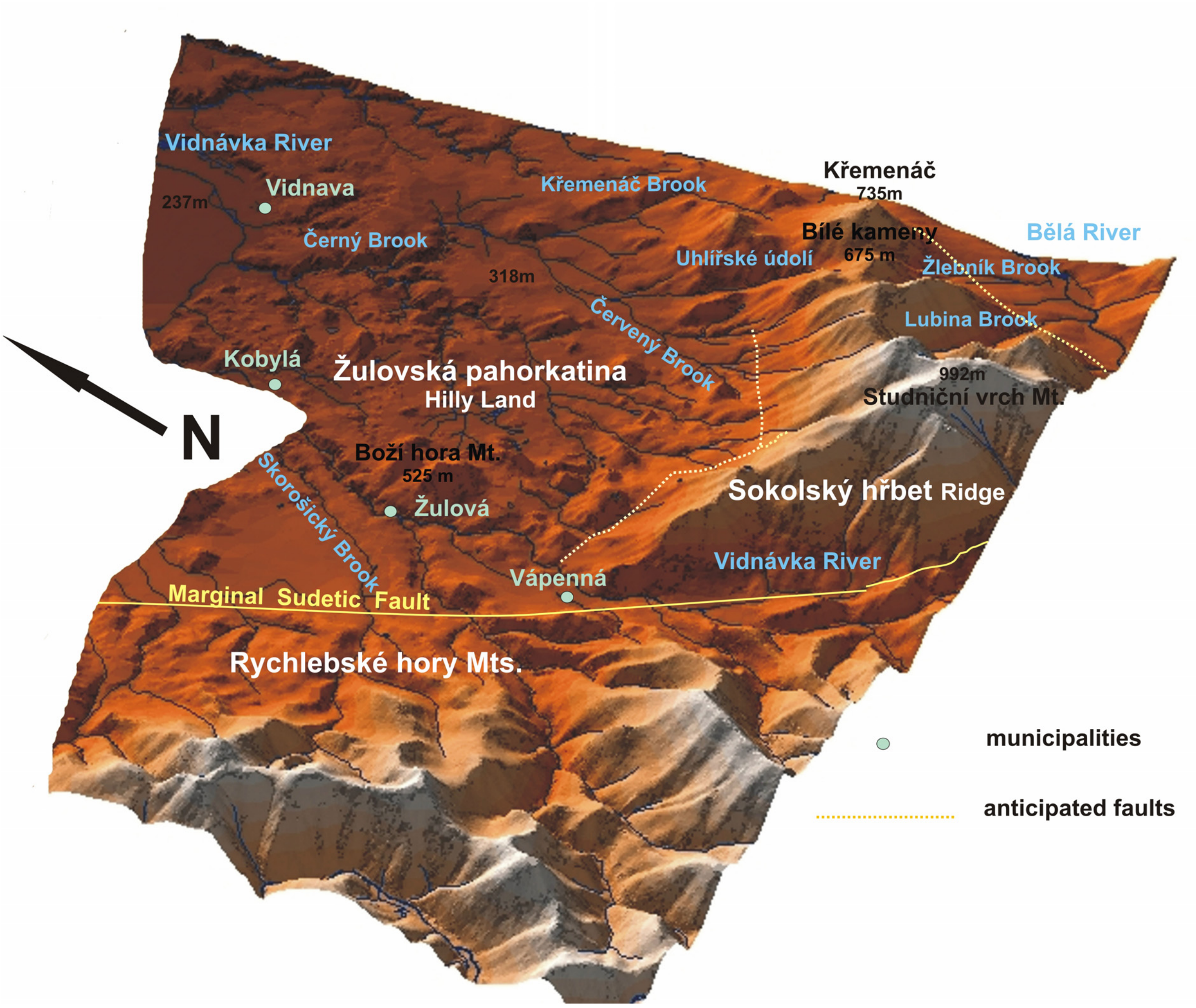

Fig. 3 Topography and morphology of the area of interest. Three times exaggerated digital elevation model.

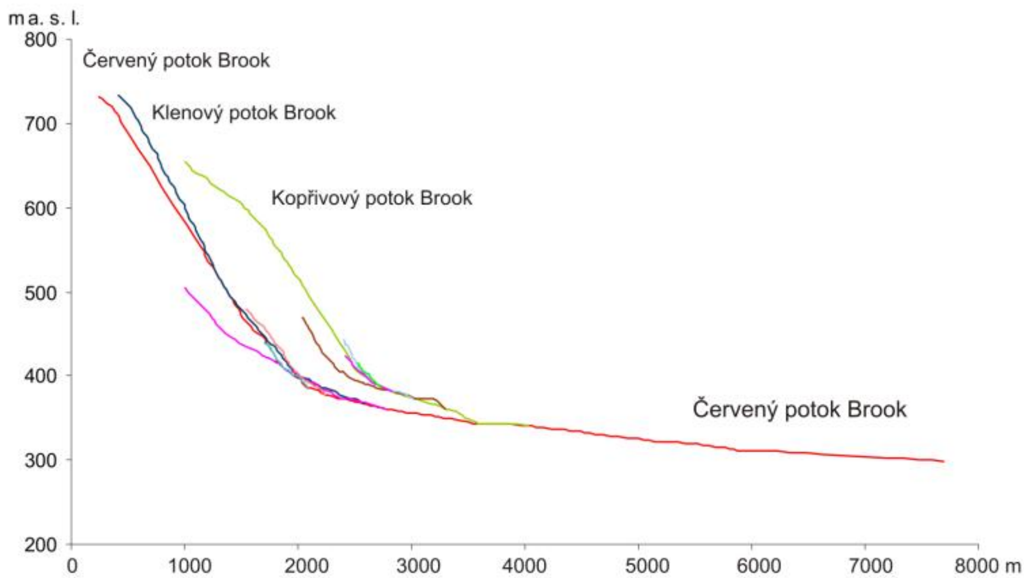

Fig. 7 Longitudinal profiles of the upper tributaries of the Červený potok Brook draining the NW slope of the Sokolský hřbet Ridge. Profiles show knickpoints close to the foothill of the Ridge at the altitude of around 400 m a. s. l.