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Preliminary outcomes of geomorphological research in the vicinity of the northwest part of the Pošumavský Zlom fault

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Abstract
The preliminary outcomes of geomorphological research brought certain new information about the activity and character of geomorphological processes in the vicinity of the northwest part of the Pošumavský Zlom fault. The localities with particularly interesting and clearly identifiable landforms were the focus of the study. Detailed analysis of these sites helped to direct future research in this area of interest.

Key words: Pošumavský Zlom fault, detailed geomorphological mapping, fluvial sediments, joint systems

Introduction

The main goal of this article is to outline the character and the activity of the geomorphological processes which form the current relief and find out whether the Pošumavský Zlom fault also participated in the formation of the relief. The Pošumavský Zlom fault is depicted in geological and tectonic maps, in some as a presumed, in others as a detected fault (Maheľ & Malkovský 1984, Chábera 1985, Kopecký 1989). Other publications represent the Pošumavský Zlom fault as a continuation of the distinguished Mariánskolázeňská tectonic line (Röhlich & Šťovíčková in Šalanský 1989). The study of fault and fissure tectonics is very important for the Bohemian Forest (=Šumava Mts.), where the tectonic movements were presented, because faults play an important role in the formation of relief.

For the purposes of this article, several typical landforms (erosion cuts, an alluvial fan and outcrops), which represent particular geomorphological processes, were selected.

The north-western part of the Pošumavský Zlom fault, which enters the area of interest (AOI) through the saddle near the Děpoltice village, spreads on both sides of the catchments of the Dešenický Potok and Žížnětický Potok streams (Hartvich 2002). Consequently the AOI was delimited as the catchments of the Dešenický Potok (more than 50% of the total surface area) and Žížnětický Potok streams (Fig. 1), with a total area of 24 km^2. From a hydrological point of view, the AOI belongs to the river-basin of the Úhlava stream (Fig. 1).

The AOI belongs to three geomorphological units, which are called "Šumava" (the Bohemian Forest), the Šumavské Podhůří foothills and Švihovská Vrchovina upland (Balatka & Kalvoda 2006). The local relief of the AOI is 621 m (450–1 071 m a.s.l.), which indicates strong relief energy.

The relief morphometry can be characterized by quite a significant area of slope inclination in the range 0–2° (11% of the surface area), but the main part of the surface is in the range of 5–15°, which occupies 63% of the surface of the AOI.

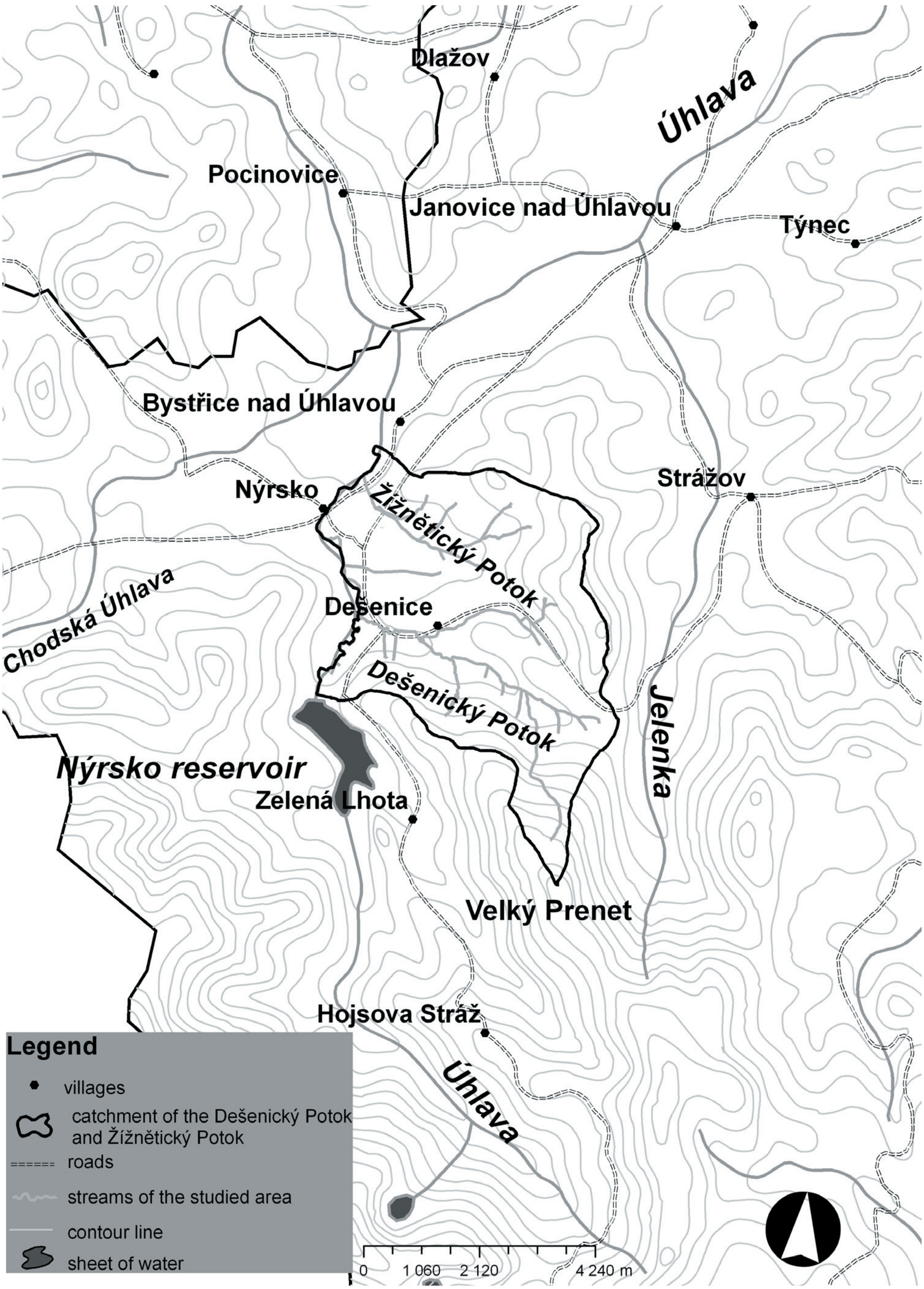

Fig. 1. The delimitation of the AOI.

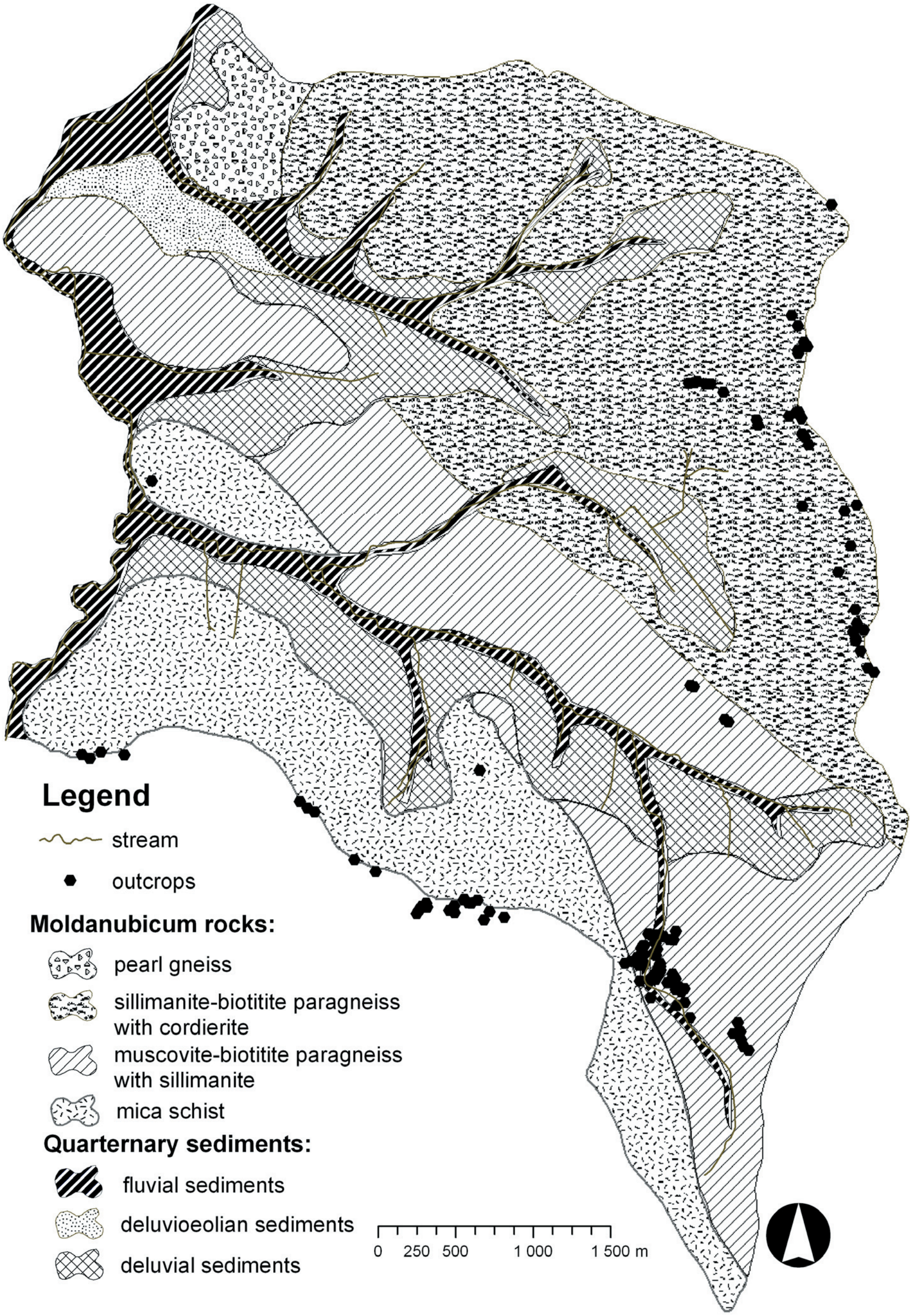

Fig. 2. The geological conditions in the studied area processed according to the geological map of Vejnar et al. (1991).

Lithological conditions

The lithological conditions of the studied area are relatively monotonous. The AOI belongs to the geological unit of Moldanubikum (Fig. 2), an ancient crystalline unit. The varied series and the Královský Hvozd belong to the partial units (Kodym 1961).

The hills on the boundary of the basin of the Žížnětický Potok stream are composed of sillimanite-biotitite paragneisses with cordierite, which appertain to the "varied series" (Fig. 2). The belt of the muscovite-biotitite paragneiss with sillimanite creates the transition stage to the Královský Hvozd on the connection line of the hills of Křížový Vrch – Velký Prenet – Můstek (Vejnar et al. 1991).

The Královský Hvozd is characterized by the garnet-biotitite-muscovite mica schists, which extend to the southwest part of the studied area. The garnet-biotitite-muscovite mica schists form the hills of Velký Prenet, Křížový vrch, and Svatý Jan.

The more significant accumulations of the quaternary sediments are located mainly in the surroundings of the watercourses (Fig. 2). In particular, the fluvial and deluvial sediments are frequent in the studied area. The quaternary sediments have a special significance, for they are the most important source of information on the relief history (Růžičková et al. 2001).

Methods

In order to describe the channel side sediments as accurately as possible, several sediment profiles were chosen from the erosion cuts. In the course of the profile construction, the thicknesses of all the various sedimentary layers were measured. The profiles were described on the site, particular consideration was given to the grain size, colour, presence of organic material, type of transition, inner structures, etc. Taking samples from each macroscopically different layer of the profile is an important part of the sediment description. The samples will be evaluated in the laboratory to assess further qualities impossible to observe in the field, such as grain size, classes ratio or organic matter content.

In the case of outcrops, rocks higher than 0.5 m were mapped. The height, width, length and orientation to the principal shape points of the outcrops were measured. GPS positioning was used for the localization of the outcrops (with accuracy 10–15 m). Eight localities with 117 outcrops were described in the studied area.

The analysis of the fissure systems consists of the measurements of the fissure direction and of the frequency of the fissures in the area of interest. A geological compass was used for taking the measurements of the fissure system direction. Altogether 1165 measurements of the fissure direction were performed. Cloose's rosette diagrams were used to evaluate the fissure measurement.

Detailed analyses of the chosen localities

Detailed field mapping was carried out in several stages during 2005 and 2006. For the purposes of this study, the following localities were chosen to illustrate typical geomorphological processes, which participated in shaping the current relief: (i) a sequence of fluvial sediments in four erosion cuts – an example of the fluvial sedimentary and erosive processes; (ii) an alluvial cone – an example of the fluvial accumulation process; and (iii) an outcrop – an example of the polygenetic landforms.

The erosion cuts and the alluvial cone bear the traces of recent activity and also show the character of the fluvial processes. The erosion cuts of the streams allow the sequence of fluvial sediments to be recognized and consequently the development of the river valley to be assessed.

The alluvial fans, created by young rivers with great energy, can show the factors participating in their formation according to their shape, size and the embedded clastic material.

The outcrops may expound the relations between the structural conditions and the present relief in the studied area (Demek 1972). The main research objective is to assess the fissure systems' influence on the morphology of relief and on the morphology of the outcrops.

The partial goals of the research procedure were: (i) to perform detailed geomorphological mapping of selected localities, (ii) to create maps and detailed plans of the localities, (iii) to characterize and describe the landforms, (iv) to find out how the geomorphological processes work on these particular sites, and (v) to recognize the relations between structural conditions and the relief.

Erosion cuts of the streams

The development of the erosion cuts in the fluvial sediments of the rivers is able to provide a vast amount of information on the history of the river sedimentation and incision processes (Kukal 1986).

The erosion cuts of the Žížnětický Potok stream

The erosion cuts of the Žížnětický Potok stream were found at 455 m a.s.l. approximately 750 m from the confluence with the Úhlava stream (Fig. 3). In this segment, the stream meanders within its own sediments. Bank scours were found in the under-cut of the meander bank.

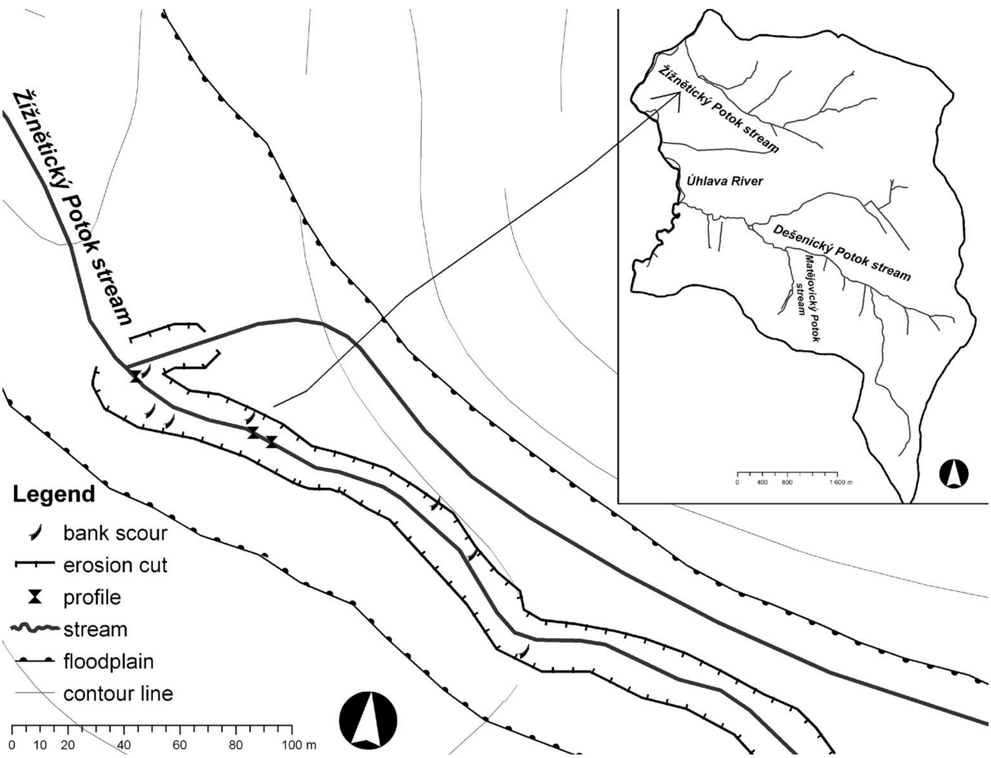

Fig. 3. Map showing the positions of profiles 1–3.

After removing the upper layer from the surface, the sedimentary sequences were described.

The sequence and the character of the sedimentation illustrate three profiles, which are subsequently characterized: profile 1 – at 453 m a.s.l. (220 cm), profile 2 – at 459 m a.s.l. (220 cm), and profile 3 – at 459 m a.s.l. (200 cm).

The preliminary on-site description of the structural and the textural features of the particular layers of the monitored profiles indicate certain differences. The map shows the position of the three profiles.

Profile 1 is distinguished by strong horizontal stratification of the sediments. The stratification could originate in the river channel under the current sedimentation conditions. This type of the stratification is caused by recurrent flood events.

Profiles 2 and 3 contain lenses of coarse-grained sand, possibly as a result of greater dynamics of the fluvial processes. This lenticular stratification is characterized by the occurrence of isolated lenses of coarse-grained sand within clayey material. The lenticular stratification could probably reflect or indicate the changing current activity with a period of stillness.

Profile features: particular layers with common structural features were found neither on the same levels nor with the same thickness, irregular deployment of the organic material, and fragments of tree branches with well- preserved structure.

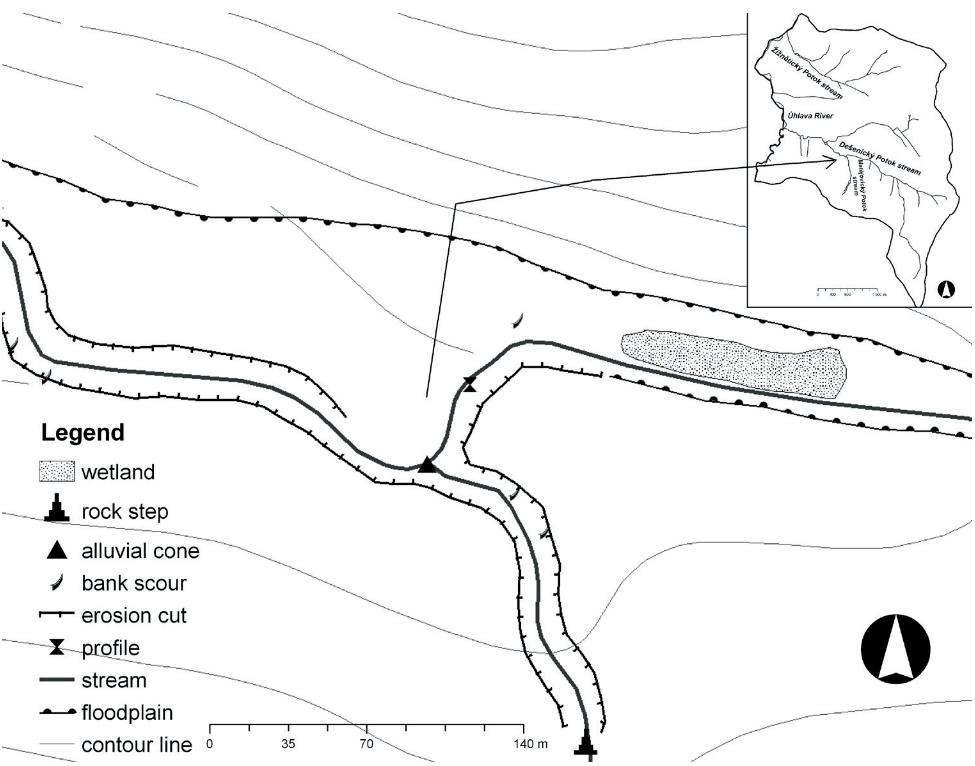

Fig. 4. Map showing the position of profile 4 and the alluvial cone.

The erosion cut of the Dešenický Potok stream

Another erosion cut was discovered a few meters above the confluence of the Dešenický Potok stream with the Matějovický Potok stream at 512 m a.s.l. (Fig. 4). The depth of the erosion cut is 120 cm.

The photo of profile 4 (Fig. 5) clearly shows the gravel layer with a thickness of approximately 20 cm, at a depth of 60–80 cm. This gravel layer could be the consequence of an extreme flood event, when the stream was able to transport coarse material from the higher parts of the studied area. This is highlighted by the lowland character of this channel segment. Contrary to the profiles on the Žížnětický Potok stream no fragments of tree branches or any other macroscopic organic matter was found here.

Fig. 5. Profile No. 4 in the erosion cut of the Dešenický Potok stream.

Fig. 6. Transformed alluvial cone at the confluence of the Matějovický Potok and Dešenický Potok streams.

Alluvial cone

The recent activity of the fluvial processes is also illustrated by the presence of a recent alluvial cone, which was found at 510 m a.s.l. The alluvial cone is created at the confluence of the Matějovický Potok and the Dešenický Potok streams (see Fig. 4). The alluvial cone no longer has the typical conical form – it was disrupted by the course of the Matějovický Potok stream (Fig. 6). Due to the fluvial activity of the stream, the material of the cone was partly washed away and sedimented a few meters further down. This erosive re-shaping of the cone documents the great energy of the stream due to the high altitude difference between the source and the cone (135 m).

The cone is approximately 4 m long, 2 m wide and 30 to 50 cm thick (Fig. 6). The upper part of the alluvial cone is covered by gravel of 10–15 cm in the longest axis. Downwards, the accumulation of the coarse-grained material changes into fine-grained gravel with clasts approximately 3 cm long.

Analysis of a rock outcrop

The outcrops belong to the most prominent shapes of the relief in the geomorphological research. The presence of the outcrops allows fissure analysis, which is an important component of morphostuctural analysis.

The studied area is built up entirely of metamorphic rocks. The metamorphic rocks are distinguished by foliation structures, which could complicate the assessment of the direction

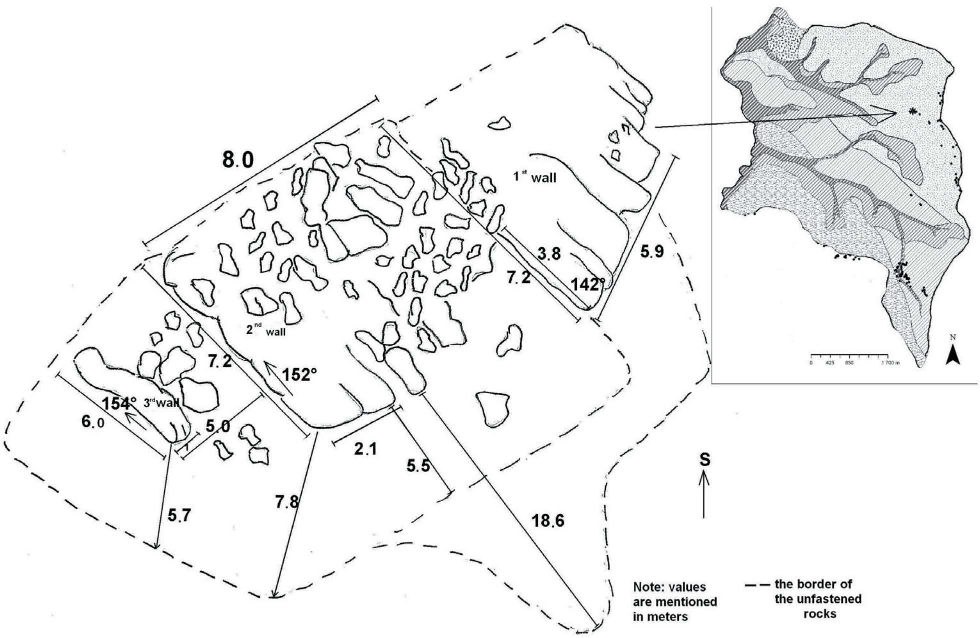

Fig. 7. Schematic map of the outcrop at the Želivský Vrch hill.

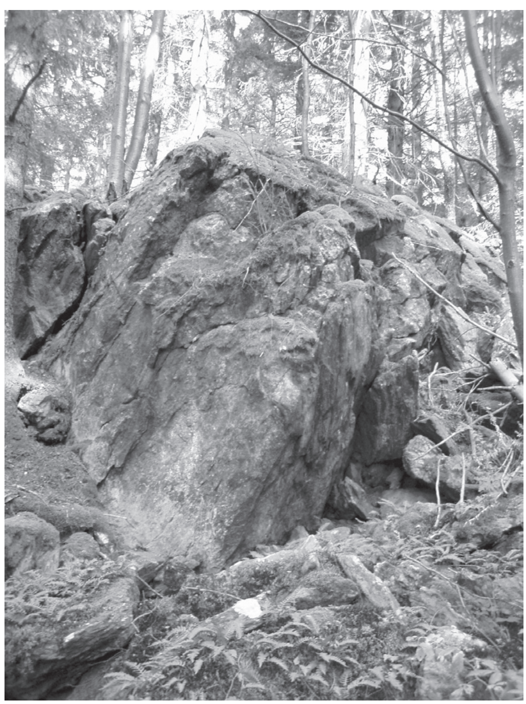

Fig. 8. A prominent wall of the analyzed outcrop at the Želivský Vrch hill.

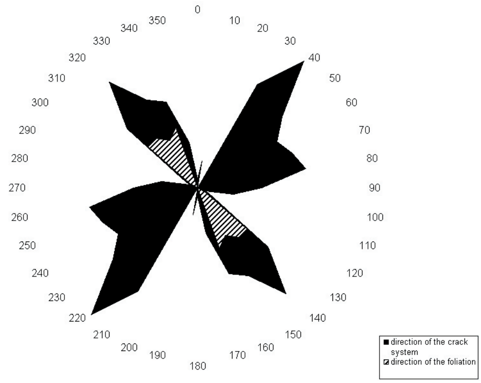

Fig. 9. Cloose's rosette diagram of the outcrops at the Želivský Vrch hill.

of the fissure systems.

On the Želivský Vrch hill, at the northeast boundary of the studied area, 38 outcrops were found. The outcrops are composed of biotite and sillimanite-biotite paragneisses with cordierite. A significant outcrop was discovered in this locality at 685 m a.s.l. (for its position, see Fig. 7).

The outcrop consists of 3 main rock segments firmly attached to the bedrock (see Fig. 7). The rock blocks are restricted by a fissure system running NW-SE. The direction of the rock restriction correlates with the direction of the Pošumavský Zlom fault.

The first rock wall is restricted by the face of the fissure by the extent of 380 cm (length) × 340 cm (height) (Fig. 8). The crack system has the direction 142°. The second rock wall lies approximately 8 m from the first rock wall, and it is limited by a fissure 1040 cm long and 510 cm high. The direction of the wall plane is 152°. The third rock wall is 150 cm high and 600 cm long. The rock wall is elongated in the direction of 154°. The schematic map displays the position of the three rock walls (Fig. 7).

The following Cloose's rosette diagram displays the directions of the fissure systems and the direction of the foliation (Fig. 9). On the Želivský Vrch hill, 145 measurements were performed. It is evident that the crack systems run in the NW-SE and NE-SW.

Proposed future geomorphological research

The chosen localities, which are described in detail in this contribution, helped in directing further research of the development of the relief in the area of interest.

Performing the following tasks is suggested for future research: (i) laboratory analyses of the sediments from the erosion cuts, (ii) dating of the fragments of tree branches using radiocarbon dating (^{14}C), (iii) verification of the thickness of dejection cones and drawing their detailed profiles, (iv) analysis of the shapes of the found rock outcrops to find out whether there are other outcrops whose shapes are influenced as strongly by the structural conditions, (v) compilation of Cloose's rosette diagrams from measurements of fissure systems from all the outcrop localities, (vi) analysis of the valley network, (vii) analysis of the relation between the structural conditions of the area and the present relief, (viii) proposal of a hypothesis on the development of the area of interest based on the performed research, and (ix) to attempt to locate the system of Pošumavský Zlom fault by the means of geophysical profiling.

Conclusions

Throughout the article, the activity and character of the geomorphological processes is examined in the vicinity of the northwest part of the Pošumavský Zlom fault at several selected localities, where the processes can be easily recognized. Preliminary outcomes of the research have brought better understanding of the processes and helped to direct further research.

Fluvial geomorphological processes are represented by the erosion cuts of both streams and the alluvial cone. The erosion cuts were available for description of the fluvial sediments of both streams.

The Žížnětický Potok stream's profiles are the consequence of the flood events. The irregularities in the presence of the gravel lenses show that the course of the stream was changing very fast. The incisive changeovers between the adjacent layers denote the presence of a hiatus in the sedimentation process. The frequent changes of the erosion and accumulation processes are significant for the Žížnětický Potok stream. The configuration and the character of the profile layers document the presence of at least two erosion phases.

The location and the description of the profiles allow us to describe the fluvial geomorphological processes in the floodplain. It is evident that the river channel was displaced in the floodplain several times. The valley of the Žížnětický Potok stream thus underwent a rather complicated geomorphological development.

The Dešenický Potok stream has one layer of gravel, very likely a consequence of a bigger flood event. Also the significant span of the altitude of the relief, through which the stream flows, (ca. 520 m) allows transport of coarser material.

In general, the difference between profiles of the Dešenický Potok and Žížnětický Potok streams is given by the different altitude span and the channel inclination.

The presence of the alluvial cone gives evidence for the great energy of the Matějovický Potok stream, which transports the material from rather distant higher parts of its catchments. The cone was very likely created in a single rainstorm event, and its deformation occurred later, also in an event of high discharge.

The outcrops at the Želivský Vrch hill contributed to the confirmation of a strong dependence between the geological conditions and the recent relief in the AOI. The rock walls of one of the outcrops are limited by the fissure systems' direction, which is similar to the one of the nearby Pošumavský Zlom fault. The Cloose's rosette diagram showed that the fissure system's orientation also corresponds to the direction of the Pošumavský Zlom fault.

The preliminary research in the studied area indicates that fluvial processes are among the leading geomorphological processes concerning their recent dynamics and influence on creating current forms of the relief. The verification of the relations between the structural geological conditions and the recent relief has to be completed by other parts of the morphostructural analysis. The geomorphological research will continue and it will be concluded by formulating a hypothesis on the development of the relief in the studied area.

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