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Geomorfologický sborník 10

Sborník abstraktů

12. mezinárodní konference Stav geomorfologických výzkumů v roce 2012
Sokolov 18.-20.4.2012

Jan Blahůt, Jan Klimeš, Petra Štěpančíková, Filip Hartvich
(editoři)



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Thermoscopic mapping of deep-seated rockslides and unstable rock cliffs in Central-European cold season

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The contribution presents a new approach of open cracks and tension zones mapping within rock slope failures and rock cliffs, based on high resolution ground-based and airborne infrared thermography (IRT). The method is restricted to cold seasons and is presented on three examples from the Northern Calcareous Alps (Gschliefgraben/ Mt. Traunstein) and from the Flysch Belt of Outer West Carpathians (Kopce Hill and Mt. Knehlyne).

The approach is based on a contrast between temperatures deeper in the rock, which in the depths of several meters represent local mean annual temperature, and the actual temperature at the ground surface. In winter, the ground emits the heat to the underground air. This air is relatively warmer and lighter than the external air. Thus the heat is transported by the air through caverns, open cracks and joints to the ground surface. This effect often helps the cavers to identify unexplored caves in cold winter season (Rinker 1975, Lesinsky 1999, Baron 2004).

In order to achieve the best contrast of the joints and loosened rock vs. stable rock, we conducted the survey at the beginning of February 2012. The external air temperatures approximately ranged from -19°C to -7°C. We used a thermal camera Flir; in order to achieve airborne images, we used an ultralight (UL) plane Scout in the Carpathians. The plane was piloted by J. Prchal from the airport in Slusovice.

The results were very promising. Single open cracks deeply affecting the rock massif, the loosened rock zones and new caves were easily identified by the thermocamera for a distance sometimes larger than 1 km. The application of an UL plane was of great help too. This way was proved the already known Nadeje Cave at the Kopce Hill, and we located the place of potentially new caves at Mt. Knehlyne and Mt. Traunstein, which will be hopefully soon investigated by cavers. The mapped open cracks will help to assess the hazard in the zone of Mt. Traunstein and in Gschliefgraben.

Keywords: thermoscopy, deep-seated rockslides, rock cliffs, open cracks, pseudokarst caves, Northern Calcareous Alps, Gschliefgraben, Traunstein, Outer West Carpathians, flysch belt, Kopce, Knehlyne

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Reconstruction of debris flows from Smědavská hora Mt., using a regional run-out model

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In August 2010, intensive rainfall triggered four debris flows on the slopes of Smědavská hora Mt. in the Jizerské hory Mts. Reconstruction of this event was performed after extensive fieldwork using a dynamic run-out regional model AschFlow, which is based on a 2-D finite difference solution of a depth-averaged form of the fluid dynamics equations. The flow is thus treated as a single phase material, whose behaviour is controlled by rheology (i.e. by a functional relationship between strain and stress). Different types of rheology (Voellmy and Bingham) are implemented within a common numerical scheme of the model, which was computed in a complex topography through a digital elevation model. The modelling results match well with the mapped debris flows and support the use of a regional model for debris flow hazard analysis.

Keywords: debris flows, regional modelling, Jizerské hory Mts.

Genesis of sub-slope accumulation in Hornsund, Svalbard

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This paper presents a study performed on a sub-slope accumulation in the area of Hornsund fjord, Svalbard. The accumulation was supposed to be a rock glacier for a long time. However, recent studies suggest that it is a rock avalanche accumulation few hundred years old. The accumulation was dated by lichenometry and Schmidt hammer. The results shown considerably younger age than neighbouring rock glaciers. To support this conclusion a rock fall modelling was performed. Rock avalanches are usually modelled as flows using different types of rheologies. In this specific case a 1-D and 2-D reconstruction was performed on a DEM using a model with material entrainment concept based on limit equilibrium considerations and the generation of excess pore water pressure through

undrained loading of the in-situ bed material. The propagation model is based on a continuum mechanics approach using a depth-integrated approximation based on the shallow water assumption (Saint–Venant equations). The flow is treated as a laminar one-phase material, in which behaviour is controlled by a visco-plastic Coulomb–Bingham rheology. The results of the modelling support the rock avalanche origin of the sub-slope accumulation.

Keywords: rock avalanche, lichenometry, Schmidt-hammer, 1-D 2-D modelling, Svalbard

Self organised conduit network in sandstone quarry: Characterization and evolution

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Self-organized conduit system created by piping was studied in Strelec Quarry, Czech Republic. Conduits are developed in marine sandstone with matrix formed by kaolinite, illite and quartz silt. Inflow into the quarry driven by groundwater pumping created within 6 years several cavities, the largest being 300 m long, several meters wide and up to 17 m high, which caused several collapses in the quarry. Some features in the quarry are morphologically identical with features observed at natural outcrops in the same sandstone. They are indicating processes, which were operating in the past under natural conditions.

The objective of the study is to describe and quantify the processes responsible for conduit evolution and enlargement.

Flow velocity in conduits and sandstone matrix was studied by tracer tests, direct measurements and infiltration tests. Erodability, sandstone strength and cement were studied by water jet tests (WJT), drilling resistance and microprobe. Conduits were mapped and studied including sediment transport and evolution history. Several erosion processes were modelled in the quarry under controlled conditions.

Flow velocity in conduits is mostly 0.4 m/s, while in sandstone pore space it is below 0.0003 m/s. Stream gradient in conduits vary between 1-5%, which is 2-10 more than hydraulic gradient in wider surroundings of the quarry. In direct surroundings of conduits the hydraulic gradient in pore space may exceed 20%. In evolving conduits there is 8-16 g/L of transported sand (1 wt. %).

Conduits are evolving by side erosion of fast flowing water in fracture network. Erosion causes the undercutting of sandstone blocks limited by subvertical fractures in overburden, which provoke collapses and enlargement of the spaces dominantly upward. WJT demonstrated that vertical fracture surfaces are less erodable than inner parts of sandstone blocks. Therefore the fractures are mostly forming the conduit walls and traces of erosion are scarce. WJT was found a fast tool to quantify the relative susceptibility to erosion by flowing water and to delimit the sandstone zones, which are prone to erosion from more resistant ones.

Study was supported by grant projects: GAUK380511, IAA300130806, MSM00216220855, AV0Z30460519.

Keywords: fluvial erosion, sapping, sandstone landscape development, piping

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Pediments and pedimentation in the Czech Republic

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Rock pediments are gently inclined slopes cut across bedrock with gradients of between 2 and 10⁰ at the foots of steeper backing slopes, usually covered by patchy veneer of deposits only a few meters thick. The world geomorphological literature presents two main theories of their origin: i) rock pediments are regarded as an active basal slope or slope of transport, left by recession of the mountain front, ii) rock pediments are formed by lateral planation by running water (Twidale 1978). Rock pediments on the territory of the Czech Republic were for the first time recognized and surveyed by J. Kinský (1938) in the South Bohemia.. The GIS based geomorphological map of the Czech Republic in the scale 1 : 500 000 (Demek et al. 2009) published in the Landscape Atlas of the Czech Republic (Hrnčiarová, Mackovčín and Zvara, 2009) enabled for the first time to obtain general quantitative data about the spatial distribution and territorial extent of rock pediments on the territory of the Czech Republic. The authors distinguished in the map i) rock pediments mostly of Pliocene age and ii) cryopediments formed by cryogenic processes in cold phases of the Quaternary. In the scale 1: 500 000 were distinguished and mapped 483 rock pediments both in the Bohemian Massif and in the Outer Western Carpathians taking the area of 1859 sq. km. Pediments in the Bohemian Massif mostly developed by the recession of the back slopes in the dry periods of the Pliocene. Rock pediments are commonly developed in two levels as result of the neotectonics movements. In some areas in the West Bohemia rock pediments coalesced into pediplains. Some rock pediments in the Outer Western Carpathians developed rather by lateral planation of rivers running from mountains. They originated initially by rills and gullies and subsequently by lateral planation of distributory streams in weaker flysch rocks. Rock pediments in Flysch Carpathians developed due to neotectonics movements in three levels in the Pliocene erosion megaphase. The digital mapping has shown surprisingly large areas of cryopediments and cryopediplains. The 121 cryopediments shown in the map take an area of 2071 sq. km. The largest cryopediments developed in the Bohemian Plateau during the cold phases of the Quaternary in the presence of permafrost. The largest cryopediplain developed in soft deposits of the Carpathians Foredeep and in the Central Moravian Carpathians. The quantitative evaluation of landforms based on application of GIS has shown that rock pediments and cryopediments are important features of the relief of the Czech Republic.

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Geomorphologic effects of young Cenozoic tectonics on the relief of the Milešovské středohoří Mts.: a geomorphometric analysis

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The morphostructural evolution and volcano-tectonic activity of the Milešovské středohoří volcanic range (SW part of the České středohoří Mts.) has predominantly been considered to be predisposed by the location of this area inside the intracontinental rift structure. On the other hand, recent detailed geological research discovered three groups of faults of different age and indicated that the resulting tectonic structure does not entirely correspond to the considered rift structure. The last tectonic development of the area, imprinted in geological setting, was surely younger than 16 Ma and very possibly younger than 9 Ma. Although geological evidences are not able to define the last tectonic activity more precisely, the effect of another younger, upper Cenozoic, stress fields and induced tectonic activity on some of mentioned faults is highly plausible. This paper presents the new results of detailed geomorphometric analyses of a digital elevation model (DEM) that were carried out in order to clarify the spatial distribution and variability of geomorphologic forms resulting from young Cenozoic activity in the area of interest. The research enabled us to verify tectonic structures discovered by geological methods. The results of performed analyses reveal various morphostructural evidences in the landscape of the NW part of the Milešovské středohoří Mts. The relief there is highly affected by post-volcanic tectonic activity caused by young Cenozoic stress fields. On the contrary, tectonic elevation in the SE part of the volcanic range mostly occurred in older, pre-volcanic phase. That resulted in the exposition of less resistant upper Cretaceous sediments that have been intensively denudated and therefore the tectonic pattern has become more indistinct. On the basis of our results, it is suggested that the tectonic behavior of the NW part of the Milešovské středohoří Mts. in its youngest developing stage differed from that of the considered rift structure. Taking into account the minimum time response needed for the attainment of a steady state river profile and the age of the best preserved lower Pleistocene terraces, it is assumed that the area was under the influence of post-volcanic young Cenozoic tectonic activity at least until 1 Ma BP.

Keywords: České středohoří volcanic range, faults, young Cenozoic, tectonic activity, geomorphometry

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Analýza přírodních ohrožení typu glof na příkladu vybraných jezer v pohoří Cordillera Blanca, Peru

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Povodně typu GLOF (glacial lake outburst flood) představují v nejzalednějším pohoří Peru - pohoří Cordillera Blanca - významnou hrozbu. Současně s ústupem zalednění v této oblasti od konce malé doby ledové dochází ke vzniku a vývoji relativně mladých, potenciálně nebezpečných jezer (a tento trend v posledních desetiletích pokračuje s nárůstem oteplování oblasti). Tato jezera jsou zde intenzivněji studována již zhruba sedmdesát let. Hlavním impulsem započítí tohoto výzkumu bylo protržení hráze jezera Palcacocha z prosince roku 1941, následované povodní GLOF, jež si ve městě Huaráz vyžádala přes 6 000 obětí. Pohoří Cordillera Blanca je zcela unikátní počtem jezer, jejichž hráze byly rozličnými technickými zásahy stabilizovány, nicméně řada dalších stále představuje reálnou hrozbu. Abychom byli schopni této hrozbě nějakým způsobem efektivně čelit, je nezbytné ji nejprve kvantifikovat. Metody hodnocení ohrožení lze podle charakteru rozdělit do tří skupin: (1) kvalitativní; (2) semi-quantitativní; (3) kvantitativní. Každý z těchto přístupů má určité výhody a nevýhody a nelze tvrdit, že některý z nich je jediný správný. Všechny jsou založeny na hodnocení vybraných aspektů stability (charakteristik jezera, hráze, mateřského ledovce a blízkého okolí jezera). Vedle stability hráze jako takové je klíčové pro relevantní vyhodnocení ohrožení také pochopení samotných příčin a mechanismů vzniku GLOFs a jejich vzájemných souvislostí, spolu s přihlédnutím k regionálním specifikům těchto událostí. Za účelem identifikace těchto specifik v jednotlivých světových oblastech výskytu GLOFs zřizujeme databázi těchto událostí. U GLOFs se známou (pravděpodobnou) příčinou v pohoří Cordillera Blanca převládá ve statistice pád odlomených bloků ledu / sněhových lavin do jezera (45 %) následovaný sesuvem / skalním říčením (35 %). Vedle vytvoření databáze je cílem výzkumných prací v pohoří Cordillera Blanca vyhodnocení ohrožení konkrétních jezer a vytvoření metody, která by zohledňovala regionální specifika GLOFs této oblasti.

Evidences of debris slope ventilation in the Tatra Mountains

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The abiotic indicators of debris slopes ventilation in the periglacial zone of the Tatra Mountains were examined. Geomorphological and meteorological influences on the ground surface temperature anomaly, hoarfrost, air ventilation funnels and snow melt windows, as well as locations of long-lying snow and permafrost patches were all analysed. The results showed that debris slope ventilation is a common phenomenon occurring in different periods of the year. Its range is influenced mainly by substratum porosity (ground and snow cover), and the difference between the pressure inside and outside this medium (pore and atmospheric air temperature/dense; wind velocity). The height of the slope is less important. Some phenomena assumed to be evidences of slope ventilation are often connected with other factors influencing the thermal balance of the ground and the size of snow accumulation.

Keywords: air circulation, debris slopes, ground temperature, sporadic permafrost, mountain environment, Tatra Mountains

Coarse sediment transport in Beskydian torrents: Evaluation of critical conditions for bedload motion

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The contribution summarizes the results of the bedload transport research in headwater streams of Moravskoslezské Beskydy Mts. We applied two methods: flood competence method and marked particle displacement method. The first method included measurement of diameters of the largest transported boulders (200-400 mm) during 5/2010 flood (Q_{25}) in uppermost part of Lubina river and Malá Ráztoka torrent. Transport of marked particles (18-152 mm) was conducted in Malá Ráztoka torrent in the period between 11/2010 and 7/2011 during which several discharges up to bankfull discharge occurred. The latter method was also used in two selected gullies of Malá Ráztoka basin to evaluate the intensity of coarse sediment transport in such initial channels. The relationship between grain diameter and critical conditions (shear stress, unit stream power and unit discharge) were evaluated and compared to than those coming from Alpine and Andine environments. Some lower trends of these relationships were observed in local torrents, which may have been caused by lower bed armouring or higher sediment supply. In step-pool morphology systems, the dynamics of sediment transport was higher in pools than on steps at bankfull flow, whereas the opposite was observed at lower flows. As we supposed, much higher intensity of sediment transport was evident in gully void of any vegetation cover unlike the gully more or less armoured with vegetation.

In addition, the contribution includes also first results of simulations in TOMSED bedload modeling software, originally developed for Alpine torrents. The simulation of 5/2010 flood event was conducted in two streams distinguished by different sediment supply conditions – rather limited sediment supply in Malá Ráztoka torrent and almost unlimited sediment delivery in Velký škaredý potok torrent. Computed bedload transports are incomparable with reality due to missing measured terrain data, but simulated intensity of incision or aggradation corresponds quite well with observations in streams after 5/2010 flood.

Keywords: torrent, bedload transport, shear stress, unit discharge, stream power, TOMSED, Moravskoslezské Beskydy Mts.

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Morphological patterns of mountain headwater channels of the Outer Western Carpathians

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Channel-reach morphology classification by Montgomery and Buffington (1997) was applied in the Western Carpathian streams predisposed by flysch geological structures. This classification was extended by two intermediate morphologies: bedrock-cascades and step-rapids. Bedrock-cascades were distinguished by occurrence of bedrock and lower sediment supply from cascades. Step-rapids are different from step-pools due to lacks of developed pools and probably higher sediment supply. General trends as widening of bankfull channels with increase of basin area were observed in local channels. By contrast, bankfull depth was recognized as an independent variable due to its low variety. Downstream coarsening was significant for slope-channel coupled reaches only. Some certain ratio of channel width and d_{90} predicted interlocking of boulder steps and origin of well-developed step-pool morphology, which supported jamming theory introduced by Church and Zimmermann (2007). Amount of large woody debris decreased with decreasing channel gradient and increasing drainage area. There was evident contribution of cleaning of active channels from woody debris by forest management especially at milder channel gradients.

There were also evaluated torrents in view of geological predispositions and composition of bed sediment. All of investigated reaches were divided into three groups based on observed amount of less resistant rocks in surface sediment layer. “A” group of reaches

contains only 0-5% less resistant claystones, "B" group 6-25% and finally "C" group 26-59% claystones. Channel-reaches with certain amount of less-resistant rocks (B group - 6-25% claystones in total amount) in bed material showed somewhat different behavior than channels with very small ratio of claystones (A group) or by contrast, with higher ratio of weak rocks (C group). Probably higher dynamics of sediment transport processes in channel-reaches with 6-25% ratio of claystones in bed sediment led to larger scatter in measured data and lower resulted correlation between drainage areas and bankfull widths. By contrast, much stronger correlation was observed in drainage area-channel slope relation in B group than in others.

PCA analysis was conducted by using some observed parameters of channel-reaches (bankfull geometry, channel slope, d_{90} , ratio of claystones in bed material, direct input of sediments, flood accumulations, amount of LWD), but any significant results arose in relation to individual channel-reach morphologies after their clustering. "

Keywords: torrent, channel-reach, morphology, bankfull, bed sediment, The Outer Western Carpathian Mts.

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Geomorphological and sedimentological effects of failure of the Vistula flood embankment near Płock*.

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The failure effects of flood embankments by the flood waters is the accumulation of large sandy cones in the foreland of created breaches and erosional cuts (eg. Gautier et al. 2009). Such forms were created in the floodplain of the Vistula River in Świniary near Płock, during a flood in 2010.

The break of the flood embankment in Świniary resulted from a water filtration through the corps of this construction and leakage through the ground. This fact has led to the scour dike on 23 May 2010. Through the gap of 120 meters width flowed into the floodplain about $900 \text{ m}^3 \cdot \text{s}^{-1}$ of water, inundating an area of 60 sq km. The erosional hole of 9-10 meters deep was created in place of dike breach. This form continues in the crevasse channel of 400 meters length and an area of 3,2 hectares. The traces of intensive sheet and rill erosion are visible on the area of 9 hectares of floodplain.

The largest form is a crevasse splay with an area of 36 hectares. It was built from the sands and gravel material of varying thickness. In the proximal part of the cone the fast accumulation of boulders and coarse gravels have occurred. This material came from the fluvio-glacial sediments, eroded from crevasse channel. Within the cone deposits the mud balls were found in many places. This shows a very rapid and short sediment transport. Interpretation of grain size indices of crevasse splay sediments shows that their depositional environments in many locations are a channel-type. Most of sediments building crevasse splay were accumulated in subcritical flow environment. Displacement at the top points on the CM diagram indicates the high-energy environment of the accumulation of cone sediments. The distribution of points on the CM diagram shows that even very coarse sand was transported in suspension. Interpretation of grain size cumulative curves of the crevasse splay sediments has indicated that deposition comes from saltation transport. It was also small, few percent deposition from the traction. The grain of similar size can be deposited in a different way. This fact indicates a great diversity of depositional environment, characterized by high energy flow regime.

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Keywords: flood, crevasse splay, sediment analysis, Vistula River

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Deep and shallow caves as seen by ERT - case studies of Strasin and Pustozlebska caves

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Traditionally, most of the discoveries of unknown cave systems are performed by patient speleological work. However, not always the connections are passable or even observable, as they are often obscured by cave infills (Hromas et al. 2010). Recently we observe the rise of the use of geophysical methods in relation to cave research (Abu-Shariah 2009, Guerin et al. 2009, Pánek et al. 2010, Hartvich and Valenta 2011). Sometimes this is done in combination with other geophysical methods (Abu Shariah 2009). These methods have many advantages: low running costs, fast coverage of large areas, and non-invasiveness (Schrott and Sass 2008).

The question of detectability of the void spaces is a complicated one. There are several problems, which may complicate the interpretation of the ERT profiles in the search for void underground spaces according to Roth et al. (2002): 3D effect, i.e. influence of mass around the profile; more pronounced in deeper layers; and, secondly, the identification of void spaces is obscured by Faraday cage effect of the cavity walls, which conduct the electric impulse around the void space. Thus the resistivity appears higher (as the path is longer), however, it is not as high as it would be in the void space (ideally, infinite). Detection of void spaces

using the ERT is thus a difficult task, with low sensitivity and precision. Therefore, to observe a void cave on the ERT profile, it must be either close to the surface, or a large one.

Contrary to these potentially problematic issues, there is one significant advantage in the search for unexplored caves: the caves in Moravian karst are typically infilled with a low-resistivity material (typically clay), thus turning the corridors into conductors. And the conductors are, contrary to insulating void spaces, very clearly identifiable with high accuracy and sensitivity.

We have chosen two illustrational case studies: the shallow Strašín cave (less than 10 m below surface), and a deeply set, large Crystal dome in Pustožlebská zazzděná cave in Moravian karst.

Keywords: ERT, caves, Moravian karst, Strašín Cave

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Complex transformation of the channels in the foothills of the Moravskoslezské Beskydy Mts.

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Long-term interference of man in Beskydian rivers has caused intensive transformation of qualitative and quantitative parameters of stream morphology and morphodynamics. The consequences of this transformation have a direct or indirect effect on

the channel management and environmental conditions within transformed catchments. The aim of this paper is to summarise main parameters of the changes using modern tools of modelling of fluvial processes. The application of the BAGS model (Pitlick et al. 2009) is presented in the case study of selected reaches of the Morávka River (Galia et al. 2012), many of which are in a state of complex transformation and the character of some of which resembles natural state of channel morphology (gravel-bed channel with a tendency to anabranching). The results are very useful for the comparison of sediment transport capacity in the channel types mentioned above. Combining standard geomorphological analyses and modelling, we were able to identify channel reaches with completely transformed fluvial processes. The state of complex transformation is presented by means of active channel metric parameters that have been derived from aerial images and historical data of water engineering projects. We have detected active channel narrowing from more than 400 m to 20 m of its width. One of the most problematic features identified in Beskydian channels is a high level of disconnectivity. Several types of channel disconnectivity have been defined (for more details see Fryirs et al. 2007). These phenomena manifest themselves by lowered input of sediments into the channels and propagation of deep erosion. On the basis of repeated measurement we were able to calculate incision rates which are one of the highest ones in the world (4 m per 18 years). Disconnectivity along the longitudinal profile is one of the most effective triggering factors of the acceleration of channel incision which is facilitated by flysch structure of the studied area. Identification of sedimentologic budget in the studied catchments could be very effective in the case of channel restoration. Recently some tributaries and relatively connected floodplain have been identified as the main donors of transportable sediments.

Keywords: river channel, incision, triggering factors, BAGS model, Outer Western Carpathians

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Paleoreconstruction of vegetation in mountain areas of the Bohemian Massif (Late Glacial – Holocene)

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Vegetation cover of a landscape is, in the first place, a result of co-influence of a complex of abiotic natural factors. Climatic, geographic, geomorphologic, geologic, hydrologic and other conditions are decisive for the appearance and composition of the vegetation cover. In addition, there is an anthropogenic factor in the landscapes influenced by humans for a long time. In early colonized regions this factor played a significant role as early as in the Neolithic.

Also palaeoreconstruction of vegetation forms part of the project “Paleogeographic reconstruction of Quaternary deglaciation in mountain areas of the Bohemian Massif”. Pollen-analytical results from the Krkonoše Mts. (Labský Valley), the Jizerské hory Mts. (Rybí loučky Mire), the Krušné hory Mts. (Fláje Mire), the Šumava Mts. (Plešné and Prášílské Lakes) can be used. The longest pollen-analytical record from the Labský Valley recorded the period roughly from 30.610 cal yr BP till subrecent. The periglacial tundra and/or the cold steppe from the end of MIS 3 turned into shrub forest tundra at the beginning of the Holocene. Then the vegetation cover was gradually passing into the forest vegetation. In the Krkonoše Mts. the mountain tundra was forced out to the extreme biotopes of top parts by this forest vegetation. The maximum size of forestation existed here in the Atlantic Period when the spruce climbed up even onto the plateaux of the Krkonoše Mts. Climax vegetation was formed by the spruce, beech and fir since the end of the Subboreal Period and since the Early Subatlantic Period. In the Jizerské hory Mts. the situation was similar only the pollen-analytical record in the sediment of the Rybí loučky Mire is shorter (from 9966 ± 61 BP). Since the Late Glacial till today the palaeobotanical data are deposited in the profile Fláje Mire (Krušné hory Mts.). Based on this profile, cryogenic processes were documented here. The Late Glacial and the whole Holocene are very well documented in the sediment of the Plešné Lake (Šumava Mts.). The pollen-analytical record in the limnic sediment of the Late Glacial Age is very similar to the situation in the Alpine lakes of the same age. It records the development of the vegetation within this area from the mountain tundra through the shrub tundra up to the vegetation of the Central European mountain forest. Similar results, for the time being only since the end of the Middle Holocene, were obtained from the Prášílské Lake.

The best pieces of information which are necessary for palaeoreconstruction of deglaciation in the mountain areas of the Bohemian Massif are deposited in the oldest sediments of the original lake biotopes. If a similar situation is not accidentally found, as it occurred in the case of the Labský Valley, where the lake sediments were found under a layer of peat, then only basal sediments of the Šumava Mts. lakes give a good perspective.

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Keywords: pollen-analyses, Late Glacial, Holocene, mountain areas, Bohemian Massif, Czech Republic

Monitoring of anthropogenic changes of relief in the Karviná region

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The Karviná region is affected by coal mining, that causes significant changes of landscape. Undermining resulting in the ground subsidence, during and after completing of mining works landscape reclamation is being carried out.

Monitoring of relief changes focuses on the measurement of ground subsidence. The subsidence is located on the surface above the mined coalface, progressively developing in the direction of mining and resulting in subsidence trough or depression. The subsidence is demonstrated in the horizontal movements on the slopes of developing subsidence trough and also in the vertical movement with maximum in its center, it can reach more than one meter per year.

Main applied method is the satellite radar interferometry (Interferometry SAR – InSAR). Processing of the SAR images allows to determine the changes of distance between satellite (SAR antenna) and the targets on the ground for specific time period. For application of InSAR results was necessary to compare and verify with results of other measurement techniques (levelling, GPS) carried out in the undermined area.

From summer 2011 I have carried out the geomorphological analysis of the undermined area, including geomorphological mapping of anthropogenic landforms, delimitation of extent of the subsiding areas, and documentation of the impacts of subsidence (e.g. road deformations).

Keywords: Karviná, undermined area, subsidence, InSAR, geomorphological analysis

Structure and age of Czarna Nida flood plain – key study near Kuby Młyny (Holy Cross Mountains)

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The Czarna Nida river with its length 63.8 kilometers and catchment area 1224.1 km² is a left-bank tributary of Nida river (upper Vistula drainage basin). It arises in Holy Cross Mountain and then cross Szydłowskie Foothills, a part of the Mesozoic margin of this mountains.

The study area covers valley section about 30 kilometers long between mouths of Morawka river and Nida river. Width of valley varies from 0.5-2.0 kilometers. The

Pleistocene terraces are preserved as narrow strips bordering the alluvial valley. Terraces, 2-4 meters height, are erosional and accumulative-erosional, with sandy-gravel deposit horizontal and cross bedded accumulated by braided river.

In the valley floor, within one morphological unit, comprise alluvial inset fills of different age formed by the river of various channel pattern: large meanders, small meanders, multichannel. Pollen diagram of organic sediments fill large palaeomeander reflects vegetation changes in the valley caused by climatic changes since the Lateglacial and human impact since the Subboreal.

Small meanders and multichannel systems were typical for the Holocene. Cut off palaeochannel was dated on 6490 ± 80 BP (Kuby Mlyny 3) and on 2530 ± 80 BP (Kuby Mlyny 4). The flood (KM4 about 1530 ± 70 BP) and an increase of sedimentation rate during last millennium are reflected in the fill of these oxbow lakes.

The traces of typical channel changes for the Central Europe were preserved in the Czarna Nida valley: the Plenniglacial braided river - Lateglacial macromeader - Holocene small meander. However due to results of our studies this model should be complete with the Holocene phase of multichannel (anastomosing, anabranching) which was also in another river valleys in Poland.

The cut off and changes of sedimentation type on flood plain of Czarna Nida river correlate very well with phases of an increase of river activity (for example 8500–8000, 6600–6000 BP) distinguished for the Centraleuropean rivers (Kalicki 2006). However some of them must (for example 7680, 2530 BP) be connected also with local events what is typical for small catchments and rivers as Czarna Nida.

Keywords: channel pattern, Czarna Nida valley, Lateglacial-Holocene evolution, Poland

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Quaternary volcanism and changes of river network in the lower part of the Valley of Volcanoes (Central Andes, Peru).

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Valley of the Volcanoes belongs to the Rio Colca catchments, which drain western slopes of Andes in southern Peru. Study area is located in the lowest section of this valley near Ayo. The valley is filled by young volcanic rocks mainly lava flows and cinder cones, referred to as the Andahua formation, rest upon older Pleistocene alluvial deposits and sandstones from the Yura Group of Jurassic age.

Fluvial complex of Rio Ayo and volcanic complex of “Mamachocha” occur in the valley bottom. Alluvia of torrential fan on the right side of the valley are cut by gully of the

Rio Ayo depth up to some tens metres. Mamacocha complex consist some generation of Andahua lava. The oldest flow is the axis of the valley and get younger towards the left slope of the valley. These lavas were squeezed out in the valley bottom parallel to its axis. Due to our observations (volcanic bombs, volcanic glass and piroclastic deposits) Laguna Mamacocha considered previously as a dammed lake is rather a lake filled depression in eruption center. Besides lake the depression is filled with youger series of volcanic flows with very distinct levee.

Volcanic rocks blocked the Rio Mamacocha in the section between Laguna Chachas and Laguna Mamacocha, some tens kilometers long. Water flows underground in this section in volcanic tubes. The river starts again from Laguna Mamacocha and flows between volcanic complex “Mamacocha” and left slope of the valley consists of folded sedimentary rocks. A littlebit upstream of mouth to the Rio Colca the river has epigenetic gorge. Limnic sediments of old dammed lakes occur also in this section.

Using GIS to analysis braided river pattern changes

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Braided rivers are very complex and highly unstable fluvial systems. This study aims to determine the temporal and the spatial extent of the morphological changes occurred in a 1,7 km long reach of a gravel bed river of the north of Slovakia (the River Belá, situated in the Liptovská basin) with braided and wandering planform. GIS is a strong and a usefulness tool for analyses braided river pattern changes and provide possibilities for better understanding its behaviour. Multitemporal analysis of historical maps and aerial photos (9 time horizons: 1837, 1938, 1949, 1961, 1973, 1986, 1992, 2003 and 2009) were used to determine spatial and temporal changes in the River Belá corridor by the GIS environment (ArcGIS software from ESRI). The mapping floodplain evolution (floodplain tracking), dating of floodplain based on multitemporal analyse of aerial photographs and historical maps, braided pattern evolution, braided index parametres, typology and classification channel forms, bar and island evolution and node density defined as a number of flow convergences and divergences were investigated. Lateral shift, braided indexes supervision, width of braidplain, bars typology, count and density of node were use for identifying braided pattern evolution and spatial changes in braided planform. Node density have been indicated areas with the biggest instability (core areas with the marked changes of number of river channel). In GIS was investigated spatial distribution and similarity of nodes in three buffer zones (12.1 m, 24.2 m and 43.7 m) between years 1949 and 2009 (average distances between nodes were 12.1 m and max. distance 87.4 m). The results indicate that the areas of instability (core area of nodes) corresponds to the evolution of braided planform, changes in topology of bars and evolution of islands with vegetation, as a stable component of braided river system. Total eroded area of study reach was 50 ha and average shift of the braided corridor was 84.5 m between 1837 and 2009. The River Belá represents very dynamic braided and wandering river system with rapidly changes in planform and creation of several channels, evolution of midchannel bars to islands and intensive lateral erosion. This research was supported by the Slovak Scientific Grant agency VEGA (Project N.2/0106/12).

Keywords: braided river, GIS, floodplain evolution, the River Belá

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Evaluation of geomorphological localities: methodological approach on example of north-western part of the Vizovická vrchovina Highland

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The evaluation of geomorphological localities is one of the tools of geoconservation. For the geomorphological assessment it is possible to use the concept "geomorphosites" which includes inventoring, evaluation and proposals for management and rational use of the sites.

Traditionally, in the Czech Republic, there is a wide spectrum of geomorphologic information including geomorphological maps. This information can serve to the purposes of detailed inventoring and as the base for evaluation of the sites.

A "geomorphosite" can be defined as geomorphological landform that have acquired certain values due to human perception. These values can be divided in two groups: 1) scientific values (an importance for understanding to a form, process or evolution, representativeness of the form and process, uniqueness and palaeogeographical significance) and 2) additional values (cultural, aesthetic, economic/social and ecological values).

Based on the methods already used for the assessment (e. g. Panizza, 2001, Reynard et al. 2007, Pereira, 2007), the special methodology for Czech ambient is presented. It includes: 1) identification of significant geomorphologic sites (based on the literature, maps and field survey), 2) a detailed inventory of selected sites (general information, geology, geomorphologic data - morphology and genesis, environmental conditions, a description of the cultural components of the site, aesthetic aspect, availability, background, presence services, current status of the site, potential threats and risks), 3) numerical evaluation of sites (scientific and additional values, economical potential, threat and risk assessment), 4) SWOT analysis, 5) synthesis (classification of the sites, management proposals, possible use of the site, proposed legislative protection).

This concept was used for evaluating of selected geomorphological sites in the north-western part of the Vizovická vrchovina Highland; the results of the assessment can serve as a base for proposals for rational use and management and other perspectives of the use of the geomorphologic assessment are outlined.

Keywords: geomorphosites, methodological approach, Vizovická vrchovina Highland

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**Mid-mountains valley heads transformation by fluvial processes.
Hruby Jeseník Mts: Rudohorsky creek case study.**

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Mid-mountain Hruby Jeseník massif is situated in the Eastern Sudety. The ridge Praded-Keprník-Šerák, which is 15km long, is characterised by domed summits (1200-1500m), separated by shallow passes (1000-1200m). In the last cooling stage of Pleistocene, approx 20 000 years ago, the front of the Scandinavian ice sheet was 160-200km north of massif slope. In the periglacial climate, in the valley heads of this massif, especially of NE exposure, weathering covers of different thickness and structure were stored. In some of these valley heads may have existed rock glaciers. The Holocene succession of forest communities (Tremel & Banaš 2008) markedly limited the transfer of weathering covers downslope.

Early human impact on the upper tree line environment (Novak et al. 2010), and later cattle grazing and the development of tourism-caused its discernible lowering, particularly in the area of valley heads. It coincided with the last cooling stage of LIA-minimum of solar activity, i.e. the Maunder Minimum-and volcanic activity (Steinhilber & Beer 2011). It resulted in the increasing of precipitation and prolonged period of snow cover, occurrence of tree falls, which increased the percolation of water in these covers. In many valley heads started the debris flows (Sokol 1959, Malik 2008). Bigger debris flows moved a long way down the valleys.

Debris flows caused “colluviation” of the upper valley sections. Later bigger floods caused by heavy rains restored the fluvial valley topography. One example of geomorphological and sedimentological record of these events is represented in the Rudohorsky creek valley head, which dissects the Keprník massif (1423m). Here, the debris flow was more than 1km long and reached downvalley the altitude of 770m. This reach is confirmed by the colluvia infilling the valley floor. Later floods caused its erosion and selective redeposition .

The oldest spruces, growing on the lower part of this debris flow, and cut in 2011, had 187 yearly increment rings. This indicates that these spruces started to grow on this part of valley floor at the beginning of the 19th century, probably after the big floods of 1813. Slightly younger trees, growing in the upper section of the debris flow, and cut in 2011, have 156 yearly increment rings. They started to grow in about 1830. These events closely correlate with historical records on extreme rainfalls and floods in the Biela river drainage basin (Polach & Gaba 1998).

In the upper section of the Rudohorsky creek valley there are found traces of former roads and bridge abutments. The trees growing on these remnants started to grow in the first decades of the 20th century. This indicates that heavy rains did not generate new debris flows. They caused only the dissection of previously deposited colluvia and restoration of fluvial relief in the upper section of the Rudohorsky creek valley. Similar events occurred in other valley heads dissecting the Pradziad-Keprnik-Šerak ridge.

Keywords: valley heads, debris flow, colluviation

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Use of EarthCaching for dissemination of geomorphological information

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Geocaching, established in 2000 (Kresta, 2010), is the modern equivalent of the treasure hunt game. The goal is to use the GPS receiver and coordinates published on the internet to find hidden boxes. From a variety of different types of caches, EarthCache was chosen to present interesting geomorphological sites. It is a virtual cache, where the player does not search for a treasure box, but through the GPS coordinates gets to the geologically or geomorphologically interesting place. The cache must be educational - to bring new information from the geoscientific disciplines.

The presentation shows examples of EarthCaches published on geocaching.com web page. It also demonstrates the possibilities of this game for the dissemination of information on threat and risk that is associated with the occurrence of landslides. Several ways how to use this game for teaching purposes on high schools as well as universities are outlined.

EarthCaching main advantage is that it is very cheap and quick to establish and maintain. Players or students gain the information directly in the field during teacher - independent work. Information published on the geocaching.com web page has potential to reach wide audience also from general public.

Presentation was financed by GAČR 205/09/P383 project.

Keywords: geocaching, geosites, geomorphology

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KRESTA J. (2010): Geocaching – pravidla, principy a možnosti využití informačními pracovníky. MU Brno, Filozofická fakulta, s. 112.

**Geomorphological mapping as a tool to study flood plain of Czarna Nida
(Polish Uplands)**

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Geomorphological mapping is a method worked out in 1970s. The legend, produced in collaboration with many geomorphologists from European countries, while the manual, a compilation of articles by 20 geomorphologists, was published in 1972 (Demek, 1972). The geomorphological map give picture of the outlook - morphography, dimension – morphometry, origin – morphogenesis and age – morphochronology of landforms on study area. All forms of determined origin are marked on a topographical map on the scale of 1:10 000 by means of coloured patches and signs. The colour of the form determine the factors (river, glacier, wind, gravity, etc.), time (geological age) and destructive or constructive activity modelled the given area (Klimaszewski 1979).

Czarna Nida valley was studied by means of detailed geomorphological mapping and cross-sectional analysis. Research started with field survey and was carried out with the help of orthophotomap (available on Geoportal via a WMS service), old topographic map, aerial photographs and digital elevation model (DEM). The final map is worked out in GIS application.

Based on comprehensive analysis of cartographic images various channel pattern was identify: large meanders, small meanders, multichannel. Several generation of palaeochannels were distinguished differing in morphology, contrasting light colors with respect to the areas surrounding on aerial photos and vegetation cover.

Geomorphological map provides initial outlook on floodplain landforms and their relations. It helps in formulating research problem and choose sites for detailed palaeogeographical studies.

Keywords: geomorphological mapping, channel pattern, Czarna Nida valley, Poland

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Comparison of micromorphology features on eluvium, moraine and debris flow quartz grains

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Micromorphology of quartz grains (exoscopy) belongs among relatively new methods used in geomorphology. This method is used to set genetic type of sediment in geology and also to set accumulation form in relief. Exoscopic literature states characteristics about basic genetic types of sediments but eluvium used to be forgotten.

This contribution deals with the comparison among micromorphology of eluvium, moraines and debris flows with emphasis on eluvium. There were compared altogether 26 samples. 18 samples of moraines were taken in the Černé jezero Lake area (Bohemian Forest), the Labský důl Valley and Důl Bílého Labe Valley (Krkonoše Mts.), the valley of Velká Kotlina (Hrubý Jeseník Mts.) and the Velická dolina Valley (High Tatras), 4 samples of debris flows were taken in Důl Bílého Labe Valley (Krkonoše Mts.) and 3 samples of eluvium were taken at Památník letcům (Krkonoše Mts.), Šerák Mountain and Vysoká hole Mountain (Hrubý Jeseník Mts.).

Sediments were examined under electron microscope and their morphological characteristics were identified and described. Analysis of variance was carried out to identify diagnostic microfeatures to distinguish eluvium from moraine and debris flow grains and subsequently, discriminant analysis was carried out to verify success rate of classification of observed samples.

Characteristic microfeatures of eluvium are angular grains with medium relief and occurrence of small conchoidal fractures, straight steps, fracture faces, edge abrasion, meandering ridges, adhering particles, silica precipitation and microblocks. Diagnostic microfeatures to distinguish eluvium from moraines and debris flows are high relief, small conchoidal fractures, curved grooves and adhering particles with 92 percent success rate. Grains of moraines have less straight steps, fracture faces and adhering particles and more impact depressions and grooves on their surfaces in comparison with eluvium. This agrees with Wang's (1985) statement that eluvium has more conchoidal fractures and angularity than glacial sediments. Grains of debris flows are more angular in comparison with eluvium and they have higher relief, more small conchoidal fractures, but less straight steps and cleavage plates.

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Keywords: eluvium, moraines, debris flows, micromorphology of quartz grains

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State, Results and Intention of Geophysical Survey of the Locality Ledove sluje (Ice Caves) in Podyji National Park, Czech Republic

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Locality Ledove sluje (Ice Caves) in Podyji National Park represents a unique type of relief and landforms of the Bohemian Highlands. There is an extensive system of pseudokarst caves and block fields developed from rock slides on the NW slope of the locality. The attention in researchers is given to a question of an evolutionary mechanism of this territory. The theories have explained it by complex of processes such as the Dyje River lateral erosion, tectonic effects (faults) and trigger event (earthquake). For verification the trigger event of the rock slides and development of pseudokarst caves is necessary to use a geophysical methods.

This paper describes a new geophysical survey with Ground Penetrating Radar (GPR, pulseEKKO PRO, Sensors & Software Inc.) and 2D Multi-Electrode Resistivity and IP Tomography (ERT, ARES, GF Instruments s.r.o.) from April, May and November 2011. It relates to the older test geophysical survey (Pospíšil, 1998) and is focused on main scarp of rock slides and buried sediments. Fieldwork counted three GPR lines (ca. 1500 m) and one ERT line (315 m). Data postprocessing have contained advanced corrections (included time-depth conversion with 2D velocity model etc.).

The authors discuss anomalies and differences in subsurface images with context of surface terrain and relief development theory. The results indicate a new fault of different direction in comparison with survey summary in 1998. It leads to idea of fault zone with high signification for relief development. Secondly, the two main scarp of rock slides and the new possible place of pseudokarst caves was determined. Thirdly, alluvial deposits from the Dyje River were found under the rock slide.

In addition to this, the paper will clarify the whole spatial situation using a 3D model with terrain and subsurface layers. The authors will intend to integrate the subsurface images in a detailed terrain model from laser scanner station and also to compare with cave maps.

Keywords: Geophysical survey, Ground penetrating radar, Electrode Resistivity Tomography, Ice Caves, Podyji National Park

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Kvantifikační charakteristiky typů údolních sítí

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Údolní síť představuje základní „pattern“ reliéfu i krajiny. Tvar údolní sítě umožňuje zhodnocení litologicko-tektonického základu a hlavních krajinnotvorných procesů. Typ údolní sítě, její tvar a hustota, bývá výsledkem složitěho geomorfologického vývoje celé oblasti a odráží intenzitu působení erozních činitelů na reliéf (Stoddart, 1997). Studium údolních sítí je komplikováno volbou hodnotícího měřítka vyplývající ze samotné fraktálové podstaty údolních sítí. Rozlišuje se šest základních typů údolních sítí (srov. Howard, 1967; Fairbridge, 1968; Demek, 1987; Babar, 2005; Husain 2005,2008), přesto určení typu údolní sítě je založeno pouze na vizuálním odhadu a nebyly doposud definovány spolehlivé kvantitativní znaky, které by reprezentativně charakterizovaly daný typ údolní sítě. Tento příspěvek se zabývá kvantifikovanými metodami popisu sítí převzatých z různých vědních oborů a jejich aplikací při studiu údolních sítí. Poster představuje hlavní kvantifikátory, s jejichž pomocí je možné charakterizovat morfologii (typ) údolní sítě. Hlavními kvantifikátory byly: orientace údolí, fraktálová dimenze údolní sítě, řádovost údolní sítě, bifurkační poměr údolní sítě, hustota údolní sítě, homogenita údolní sítě a propojenost údolní sítě. Orientace údolí, fraktálová dimenze, řádovost a homogenita údolní sítě byly aplikované na cvičnou mřížkovitou údolní síť v oblasti CHKO Kokořínsko, jehož hlavní údolí je protékané řekou Pšovkou. Vzhledem k fraktálové podstatě údolních sítí bylo nutné zvolit vhodné měřítko při popisu údolních sítí. Pro cvičnou mřížkovitou údolní síť o rozloze přibližně 100 km² bylo stanoveno měřítko 1 : 25 000. Ukázalo se, že při volbě odlišných měřítek jsou charakteristiky údolních sítí neporovnatelné. Údolí I. řádu cvičné mřížkovité údolní sítě bylo orientované ve směru SV–JZ. U údolí II. řádů převládala orientace SZ–JV a u III. řádů převládala orientace SV–JZ. Úhly mezi údolními měly velikost přibližně 90°. Ve cvičné údolní síti vzniklo 63 společných ústí, kde se setkávalo tři a více údolí, což vytvořilo mřížkovitý tvar údolní sítě. Fraktálová dimenze cvičné údolní sítě byla 1,43, což odpovídá hodnotě fraktálové dimenze schématické mřížkovité údolní sítě. Cvičná údolní síť se skládala z jednoho údolí I. řádu, do něhož ústilo přímo a nebo zprostředkovaně 486 údolí nižších řádů. Hlavní údolí bylo dominantní svou délkou a vedlejší údolí byly dominantní počtem, což je typický znak mřížkovitých údolních sítí. Cvičná údolní síť nebyla z hlediska délky údolí jednotlivých řádů homogenní (sensu Mangold, 2005), což je rovněž v souladu s kontrolní schématickou mřížkovitou údolní sítí.

Contemporary changes in the relief of raised bogs on the example of the Polish Carpathians

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The subject of this paper is the problem of anthropogenic changes in the relief of raised bogs in mountain areas. This problem has not received a great deal of attention in the research literature. All peat bogs in the Polish part of the Orawsko-Nowotarska Basin in the Western Carpathians and in the Bieszczady Mountains in the Eastern Carpathians were analyzed. Special attention was paid to the remnants of peat domes and post-peat areas and the scarps separating them. Scarps are initially vertical or step-type, often forming zigzag-shaped sequences. Another important landscape element is numerous hollows filled with water. Older post-peat areas, deprived of peat cover, are used for agriculture. The purpose of this paper is to describe the rate of shrinkage in the surface area of peat domes in mentioned areas in the Polish Carpathian Mountains. Peat dome surfaces have been shrinking since the middle of the 19th century, in addition to earlier changes. A second purpose is to describe the rate of growth in the surface area of older and younger post-peat areas. With that in mind, the direction and rate of change of landforms typical of younger post-peat areas, such as peat extraction scarps, post-extraction hollows, drainage systems including ditches and regulated stream channels, were analyzed in detail. A special emphasis was placed on the period of time when the restoration of such areas has taken place. The paper is based on an analysis of maps produced over the last 230 years as well as on aerial photographs taken in the last 50 years. Field data were also analyzed. Fieldwork included the geomorphological mapping of specified landforms within peat bogs using GPS methods and morphometric terrain data from the last 15 years. Information obtained from local water management authorities and other institutions as well as information gathered by interviewing individuals involved in peat extraction for many years were also included in this research. Information from the research literature on the subject was also considered. The surface area of selected raised bogs as well as their total surface area within the study area were estimated. The estimates reflected the most likely values of the areas for the period prior to human impact. The present-day surface areas of the remnants of peat domes as well as younger and older post-peat areas were also estimated. Six phases in the development of scarps were identified. The rate of relief change was estimated and the role of exposure was assessed. Attention was paid to changes in the relief of post-peat areas that are occurring because retention ponds and drainage ditches have become more shallow because of beaver activity and the results of stream channel regulation. Special attention was also paid to the geomorphological aspects of the restoration of post-peat areas. Raised bogs in the Orawsko-Nowotarska Basin and the Bieszczady Mountains, which had formed across fluvial and fluvio-glacial landforms with a small gradient, are characterized by weak mass movements that today affect only post-extraction scarps and their base.

Water circulation and chemical denudation in the upper Skawica River flysch catchment (northern slope of the Babia Góra massif), Western Carpathian Mountains

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The paper characterizes subsurface water circulation on the slopes of the upper Skawica River catchment in the Western Outer Carpathians in Poland that includes deep translational and rotational landslides. The catchment is located in the highest part of the flysch Carpathians, with elevations up to 1,725 m. Abundant water resources and relatively deep circulation foster subsurface dissolution of flysch strata, enabling the formation of deep landslides and increased groundwater penetration in interbedded marly shale and sandstone. The purpose of this paper is to describe water circulation based on an analysis of spring water temperature, chemistry, discharge, and to estimate the amount of chemical denudation in the upper Skawica catchment by calculating the outflow of dissolved solids by springs. The methods used in the research included repeated measurements of spring discharge, temperature, and quantity of dissolved solids produced by selected springs in the catchment. The discharge of dissolved solids by springs varies with elevation, with differences also being observed between cuesta-type slopes and slopes following the dip of the local strata. The largest rates of discharge of dissolved solids were measured between 900 and 1,300 m of elevation ($4,200 - 5,500 \text{ mg s}^{-1} \text{ km}^{-2}$), where the thickest colluvium recharging numerous large springs occurs. Chemical denudation on cuesta slopes leads to sharpening of existing geomorphic contrasts, while slopes following the dip of bedrock strata become gentler and smoother. It has been shown that chemical denudation of the upper Skawica flysch region, which locally reaches $150 \text{ tons yr}^{-1} \text{ km}^{-2}$, is more dependent on groundwater resources than on bedrock lithology. A characteristic feature of the catchment in question is the more pronounced (versus other flysch mountains) influence of distant and relatively deep water circulation in colluvia and fractured rocks upon dissolution of the bedrock.

Recent channel changes of a large river – example of the Nile in desert zone

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The Nile riverine landscape has been and still is the important settlement corridor as well as the axis of movement of people, goods and animals. While much of its basin is sparsely populated extensive tracts of agricultural land and settlement points on the valley floor in desert zone are heavily or totally reliant on Nile water and sediment flows, bank shift and river islands development. Thus its morphologic-sedimentary behaviour is crucial for the sustainable development. Diachronic (multi-temporal) and synchronic (spatial) analyses based on interpretation of aerial photographs in GIS environment have been used to classify and map changes in river morphology. The arid (cataract) zone of the Nile course (from Khartoum to the Aswan lake, 1,885 km length) has been selected as the study area. Aerial photographs

(1985), satellite images (2000 and 2005), geological map, Google maps and settlement point census were used for making up the GIS database consisting of information concerning the area and boundary of erosion corridor, channel centreline, right and left bank line, area of channel islands, sand dunes encroachment areas and land cover and settlement structures. A channel centre-line generated from 2005 Landsat photographs were digitized and has been used as a reference benchmark for the estimation of the right as well as left bank shift in the past. The buffer zone of centre-line 18 km in width cut by cross-sections spacing 5 km and river erosion corridor have been used for the analysis of spatial variability of river morphology – for identification of segments and river reaches. It is found out that significant changes in river morphology have been occurred across the study area which is documented by several tables and pictures. General conclusion is that the study river course of the Nile has shifted gradually towards the East during 1985 – 2005, the maximum bank shift has been estimated up to 1300 m and increasing in the erosion corridor width is evident, too. Finally, the density and kind of settlement points along river reaches together with results concerning rate of bank shift have allowed us to work out an assessment template for a bank erosion risk.

This research was supported by the Slovak Scientific Grant agency VEGA (Project N.2/0106/12).

Keywords: Nile, channel behaviour, bank shift, Sudan, flood risk

The Kněhyně cave - an indicator of type, genesis and succession of slope movement (Moravskoslezské Beskydy Mts., Czech Republic)

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The Kněhyně cave (Moravskoslezské Beskydy Mts., Outer Western Carpathians, Silesian Nappe) is one of the most pronounced crevice-type cave system in the Czech Republic. With its total depth of 57,5 m and overall length of the passages overlapping 280 m this cave belongs to the significant examples of pseudokarst phenomena.

The crevice-type (rock-slide) cave has developed in the context of propagation of deep-seated gravitational slope deformation (DSGSDs). Slope instability follows WNW-ESE trending tectonic fault, one of the most important direction of discontinuities driving gravitational disruption of whole Kněhyně ridge. By using speleological technics we can follow the inner structure of landslide right in underground. Through the microstructural measuring of main discontinuity sets (joints, faults and bedding planes) and their correlations in various parts of the cave, main types of mass movements leading to the formation of crevices in the different passages and horizons can be discovered. On the contrary to previous research supposing toppling model for the evolution of cave, our investigation reveals that crevice-type has originated due to the complex pattern of slope processes.

The superficial research with application of 2D electrical resistivity tomography (ERT) methods and geodetic measurement give us the answers about the succession of slope movement. Thanks to the proper connection of detailed topographical map and speleological

plan of the cave, distinct evolution between the surface topography and underground structures can be detected.

Keywords: pseudokarst, crevice-type caves, Outer Western Carpathians, deep-seated landslides, microstructural measuring, electrical resistivity tomography

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Controls on longitudinal variability of large woody debris in submontane river – an example from the Morávka River, Czech Republic

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Large woody debris (LWD) is recently acknowledged as an integral component of stream and river channels in forested watersheds. LWD influences physical and ecological processes such as channel hydraulics, sediment routing and deposition, changes of channel morphology, creation of aquatic habitats, and nutrient spiralling. Nevertheless, majority of work has been done on a reach scale, in small watercourses, and in streams flowing through old growth forests. Less information is available about abundance and functions of LWD on watershed scale and in medium and large rivers flowing through developed landscapes with managed forests. We address the problem of quantity, spatial distribution and properties of LWD along the entire length of the submontane Moravka River in the industrial region of the north-eastern Czech Republic. The main objective of the study was to identify controls of LWD occurrence in terms of channel geomorphology, floodplain vegetation and anthropogenic influences. The Moravka River has been chosen as an example of the watercourse with exceptionally high geomorphic variability with alternating natural and highly modified reaches. The river spans the environments including mountainous terrains upstream (elevation above 900 m) to gently rolling terrain downstream (elevation below 250 m); the length from source to mouth is 30.9 km. Bedrock river reaches alternate with alluvial reaches of various geomorphic style (cascade, step-pool, multiply-channel gravel bed, incising plane bed). The human modification of the channel and floodplain is also quite significant

(water reservoir in the upstream section, bank stabilization, check dams and weirs, water diversion, control of sediment transport on tributaries). We registered following variables for LWD: geographical coordinates, diameter, length, orientation, decay status, position within the channel, and recruitment mechanism. Survey of LWD was accompanied by mapping of overall geomorphic style (type) of the channel, inventory of bed forms, recording anthropogenic channel modifications and describing the type and extent of riparian woody vegetation. Altogether eleven reaches (zones) with distinct geomorphic style and different assemblages of bed forms was distinguished along the river channel. The quantity and properties of LWD varied considerably among these zones. There is a distinct maximum of LWD abundance in the middle course of the river and secondary maxima upstream (source section) and downstream (close to the mouth). The highest quantity of LWD was recorded within wide gravely active zone with multiply wandering channel. The steady supply of LWD is enabled by bank erosion of the deciduous floodplain forest. Upstream maximum is located in the section with cascade and step-pool geomorphic styles in the mountain coniferous forest. Relatively high supply of LWD is sustained by wind throws and icings. Downstream maximum of LWD is a result of accelerated (human induced) incision of the channel bed causing destabilisation of banks that are up to 7 m high. Subsequent bank sliding brings trees from the surrounding deciduous forest to the channel. The transport of LWD in the upstream reach is limited due to the large dimensions of fallen trees and incompetence of the river to export it downstream (large LWD piece length to channel width ratio, small discharges). The export of LWD in the middle reach (with maximum LWD abundance) is constrained only to smaller pieces. LWD pieces are generally large there, rather stable and easily trapped on numerous gravel bars and islands. Mobility of LWD may be high, but transport occurs only for short distances. The most active transport of LWD is in the downstream deeply incised channel that is lacking obstructions for trapping floating wood. Regulated river reaches have generally low quantities of LWD with rather small dimensions due to sparse riparian vegetation and channel stabilization; both limit the recruitment of wood from riparian zone. Within the regulated channel reaches most frequent recruitment category are wood pieces floated from upstream.

Keywords: large woody debris, longitudinal variability, submontane fluvial system, the Morávka River

Morphostructural analysis of the boundary of the Cheb Basin and the Krušné Hory Mts., NW Bohemia

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The study area is situated on the border of the Cheb (Eger) Basin and the Krušné Hory Mts. (Erzgebirge). This border is known to have had recent seismic activity. The West Bohemia region and the Vogtland region are monitored by the seismic networks and by GPS geodynamic network GEONAS. The geological and morphological conditions in this area have not yet been sufficiently studied.

A morphostructural analysis was carried out in this area with the aim of finding the structural factors that control the relief. Our study focused on mapping the valley forms and the drainage patterns, and their correlation with dislocations (faults, joints). The valley relief was found to be strongly influenced by the structural conditions and by the position on the border between morphologically different units. The Mariánské Lázně Fault Zone divides the area into two different parts: the Cheb Basin and the Krušné Hory Mts. Two main fault systems are dominant in the Krušné Hory Mts.: NW–SE (as Mariánské Lázně Fault Zone) and NE–SW (as Eger/Ohře Rift Zone). Both directions can also be seen in the drainage pattern.

The tectonic effect is obvious in the asymmetric cross profiles of most of the valleys in the northern part of the Cheb Basin and adjacent areas. There are changes of direction of all water flows on the Mariánské Lázně Fault Zone. Recent tectonic activity is also reflected in the existence of mineral springs and moffetes along the main fault zones. Recent manifestations of the evolution of the relief can be seen on the slope deformations, mainly along the Mariánské Lázně Fault Zone or newly described Počátky–Plesná Fault Zone (N–S orientation) in the Cheb Basin. Several faults were filled with clay-rich gauge.

Keywords: Cheb Basin, Krušné Hory Mts., drainage pattern, morphostructural analysis, slope deformation, topographic relief profile

Tectonic characteristics of waterfalls in the Slovak Carpathians

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The main objective of our contribution is to describe the structure and inputs of a database of waterfalls in Slovak part of the West Carpathians. The presented waterfall database helps to resume and widen an older incomplete waterfall database prepared by SAŽP (online

http://www.sopsr.sk/vodopady/show_organutvar.php?idOrgUtvaru=20&idVodopadu=180).

Waterfalls of four geologically and morphologically different units: The High Tatras, The Low Tatras, Slovenský raj Mts and Slovenský kras Mts were selected at the beginning of our investigation.

Each waterfall is characterized by a set of parameters: the height, width, elevation (m a.s.l.), width of a stream under the falls (m), cascade weir, etc. The emphasis is on a characterization: rock, width of a valley, slopes, genetic type /feasible genesis, and tectonic features of the fall. The database also includes common information such as the name of the

waterfall, its location, river/stream, town/village, county, protected area, and geomorphological unit. Input data come from various sources (field research, morphometric and morphostructural analyses, morphological profiling, adopted layers like geology and tectonics, etc.). The completed database could be used for geomorphologic research, tourism, etc.

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Keywords: waterfalls, database, tectonics, High Tatras, Low Tatras, Slovenský raj Mts, Slovenský kras Mts

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New insight into stratigraphy of moraines in the High Tatras based on the Schmidt Hammer test

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During several cold phases of the Pleistocene, the local mountain glaciation was formed in the High Tatras. Based mainly on morphostratigraphy of moraines, three main glaciations using alpine nomenclature named as Mindel (correlated with MIS 12), Riss (MIS 6 - 10) and Würm (MIS 5d - 2) have been recognized (e. g. Lukniš, 1973; Klimaszewski, 1988). The character of the older glaciations, in the area represented only by glacialfluvial deposits, is more difficult to distinguish (e. g. Lindner et al., 2003).

The aim of this paper is to determine the number of glaciers' oscillations based on relative dating of moraines by Schmidt Hammer (SH) test. SH measurements were undertaken in the Batizovská dolina Valley and the Velická dolina Valley where several groups of moraines belonging to different stadials (marked as A-E, sensu Lukniš, 1973) of the last glaciation and one remnant of moraine presumed to have origin in penultimate glaciation were recognized by Lukniš (1973).

The standard N-type of SH was applied in accordance with descriptions of the technique in previous studies (e. g. Sumner & Nel, 2002; Goudie, 2006; Engel, 2007). On each studied moraine, five boulders were chosen. Subsequently, on naturally weathered (intact) surface of each boulder, 25 hammer impacts were taken.

Mean R-values of individual moraines range between 29.48 and 48.16. The lowest value was found on degraded surface of moraine at the mouth of the Velická dolina Valley correlated by Lukniš (1973) with penultimate glaciation, contrarily the highest value was found on fresh ablation moraine in cirque of the Batizovská dolina Valley assigned by Lukniš (1973) to early Holocene origin. Results of the ANOVA showed no significant differences

between mean R-values of moraines belonging to stadials A, B and C (sensu Lukniš, 1973). Therefore, five different types of moraines in the Batizovská dolina Valley and four different types of moraines in the Velická dolina Valley can be recognized.

Schmidt Hammer test was unable to distinguish moraines of older stadials (A, B, C, sensu Lukniš, 1973) of the last glaciation which can be explained by decreasing resolution of the SH method with increasing age of tested surface. On the other hand, results of this paper may point to inaccuracy in Lukniš's (1973) findings about the Pleistocene glaciations of the High Tatras.

Keywords: moraines, Schmidt hammer test, High Tatras

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Geomorphologic and geophysical investigation in search for volcanoes

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Volcanoes are extremely important geological phenomena attracting attention of not only geoscientists, but a big part of common population as well. The reason is the beauty and interesting (morphological) features of (active) volcanoes, but first of all the threat and hazard they represent for the region and inhabitants.

Volcanoes are usually forming striking morphological shapes, mainly cones, calderas or lava flows. But what if not? Then we need some tools to recognize a volcanic structure hidden in the normal or not-typical topography. Geophysical techniques definitely play a significant role in volcanic investigations. As the most important we consider gravity and magnetic surveying. The reason is that these techniques can indicate, locate and delineate a hidden volcanic body that may have no clear morphological expression on surface. A volcanic body often exhibits anomalous petrophysical properties of the rocks (hard volcanic rock, breccia, tuff, tephra, etc.), like density, porosity, magnetic susceptibility, etc. that can be

recognized by geophysical measurements. This may happen during a specific volcano-oriented survey, but also during any other surveys performed in a volcanic region.

We identified a volcanic structure during the gravity mapping in the scale 1:25.000 where a single point with negative anomaly gave origin to a detailed survey discovering a small complex volcano. The structure was located in a negligible topographic depression, with no real indication from morphological shape (Mrlina et al., 1989). On contrary, volcanic craters in the Coastal Mts. in Syria are forming extreme inverse conical shapes with flat bottom in great size up to 3 km length and 300 m depth. However, only thanks to geophysical surveying it was possible to locate the volcanic chimneys (investigation targets) on the crater floor (Mrlina, 1993).

One extraordinary volcano has been recently found in West Bohemia. Based on observing an unusual topographic element – an almost circular depression (hardly to be seen in the field due to forest), and a follow-up gravity-magnetic scouting survey (Mrlina et al., 2007), we found a Quaternary maar near Cheb. The follow-up detailed geophysical survey enabled to position an exploratory well that confirmed the existence of a maar-diatreme volcanic structure (Mrlina et al., 2009).

Keywords: volcano, volcano topography, volcanic structure, geophysical indication, gravity anomaly, surface morphology.

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Response of an old river channel to the by-passing (the Váh River, Slovakia case study)

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The river channels represent dynamic components of the landscape and their morphological properties are the result of complex interaction of the landscape elements. The changes in the landscape are thus reflected also in the channel morphology that gradually or suddenly adjusts to the changed conditions. In most of well-developed countries, direct (e.g. damming, river training) or indirect anthropogenic impacts have become crucial. The

knowledge of the modified river system evolution is important for the restoration projects, since there is usually lack of reference data necessary to the natural state reconstruction (e.g. Hohensinner et al. 2008). The aim of this study is to analyse the response of an old river channel to the by-passing. The by-passing represents one of the most significant examples of anthropogenic river modification, when the stream is divided into two channels - an artificial canal and old natural channel - under a dam. The discharge and sediment load regimes in an old channel change consequently. The river response to the by-passing is usually connected with the channel narrowing and associated vegetation expansion (Arnaud et al. 2011). Many studies emphasise interactions between fluvial processes and riparian plants that sometimes play critical role in the re-establishment of equilibrium conditions of strongly modified river systems and may fix changed morphology (e.g. Hupp and Osterkamp 1996).

The Váh River is the longest river of Slovakia. It is 403 km long and almost half of its course has been by-passed in the second half of the 20th century. The drainage basin of the Váh River could be divided into several different segments (in sense Lehotský 2004) and in our study we would test the hypothesis that various geological and geomorphological conditions will cause different character of changes and processes of river response. Basic approach to evaluate these processes is based on analysis of series of aerial photographs from different time horizons and recognition of changes in the channel – floodplain planforms as well as riparian vegetation bodies. This research was supported by the Slovak Scientific Grant agency VEGA (Project N.2/0106/12).

Keywords: the Váh River, by-passed river, channel evolution, riparian vegetation

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Ice-wedge casts as the indicator of relict permafrost

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Ice-wedges are geomorphological phenomena closely connected with periglacial environment and also with occurrence of permafrost (Péwé, 1959). The fossil forms of them

are still visible like pseudomorphs on the area of the Czech Republic (Czudek, 2005). And they can be used as the indicators of paleoenvironmental conditions (Sekyra, 1960). Their presence is limited to the regions of the eolian sediments and mostly on the river terraces. Ice-wedge casts are on the surface visible like polygons, which are finally connected to the nets (French, 2008). By the good conditions (vegetation cover, clear sky and season) we can observe the polygons nets on the aerial photograph (Ghysels and Heyse, 2006).

We have detected occurrence of polygons net made by ice-wedge casts in the area near Kostomlaty pod Řípem. Using the basic statistical methods we found out, that there are about 394 polygons. The shapes are mostly pentagonal and their diameter is between 3-25m, width of frost crack is in the range 0.5 - 6 m. In comparison with other localities is possible to expect, that height of wedges in the Bohemian Cretaceous Basin is in range 0.45 – 5.37 m.

Field study showed in vertical profile two shapes in depth 0.4m, which have been probably made by frost cracking. Sedimentary material in the gap (inside the wedge casts) was visibly finer than gravel-sand outside material from fluvial sedimentation. Laboratory study detected mostly sandy sediment from transport in eolian environment. But there were differences between infill sediments from both shapes. Also the morphology was not the same, since one wedge have been deformed probably by degradation of permafrost.

Infill sediments have been dated by OLS method from both shapes. One wedge-cast seemed to be older (from 36.23 ± 3.67 ka to 46.53 ± 4.79 ka BP) than the other (from 30.09 ± 2.49 ka to 40.88 ± 4.11 ka) and upper parts of shapes were also younger. The question is relationship between both shapes and their development and filling. Conclusion is that the last continuous permafrost table was in the area of the Bohemian Cretaceous Basin before 28.41 – 44.99 ka years ago.

Keywords: ice-wedge casts, permafrost, periglacial environment, frost cracking, sediment analysis, Bohemian Cretaceous Basin

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Glacial history of James Ross Island since the Late Glacial

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During Pleistocene glacial times, the local James Ross Island Ice Cap (JRIIC), covering the James Ross Island (JRI) was connected with Antarctic Peninsula Ice Sheet (APIS) via individual ice streams, such as Northern Prince Gustav Ice Stream flowing from the Antarctic Peninsula to the continental shelf edge. The ice recession started after 18 ka BP from outer continental shelf in Erebus and Terror Gulf and by 12.9 ± 1.2 ¹⁰Be ka (from erratic boulders at the Cape Lachman neck, JRI) the ice sheet front receded to the inner continental shelf. This age corresponds also with the transition from grounded ice stream to floating ice shelf in the inner continental shelf of northern Prince Gustav Channel and the JRIIC thus became connected with the APIS by Prince Gustav Ice Shelf (PGIS). The extent of PGIS fluctuated during Holocene times and the marine record shows at least one break-up of PGIS in the mid-Holocene times. These changes correspond with changes of local land-terminating and tidewater glaciers. Some mid-Holocene advances of local glaciers have been documented on JRI. Whisky Glacier advanced ~7 km towards the Brandy Bay, which was probably not covered by PGIS at the time of its culmination at ~4.7 ka. The glacier receded shortly after that time leaving long boulder train with hyaloclastite breccia boulders up to 20 m large, in which many lakes evolved, some of them persisting till present (Monolith, Katja, Dan Lakes). The last glacier advance took place during the Little Ice Age (LIA), when prominent ridges of frontal and lateral moraines surrounding present glaciers developed. In spite of the unknown timing of LIA glacier advances, we can calculate their areal and volumetric changes since that time. Five small glaciers in the northern part of the Ulu Peninsula, JRI retreated by 75–120 m and experienced surface lowering of 9–23 m since the LIA. A substantial portion of this change occurred during the last three decades as a result of prominent air temperature warming around the northern AP. This is not only evidenced by PGIS break-up in 1995, but also by the comparison of Digital Elevation Models from 1979 and 2006, which reveal average surface lowering of 8.5 m and 10.1 m for Davies Dome and Whisky Glacier, respectively. Since 2006, the rate of surface elevation change of these glaciers remained in the same order. According to mass-balance measurements on the two glaciers, the elevation differences ranged from –0.4 to +1.1 m, with a mean annual lowering up to 0.3 m yr⁻¹. The position changes of mass-balance measurement sites suggest higher surface velocities on Whisky Glacier compared to the Davis Dome glacier.

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Keywords: glacial sediments and landforms, cosmic ray exposure dating, glacier changes, Late Glacial, Holocene, Antarctic Peninsula

Catastrophic long-runout landslides in Flysch Carpathians (Czech Republic/Slovakia): recent failures and Holocene perspective

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Long-runout landslides (mostly roto-translational landslides combined with earthflows and to the lesser extent rockslides and rock avalanches) present locally important geomorphic agents for the Late Quaternary evolution of medium-high mountains of the Flysch Carpathians (Czech Republic/Slovakia). Despite the fact that they are not typical mass movements for medium-high mountains, unfavorable structural settings presented by anisotropic flysch bedrock, deep weathering concentrated along structural discontinuities and progressive weakening of rocks by deep-seated gravitational slope deformations (DSGSDs) form some slopes especially susceptible for this type of landslides. Radiocarbon dating of organic matter incorporated into landslide debris or deposits directly connected with landslide bodies (landslide-dammed palaeolakes, peat bogs overlying landslides) suggest, that majority of studied instabilities collapsed several times throughout the Holocene. Preceding Holocene activity was recognized also for catastrophic landslides emerging during extreme hydrometeorological situations in the last decades (i.e. events recorded during July 1997, April 2006 and May 2010 events). This finding is important for evaluation of landslide hazards in the study area. The recurrent nature of slope instabilities is given either by retrogression of the upper parts of landslides due to the presence of unfavorable oriented (and weakened) structural inhomogenities or periodical collapse of material accumulated by previous landslides in the middle or lower parts of slopes. Although our chronological dataset is biased by limited occurrence of long-runout landslides in the study area and by erosion of older landforms, majority of dated reactivations can be correlated with regional phases of increased humidity stated previously by various palaeoenvironmental proxies. Dated forms emerged at the Younger Dryas/Holocene transition (12-9.5 cal ka BP), Atlantic chronozone (7-7.5 cal ka BP), at the beginning of Subboreal chronozone (ca 4.5 cal ka BP) and primarily within the Subatlantic chronozone in the interval 1-2 cal ka BP (35% of dated events).

Keywords: long-runout landslides; landslide recurrence; Holocene; Flysch Carpathians

Landscape evolution and tectonic geomorphology as a fundamental key for understanding the late Eocene to Recent crustal deformation along the western Eger Rift

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The Eger (Ohře) Rift is the most spectacular neotectonic structure in the northern part of the Bohemian Massif. Plio-/Pleistocene to recent uplift and differential block movements exceed several hundreds of meters with the consequence of sharp morphotectonic structures. Our investigations have focused on the neotectonically active Cheb Basin which is located in the western part of the Cenozoic rift. In this area the rift is cross-cut by the more than 150 km long and in its northern part seismically active Mariánské Lázně Fault (MLF). This fault forms a prominent escarpment separating the subsiding Cheb Basin from the uplifted part of the Eger Rift (including the Eger Graben) to the east.

On the base of mapping of the morphotectonic features from the DEM, satellite and aerial images, and in the field, the compilation of the morphostratigraphic and the sedimentary record, we were enabled to reconstruct the neotectonic evolution of the Cheb Basin and to conclude some important implications for the late Pliocene to Recent crustal deformation of the western part of the Eger Rift.

The Eger Rift subsided during the late Oligocene and early Miocene. Whilst the Eger Graben underwent mainly uplift and inversion since the mid-Miocene, subsidence of the Cheb Basin resumed during the late Pliocene development of the NNW-SSE striking Cheb-Domažlice Graben in response to intense activity along the MLF. During the Quaternary the Cheb and the Domažlice Graben were separated in conjunction with uplift of the southern shoulder of the Eger Rift. Ongoing tectonic activity along the MLF is manifested by earthquake swarms along its northern segment. The spectacular Plesna Fault which is accompanied by CO₂-emanation centers and an up to 20 m high scarp is interpreted as a splay fault branching off from the MLF in the main earthquake region in the Nový Kostel area.

The crustal-scale MLF separates in the western part of the Eger Rift basement units that are characterised by different styles of neotectonic response to the late Pliocene to Recent stress field. This is one of the main reasons why the large-scale topography of the Bavarian part of the Eger Rift including the Cheb Basin strongly differs from the “classical” region of the Eger Graben.

Documentary data in the research of geomorphologic risks in the Czech Republic: frameworks, constraints, examples

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Geomorphologic hazards and risks such as landslides, rockfalls, flood-related surface transformations and accelerated erosion represent significant disturbances to the landscape of the Czech Republic. Although the recent study of geomorphologic hazards and risk processes is mainly based on field and laboratory techniques (mapping, geophysics, dating, etc.) and on modelling approaches, several authors (mostly from abroad) have pointed out that the spatiotemporal variability in distribution of geomorphic hazards and risks and their impacts must also draw upon rigour study of documentary sources (e.g. Ibsen, BrunSDen 1996; Dominiguez Cuesta et al. 1999; Tropeano, Turconi 2004). Moreover, the use of these sources helps to study the social dimension of geomorphologic risks (social perception and representation), thus helping to optimize risk management. Drawing upon fundamental - yet 40 years old - work of Špůrek (1972), on current studies from abroad and on our own detailed historiographic and historical-geomorphologic analyses of several documentary sources, we set up the conceptual framework for the use of documentary data in the research of geomorphic hazards and risks in the Czech Republic in order to study their spatiotemporal distribution, impacts and social perception. Firstly, we introduce the problematic of geomorphologic hazards and risks and of the use of documentary data in an international context. After then, we describe the nature, spatiotemporal coverage and informational potential of documentary data sources in the Czech Republic for the period of Middle Ages to the mid-20th century. We divide these data into two basic groups: (a) stationary sources with larger spatial coverage (e.g. inventories at-one-go, maps, research reports), (b) continual sources with varying spatial coverage (e.g. administrative records, newspapers, chronicles). We assess the basic characteristics and availability of these types of documentary data. Finally, we present the concrete examples of documentary data sources of differing type in order to show their contribution to our understanding of past geomorphic hazards and risks and we also discuss the methodical constraints in the use of these data, including their availability, reliability, sensitivity and subjectivity.

Keywords: geomorphologic risks, documentary data, archives, Czech Republic

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Historical Jeroným Mine in the Slavkovský les Forest – geomorphological and geomechanical study of medieval mining working

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The national cultural heritage site Jeroným Mine is well-conserved abandoned historical underground working of medieval tin ore exploitation. The major mining period lasted from 16th to 17th century, afterwards the production gradually decreased (Beran et al. 1995). Its basic characteristics are cited. In connection with intention of making this locality accessible to wider public community (establishment of mining museum), extensive polytematic geoscience monitoring has taken place there at recent time (Žůrek et al. 2008), dominantly concentrating on evaluation of the object geomechanical stability from view both of natural influences and anthropogenic impacts related mainly to accessing activities. In the locality and its surroundings a geological, geomechanical, geophysical, seismic and geomorphological research has been executed. The contribution presents its some selected aspects and results concerning the monitoring of structural and stability conditions with determination of critical places (Kaláb et al. 2006), displays of anthropogenic transformation of surrounding relief (Kirchner, Roštínský 2011) and, marginally, also superficial geophysical sounding and seismic vibration analyses.

Keywords: Jeroným Mine at Čistá, geoscience monitoring, geomechanical stability, Slavkovský les Mts

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Project Esblygiad Cymru: a reinterpretation of the erosion and uplift history of Wales, United Kingdom.

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Project Esblygiad Cymru presents a reinterpretation of the erosion and uplift history of Wales, United Kingdom. The region is dominated by structurally complex lithologies spanning the Precambrian to Upper Palaeozoic. It has long been recognised that the landscape hereabouts is characterised by a number of conspicuous denudation surfaces that exist without regard to the underlying geological structure. The development of the regional landscape is usually explained by one of two opposing hypotheses. The traditional polycyclic hypothesis explains it in terms of pulsed eustatic uplift whilst the more recent morphostructural hypothesis explains it in terms of the differential uplift of adjacent blocks. There has been a marked tendency for the morphostructural proponents to reject the evidence previously forwarded by the polycyclic proponents. The impetus for the present project was provided by the advent of high resolution global DEMs. These enable the traditional geomorphological evidence to be rigorously reassessed within the conceptual framework offered by the morphostructural proponents of regional landscape development. In the first stage of the project, the traditional geomorphological evidence was completely reassessed. It was found that there was a surprisingly close correspondence between the results obtained by the earlier field-based studies and those obtained from the DEM. In the second stage, a database was constructed in order to rationalise all the relevant data obtained by allied disciplines. The database includes details of the regional crustal structure, the distribution of ongoing seismicity, and the results of thermochronological studies. It also includes details of the offshore sedimentary record and onshore deposits preserved by the mechanism of solution-subsidence. The latter provide a fundamental control with which to constrain the regional erosion and uplift history. These lines of evidence were then used to construct various maps within a GIS. In the third stage, the integrated evidence was used to reconstruct the regional erosion and uplift history. It is proposed that the highlands initially emerged during the Palaeocene as a result of the compressional stress induced by sea-floor spreading in the North Atlantic. It was at this time that the present distribution of land and sea became established. However, the existing mountainous landscape developed later as a result of plate reorganisation during the Miocene.

Keywords: uplift, erosion, denudation surfaces, landscape inheritance, Wales

Further reading:

ROWBERRY, M.D. 2011: A comparison of three terrain parameters that may be used to identify denudation surfaces within a GIS: a case study from Wales, United Kingdom. *Computers & Geosciences* (doi:10.1016/j.cageo.2011.09.016).

ROWBERRY, M.D., BREWER, P.A., MACKLIN, M.G. 2007: The number, form and origin of sub-horizontal surfaces in north Ceredigion, Wales U.K. *Norwegian Journal of Geology* 87: 207-222.

Research of lateral shift of gravel bed river channel by application of remote sensing and GIS

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The aim of this study is to evaluate the lateral shift and changes in channel planform of the selected bed gravel, less regulated and laterally partly-confined rivers in northeastern Slovakia flysch areas based on multitemporal analysis output of remote sensing between 1987, 2002 and 2009. Ondava River (from mouth to the dam Veľká Domaša to the city Stropkov, 13.2 km in length) and Topľa River (in the section from the city Giraltovce to Bardejov, 39.8 km in length) were studied. Individual changes of the selected rivers were studied in the GIS environment on the basis of the degree of sinuosity, lateral shift obtained from aerial photographs, orthophotographs and satellite images, bank erosion, and changes in the channel (gravel bars) and landscape structures. In this area, monitoring of the impact of extreme discharge events on the movement of riverbed and anthropogenic interference in the watercourse were investigated. The frequency of floods (every two years) over the past ten years had lead to increased erosion, thus the channel is unable to stabilize due to development of vegetation and by the connection of lateral or point bars to the bank. The lateral shift and areas of erosion showed a significant increase: during 1987-2002 period the area of 52.2 ha was eroded, whereas during the following period (2002-2009) of frequent and intensive floods up to 67.8 ha was eroded. Likewise, the maximum channel shift was 260 m and 443 m in 1987-2002 and in 2002-2009 respectively. One of the consequences of lateral shifting is the bank shot and erosion. The percentage of arable land erosion from the area of this type of landscape in riparian zone (20 meters buffer) ranges from 34 to 41 %. The total eroded mass of this type of landscape was 31.2 ha. The individual areas of accumulation created in the old channel after its moving are formed primarily by forests with a percentage ranged from 96.17 % to 99.5% of the total accumulation area during the periods of 1987 to 2002 and 2002 to 2009 years in both rivers. As a consequence in the riparian zone, a gradual increase in the proportion of forests and reduction of other types of landscapes structure, which are gradually eroded and replaced by floodplain forests, can be observed. The significant processes occurring are related to meandering, the movement of the river bends, straightening; it corresponds to the structure and changes in the distribution and size of the gravel bars. Movements of bars, their adaptation and changes are closely connected to the movement of the channel itself. Monitoring of both leads to a partial understanding of the behavior of the river and processes in geosystems with the possibility of predicting future developments. This research was supported by the Slovak Scientific Grant agency VEGA (Project N.2/0106/12).

Keywords: river channel, lateral shift, gravel bed river, Ondava River, Topľa River

Zemní proud v Lemešné

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Dne 2.6.2010 na jižním svahu Lemešné (950 m n.m.) u Velkých Karlovic, okres Vsetín, vznikl v důsledku intenzivních srážek dosahujících trojnásobku měsíčního průměru zemní proud. Významný vliv na vznik deformace měl i pramen Srní voda, jehož voda je propustkem svedena do postiženého svahu. Lokalita se nachází ve flyšových Karpatech charakteristických rytmickým zvrstvením a střídáním klastických sedimentů, převážně písčitých a jílovitých. Toto prostředí vykazuje velmi vhodné podmínky pro vznik a rozvoj svahových deformací. Zájmová oblast byla zmapována a podrobena terénnímu průzkumu. V okolí bylo identifikováno několik dalších starších svahových deformací, které na jižním svahu Lemešné dokazují značnou sesuvnou aktivitu. Pomocí odtokových linií byly zjišťovány dráhy soustředěného odtoku na svahu, které předurčují možnou dráhu pohybu dalších svahových deformací.

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Geomorphology of the Satina river valley (Lysá hora mountain group, Moravskoslezské Beskydy Mts)

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The abrupt change in valley floor development occurs throughout the Last Glacial – Interglacial cycle. The presented study is a part of wider research of the Holocene development of the Satina river incision in the Lysá hora mountain group. Detailed sedimentological analysis of a bank outcrop on the Satina river upper reach left bank reveals the presence of colluvial layers formed by debris flows with fluvial intercalations. The river channel is vertically cut into sediments of a relative depth of c. 19m and further into another 4m of the bedrock formed by thinly laminated claystones. We used grain-size, fabric, clast orientation and particle shape analyses in order to determine the genesis of the particular layers. 14 separate fluvial and colluvial layers of sediments have been distinguished in the vertical profile of the total depth of 22m. The method of electrical resistivity tomography has confirmed deep-seated disintegration of the Lukšinec ridge and the occurrence of several generations of rockslides and rather shallow debris slides on a slope above the studied site.

We consider accumulations of the landslides as a source area of a large volume of colluvial sediments in the Satina river catchment. The alternation of layers of different genesis indicates high dynamics of the relief development in the area. Particular debris flow events were separated by periods of prevailing fluvial processes. Due to lack of suitable material, no dating methods could be used. After extreme rainfalls in the summer of 1997, the landslide area saturated part was reactivated and a new debris slide was formed. In the 2010, autumn extreme rainfall event accelerated river incision and the river channel was cut another 0.7 to 1.2m into the thinly laminated claystone bedrock. The studied site is characterized by the geomorphological processes pattern change observed in the formation of a large accumulation in transport limited conditions of a colder period of the Pleistocene (forest-free area) and intensive vertical cutting in supply limited conditions of the Holocene.

Keywords: sedimentology, granulometry, valley development, ERT

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The research of geological structure of metamorphic rock mass using geophysical methods (Hrubý Jeseník)

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This paper presents the results of the two-dimensional (2D) electrical resistivity imaging and VES methods which were used to recognize geological structure of mountain massif. The studies included measurements of the depth of quartzite cover in upper parts of slope localized in the Hrubý Jeseník (Czech Republic) and also the sequence of particular geological layers in rock mass. The area belong to Medvědska Hornatina - part of Hrubý Jeseník and border with lower mountain ranges like: Zlatohorska Vrchovina from north along Černa Opava river, Nizký Jeseník from south and further with Opavska Pahornatina from east. Describing part of Sudetes is qualify to Silesian-Moravian structure, belongs to Eastern Sudetes Metamorphic unit. The Proterozoic and Lower Devonian rock complex is folded and

strongly metamorphosed with Proterozoic rocks of Desna Massif. Used geoelectrical methods (ERT, VES) allowed to recognize the variable geological structure and to get information about their depth and thickness of each strata. A conventional vertical electrical sounding (VES) survey was used for quantitative interpretation where the center point of the array remains fixed and the electrode spacing is increased for deeper penetration. Three soundings were carried out about the total length 180m using Terrameter SAS4000 with Multimac System. The electrical resistance tomography (ERT) technique was chosen to provide some redundancy to the VES data and to improve the quality of the apparent resistivity responses. Three ERT profiles were measured P.A.S.I. equipment using Wenner-Schlumberger and dipol-dipol configuration.

In the process of interpretation on the basis of collected resistivity values it was distinguish three-layered rock mass: weathered Devonian quartzite, phyllite and frequently metagranitoids – both fine-grained forms, biotite-plagioclase and laminating with coarse-grained forms locally metamorphosed. The recognition of rocks building Orlik Massif and the definition of the value of their resistances will help to recognition of geological rocks in the neighborhood.

Keywords: metamorphic rocks, electrical resistance tomography (ERT), VES, Hrubý Jeseník

Morphostructural analysis of the Hřibovská hornatina Mts.

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The contribution deals with morphostructure analysis of the Hřibovská hornatina Mts., a part of the Rychlebské hory Mts. Northeastern border of the studied area is formed by the mountain-front slope controlled by the Sudetic Marginal Fault, which is one of the most conspicuous tectonic structures in central Europe. This is the main reason why works were focused on the analyses of stream network parameters and spatial distribution of those selected landforms which could potentially indicate recent tectonic activity in the studied area. As a result, supposed courses of faults marked in morphology were suggested. Fault activity assessment was considered on changes in erosion intensity indicated in longitudinal and crosswise profiles of stream valleys. Based on the values of Stream-Length index the areas with recent tectonic activity were delimited. Results of the analysis will be presented.

Keywords: Morphostructural analysis, active tectonics, Sudetic Marginal Fault, Hřibovská hornatina Mts.

Recent tectonic activity influencing the slope deformation development: examples from the Bohemian Massif and the Western Carpathians

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Systematic 3-D long-term monitoring of displacement along faults in the Czech Republic has started since 2001. Several monitored sites are placed also inside the deep seated slope deformations in the Bohemian Massif (e.g. Šeptouchov Cave or Mužský Hill) as well as the Western Outer Carpathians (e.g. Kněhyně Cave, Cyrilka Cave).

Recent records from a series of caves instrumented with 3D crack gauges TM71 displayed similarities in development which occurred irrespective of the position of caves in the structure of Bohemian Massif. A conclusion was drawn that registered displacements are very likely connected with significant changes in the recent configuration of tectonic stress field. Periods of relative tectonic stability, as well as of increased tectonic activity were identified.

Results indicate interference of aseismic tectonic impulses into slope deformation processes in an extent more effective than anticipated before. It will be presented by above mentioned examples from Bohemian Massif and Western Outer Carpathians.

Keywords: Tectonic activity, slope deformation, Bohemian Massif, Western Outer Carpathians.

Flood sedimentation record in the Danube river's overbank alluvia in Slovakia

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Danube river fluvial system in Slovakia represents a complex, third degree anabranching (more than 65% of flood plain has a multiple channel pattern) gravel-bed river channel pattern system (Lehotský et. al. 2010, Szmańda, Luc 2010). In the overbank alluvia of the Danube river flood plain in Bratislava and between Čunovo and Gabčíkovo, on the Slovak-Hungary border, the condition of a flood flow since the Atlantic age has been recorded (Szmańda et. al 2011). The interpretation of the flood flow regime was reconstructed with the use of the method after Sly et. al. (1983). Furthermore, the sediment transport condition during the different flow regime was interpreted with the use of two methods: (1) the analysis of samples distribution on the CM diagram (Passega 1964) and (2) the analysis of a shape of a

grain size composition cumulative curve (Moss 1962, 1963 and Visher 1969). Based on results of these analyses the conclusions are:

- (1) 88% of overbank deposits were accumulated in a lower flow regime, 5% were accumulated in the upper flow regime and 7% were accumulated in the transitional flow regime,
- (2) 90% of sediments were deposited from the suspended load,
- (3) percentage and size of grains moving in a different type of transport were changed depending on the flow velocity,
- (4) during the lower flow regime, just before the deposition 72-99% of grains (sand and silt fractions) were transported in the saltation, 1-28% of grains (silt and clay fractions) were moved in a suspension or in an intermitted suspension and less than 1% of grains (gravel) - in traction,
- (5) during the upper flow regime 45-72% of grains (sand fraction) during deposition were moved in the saltation, 23-54% of grains (gravel and cobbles) - in traction and ca 1% of grains (silt and clay fractions) - in suspension.

Because during the deposition of the overbank deposits the saltation was a primary process of the grains' transport, so the accretion was not vertical but frontal and compatible with the flow direction on the flood plain.

Keywords: fluvial sediments, sediment analysis, lithodynamic and hydrodynamic interpretation, Danube river flood plain

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Current trends in the morpholineament extraction: Comparison of the automated and expert based methods

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One topic of the geomorphologic research is the morphostructural analysis. Investigation of the organisation and structure of the morphological (geomorphic) network is a part of this analysis. For this purpose, the basic elements of the network – the morpholineaments – must be delineated.

Spatial and temporal changes in the morphotectonic field [Minár, Sládek 2009] or coincidence of tectonic lines and morphological networks [Urbánek 2005] are examples of such researches.

Lineaments are often used in the applied geomorphology. [Nyborg et al. 2007] described the using of lineaments to explore groundwater flows for finding a safe repository of nuclear waste. The paper [Ramli et al. 2010] used both expert based lineaments and automatically mapped lineaments to prevent landslide hazards.

According to method used to identify lineament, several types of lineaments are distinguished (see [Minár, Sládek 2009]). This paper mainly concerns with morpholineaments which are derived from Digital Elevation Model (DEM).

The starting point for morpholineaments delineation is DEM. Thus it is very important to know all parameters of DEM which influence the result. Not only the cell size (the value of DEM's resolution) but also the accuracy in height is very important. Many of studies are concerned with assessment of DEM's accuracy [Svobodová 2008], [Wise 2007] and [Gallay et al. 2010]. According to the methodology described in these papers, the comparison of available DEM's and their impact to morpholineaments extraction is mentioned.

During two last decades several algorithms of automated lineament extraction were developed for different reasons with more or less success. They differ in the methods, the input data and the application field. The study [Ramli et al. 2009] brings a detail review of such methods with conclusion that algorithms for automatic extraction of lineaments are not ready yet to provide sufficient results.

This paper focused on current available algorithms for automated morpholineaments extraction. Three approaches are compared:

- [Abdullah 2010] which used PCI Geomatica software to extract lineaments using combination of shaded reliefs.
- [Zlatopolsky 2012] developed a program LESSA (Lineament Extraction and Stripe Statistical Analysis) which could compute lineaments from DEM.
- [Abarca 2006] described algorithms for processing DEM in order to extract lineaments.

The results of these approaches are compared with manually delineated morpholineaments. The different locations and scales are used with kind permission of authors [Minár et al. 2011] and [Sládek 2010] and Veronika Staškovanová.

The comparison shows the need for new algorithm which should be available to public.

Keywords: morpholineaments, digital elevation models, geotechnologies,

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Spatial and temporal reconstruction of slope movement on active landslide area with the use of dendrogeomorphological methods (case study Mazák, Moravskoslezské Beskydy)

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The most active landslide around Lysá Hora in Moravskoslezské Beskydy called Mazák was studied by spatial and temporal reconstruction of slope movement on active landslide area with the use of methods dendrogeomorphologic and dendrometric methods. In this area are dominant coniferous trees. The largest representation of types has *Picea abies* (86,6 %). From 176 most disturbed trees (all *P. abies*) from 1680 trees in landslide area was obtained 712 increment cores. 560 growth disturbances from cores was identified as caused by landslide activity. Reconstructed period of landslide movement covers interval 1912-2011. In this period was detected 9 years with certain landslide event (1929, 1940, 1949, 1960, 1972, 1980, 1985, 1997 and 2000) and 6 years with probable years (1933, 1945, 1955, 1958, 1977, 1996). From results of spatial reconstruction of tilted trees follows fact, that some trees are located along tectonic line.

Keywords: dendrogeomorphology, dendrochronology, landslides, landslide events, Moravskoslezské Beskydy Mts.

Tree-ring analysis in the reconstruction of slope instabilities associated with earthquakes and precipitation (the Crimean Mountains, Ukraine)

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The Crimean Mountains (Ukraine) represent a seismically active region that is abundant in various types of mass movements. Especially limestone escarpments rising above the Black Sea coast in the vicinity of Yalta town are affected by intensive rockfall, landslides and debris flow processes that often endanger infrastructure and human lives. One of these very active slopes is the area of ancient Taraktash rockslide characterized by active block-type movement (lateral spreading, toppling, incipient sliding), rockfall, ongoing sliding activity and debris flows. In our study we aim (i) to reconstruct more than a two-century-long tree-ring record of slope instabilities (mainly block-type movement, rockfall, landsliding and debris flows) within the Taraktash slope deformation and (ii) to correlate periods of enhanced slope activity with historical earthquakes and climatic data. In order to reconstruct the temporal frequency of distinct slope processes a tree-ring analysis was conducted using 738 increment cores from 255 individuals of *Pinus nigra* ssp. *pallasiana* (Crimean pine). The tree-ring record reveals very sensitive periods of increased activity of block-type movements, rockfall and sliding during major earthquakes in 1790, 1875, 1927 and 1986. Despite the fact that the studied slope processes are predominantly driven by seismic activity, their intensity

and duration is also dependent on climatic characteristics. This holds true especially for landslide activity and debris flows that occurred mainly in years characterized by high precipitation totals. The performed study shows great applicability of dendrogeomorphic techniques in the reconstruction of the chronology of slope processes driven by earthquakes.

Keywords: Crimean Mountains, Taraktash slope deformation, dendrogeomorphology, Crimean pine, earthquake, rockfall

Long-term denudation and faulting history of the Sudetic Marginal Fault constrained by multi-system thermochronology (Eastern Sudetes, Bohemian Massif)

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This work investigates both the post-orogenic exhumation history of the Rychlebské hory Mountain region in the Sudetes (NE Bohemian Massif) and the paleoactivity along the NW-SE striking Sudetic Marginal Fault (SMF). Three low-temperature thermochronometers [zircon (U-Th)/He (ZHe), apatite fission track (AFT) and apatite (U-Th)/He (AHe)] with ~200-40°C temperature range were applied to 14 samples of crystalline basement and post-orogenic Cretaceous sediments.

The new thermochronological data reveals Permian-Triassic ZHe ages found in the Rychlebské hory Mts. south of the SMF. These are interpreted to have recorded cooling of the basement related to exhumation and post-orogenic unroofing after the Variscan orogeny. The magnitude of post-Variscan erosion in the RH block is 7 km. In the Late Cretaceous at ~95-80 Ma, the Carboniferous-Permian basement blocks SW and NE of the SMF were buried to ~4-7 km and >6.5 km depths, respectively, by sediments of the Bohemian Cretaceous Basin System as it is evidenced by resetting of the AFT thermochronometer in the Turonian sandstone, full resetting of the AFT thermochronometer in all bedrock samples and the full resetting of the ZHe thermochronometer in bedrock samples NE of the SMF. This finding contradicts the traditional paleogeographic reconstructions that suggest exposure of large portions of the Sudetes as an “Eastern Sudetic Island” for most of the Mesozoic-Cenozoic period. During the burial by the Cretaceous sediments, the SMF acted as a normal fault as documented by offset ZHe ages across the fault. At 85-70 Ma, the basin was inverted, Cretaceous strata eroded and basement blocks were exhumed to the near-surface at a rate of ~300 m/Ma as evidenced by Late Cretaceous-Paleocene AFT ages of 80.6±5.0 to 50.0±3.7 Ma and thermal modelling results suggesting rapid cooling at that time. There is no appreciable difference in AFT and AHe ages across the fault suggesting that the SMF acted as a reverse fault during exhumation. In the Late Eocene-Oligocene, the basement was locally heated to <70°C by magmatic activity related to opening of the Eger rift system. Neogene or

younger thermal activity was not recorded in the thermochronological data, confirming that late Cenozoic uplift and erosion of the basement blocks was limited to less than ~1.5 kilometres in the study area. The new evolutionary model for the Sudetes presented here may also have implications for other seemingly controversial thermochronological datasets reported from other parts of the Bohemian Massif (Danišík et al. 2012).

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Late Quaternary activity within the Mariánské Lázně Fault zone as revealed by trenching survey; Cheb basin, Kopanina site

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The NNW-SSE trending Mariánské Lázně Fault (MLF) zone is one of the most striking geomorphologic features in the western part of the Bohemian Massif. The northern segment limits the Tertiary Cheb Basin, which is typical of present-day earthquake swarms and abundant occurrences of mantle-derived carbon-dioxide emanations (e.g. Horálek and Fischer, 2010).

The study locality is situated at the mountain front line of the Krušné hory Mts. controlled by the northern termination of the MLF, referred as the Eastern Marginal Fault of the Cheb Basin. The trenching site was chosen based on the geomorphologic analysis, which suggests that the fault trace occurs at the point where series of sub-parallel valleys become deeply incised into an apparently uplifted blocks and that it controls the most recent morphology of the marginal slope. The trench of 100 m length, azimuth of 62°, and varying depth of 1.5 to 2.5 m was placed at the site situated between Nový Kostel and Kopanina villages. It exposed a succession of sedimentary units, whose lithologies are briefly described downhill southwestwards as follows: in the very upper part of the trench fluvio-colluvial sandy deposits with cobbles fill the depression in clayey-sandy colluvial sediments, which cover completely disintegrated, chemically weathered mica-schists basement. Following inclined beds of probably Lower Clay and Sand Formation overlaying the basement consist of basal conglomerates with ferric cement, heterogenous units of poorly sorted sandy gravels with clayey silty matrix, and reworked gravelly sands with ferricretes. This formation is terminated by the fault striking at 162° towards the following Vildstein Formation, which is formed by diagonally stratified fine gravels and sands. These sediments are disturbed by minor sub-parallel 137°-142° striking normal faults with offsets of ca 10 cm. Further downhill, up to 45° tilted heterogeneous layers of overlying fine gravels and sands are cut by the sub-vertical fault with strike of 132°. This fault filled with white clay is accompanied by distinctive iron mineralization penetrating laterally. Very preliminary results of OSL dating suggest the age of the sediments cut by this fault as cca 260 ka. The following layers of clayey

sand to clay are downwarped and deformed by the youngest 134° striking fault, which separates them from deformed stratified coarse sands to the southwest. This youngest fault coincides with the slightly convex morphology of the fault scarp on the foot of the slope. The youngest sediments downwarped by this fault were dated by radiocarbon dating method as cca 4.8 ka BP and further current dating is expected to might show even younger age. In the lowest part of the trench clayey sand to clay is overlain by loamy gravelly colluvium.

Keywords: Mariánské Lázně Fault zone, Cheb basin, trenching, paleoseismology, Quaternary tectonics

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Goelectrical methods in study of active tectonics on example of the Mariánské Lázně Fault (Cheb Basin, Czech Republic)

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Presented contribution deals with application of goelectrical methods on the Mariánské Lázně Fault (MLF), which limits the Cheb Basin to the east. The MLF intersects the seismoactive zone of Nový Kostel of which present-day geodynamic activity is expressed by earthquake swarms and ubiquitous emanations of mantle-derived carbon-dioxide. Two groups of goelectrical methods were used: first group (DC direct current methods) – combined profiling (KP) and electrical resistivity tomography (ERT); and second group (EM electromagnetic methods) represented by dipole electromagnetic profiling (DEMP), method of very long frequencies (VLF/VDV), and, in particular, ground penetrating radar (GPR). Methods of DEMP, VLF and KP were employed for searching of the MLF trace in the area selected based on morphology and drainage network. Since the geophysical survey had not brought any clear evidence of the MLF faults, a trench of total length 97 metres and average depth 1.7 metres was situated accordingly to morphology. Nevertheless, trenching offered the evidence of several faults within the MLF zone. Further, the goelectric methods were applied in order to study geophysical expression of the logged geological structures exposed in the trench and their continuation laterally and to the depth. In order to extend the geological information we applied 3-D GPR survey and the 2-D multi-electrode DC system (ERT). For

3D-GPR survey we used the shielded 250 MHz antenna and rectangular grid 40 x 60 meters. The detailed ERT measurements were performed on two profiles of 100m length (one of them with extended length of 207m) with 1 m electrode spacing and Wenner-Schlumberger electrode array. The ERT measurements displayed a shallow high-resistivity body, which corresponds to the sandy and gravelly deposits documented in the trench, and which is clearly depicted by high amplitude reflections on 3-D GPR radargrams. Lower resistive substratum (<150 Ω m) in the ERT results, which is formed by the clay-rich colluvium and deep-weathered crystalline basement, corresponds with zones of attenuated GPR signal. The evidence of the faults is rather related to the altering lithology (depicted as changes in the resistivity distribution and alternating GPR reflections) than to direct geophysical expressions typical for fault zones (usually low resistive subvertical structures). The GPR time slices revealed a new fault and suggested its kinematics as well as it confirmed the faults strikes inferred from the trench. The combination of direct trenching and geophysical survey allowed us to extend our interpretation of the subsurface structures laterally and to the depth and to figure out some mechanisms related to the tectonics. Mere application of geophysics would have definitely not brought us enough information on tectonics or lithology of studied area. However, together with the information obtained by the trenching, geophysics proved as a useful tool for non-invasive survey of the wider area and also of the deeper geological structures.

Keywords: Mariánské Lázně Fault, geoelectrical methods, DC methods, EM methods, trenching

References:

FISCHER T., ŠTĚPANČÍKOVÁ P., KAROUSOVÁ M., TÁBOŘÍK P., FLECHSIG CH. (2012): Imaging the Mariánské Lázně Fault (Czech Republic) by 3-D ground-penetrating radar and electric resistivity tomography. *Studia Geophysica et Geodaetica*, (submitted).

The structure of relict sorted polygons related to environmental characteristics: a case study from Mt. Luční hora, the Krkonoše Mts.

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Sorted polygons are periglacial features typical of sorted clasts due to intense frost action which create more or less symmetrical forms on the earth surface (Washburn 1979). The origin of sorted polygons in the Krkonoše Mts. is presumed in the late Pleistocene (Traczyk et Migoń 2000, Sekyra et al. 2002) and they are suggested to be recently inactive (Křížek et al. 2010). Their occurrence is linked to the topmost localities with flat surfaces and intense wind action which causes low snow cover and allow deep freezing (Sekyra et al. 2002) and intense freeze-thaw cycles (Křížek 2007).

This paper deals with the influence of environmental characteristics on morphology and sorting degree of relict sorted polygons. Poorly sorted polygons indicate that the clast sizes are similar in the whole landform whereas well sorted polygons indicate that the clast

sizes are decreasing from the edges towards the centre of the polygon. The field research was carried out along a transect tracing the microclimatic extremity gradient represented by altitude (increasing deflation intensity and decreasing temperature with increasing altitude) on Mt. Luční hora in the eastern part of the Krkonoše Mts. Morphometrical characteristics (length of main and minor axis, height) and size distribution of clasts along main and minor axes of sorted polygons were measured. Sorting degree was evaluated by sorting index. Snow and soil temperature measurements were also conducted during the winter and freeze-thaw seasons, respectively.

With increasing altitude there is an increase in perfection of frost sorting (greater sorting degree) and relative height of sorted polygons. Smaller and more domed landforms were better sorted than those with opposite characteristics. Statistically significant changes of morphometrical characteristics and sorting degree of sorted polygons indicate high sensitivity of sorted polygons to increasing microclimatic extremity and it also suggests the presence of prevailing north-west winds in the Krkonoše Mts. at the time of sorted polygons formation as well as geomorphological evidence of Jeník's (1961) theory of anemo-orographic systems.

Keywords: morphometry, frost sorting, sorted polygons, the Krkonoše Mts.

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