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DIFFERENT RATE OF FROST ACTIONS ON RIVERBANKS IN THE CZARNY DUNAJEC AND ROPA BASINS

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Keywords: multigelation, frost processes, erosion, Czarny Dunajec basin, Ropa basin

Transformation of riverbanks is conditioned by three major factors: fluvial erosion, mass movements and subaerial processes. Within the last one of them frost actions are probably one of the most underestimated processes. It seems that their influence on the modifications of riverbanks is much greater than previously estimated and the effects of frost actions can in many places equal the effects of fluvial erosion.
To determine the amount of riverbanks erosion as the result of frost action study sites were located on banks with different internal structure. Two of them were on sandy-loam banks, ten – on banks built with fine gravels and loam, five – built with medium gravels, eight – with coarse gravels and three – with solid rock flysch. Studies were conducted from November to April at the turn of 2011/2012. Bank retreat was measured during multigelation periods by erosion pins. This method was used in many places around the world (Lawler, 1993; Saynor i in., 2003; Couper, Maddock, 2001). Forming processes and effects of frost actions on each of the above groups were varied. Banks built with sandy-loams and silty-loams eroded in the same rate in the entire height of their profile. Only the upper, edge part of banks, strongly linked by the roots of plants, eroded much slower. On the banks built with medium gravels erosion proceeded bidirectionally and selectively. The finest material eroded as first and it was accumulated as debris talus at bank toe. Then medium fragments lost stability. During their saltation down the slope they lead to weakning the intermolecular bonds in the lower parts of the banks. In a consequence the rate of erosion increased. Strongly bounded, by plant roots, the upper part of the banks led to the formation of turf cantilevers, which in the summer period usually collapsed. Erosion on the riverbanks built with flysch layers and medium gravels was similar. Shale layers were destroyed more rapidly. It's a consequence of stronger and more densely fractured of this material. Sandstone blocks fall off as a result of the lack of support by the underlying shales.

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GEODETIC MONITORING OF THE SLOPE DEFORMATION DOLNÍ ZÁLEZLY-DUBICKÝ KOPEC, ČESKÉ STŘEDOHOŘÍ MTS.

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Keywords: landslide monitoring, accuracy, photogrammetry, laser scanning, trigonometry

In conditions of the Bohemian Massive are the rates of slope deformations often very slow. If we want capture such a small change of position, we must carefuly analyze the situation in field and choose the appropriate method of measurement. For maximum accuracy, it is necessary to fully utilize the potential of equipment available to us. That is not easy to start without experiences and previous training, because there are many factors they have negative influence on quality of results. This is not only technique of measurement, but also techniques of stabilisation and data processing. This informations wee need to have before we start every field work.
This presentation shows the current state of research of the slope deformation Dolní Zálezly-Dubický hill. The site is used as a model site, where we now use several methods of geodetic monitoring. Here are now tested three different methods of geodetic measurements: trigonometric measurement, laser scanning and close-range digital photogrammetry. Every of theese methods has own specifications and apriory estimate accuracy of results is complicated especialy in case of measuremets in large trigonometric networks.
The main goal of this work is to show the real accuracy achievable using individual methods and specific equipment in concrete field conditions. Which factors have influence on accuracy of results, which can not be ignored and how to reduce their negative impact. These findings then be applied to other localities to increase the overall efficiency of fieldwork and subsequent processing of measured data.

MORPHOSTRUCTURAL ANALYSIS OF THE BODVA RIVER CATCHMENT

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Keywords: morphostructural analysis, morphostructures, morphological network, base-level maps, Bodva river catchment, Slovak karst

This work focuses on the selected partial methods of the morphostructural terrain analysis in the Geographical Information Systems (GIS) with their application on the Bodva river catchment (Eastern Slovakia) and its vicinity. The specifics of this study area were that it is partially formed by karst plateaus of the Slovak Karst.
Methods such as analysis of a valley network, a base-level maps (or isobase surfaces) and morphological (or in this case morphostructural) network were used. First, the valley network was derived from SRTM DEM (Jarvis et al. 2008) with resampled spatial resolution of 25 m using GRASS GIS tool proposed by Jasiewicz and Metz (2011). Next, the base-level maps were constructed according to the methodology described in Grohmann et al. (2011). Also, the morphological networks were identified from the current surface as well as from the base-level maps following the work by Minár and Sládek (2009). Obviously, it was necessary to take into account the correlation between the karst surface (mostly its geological structure) and its valley network. Thus, derivation of the valley network with regard to local geological conditions provided better outcomes and following changes in base-level maps.
The findings of the presented methods can be used as supporting arguments for better understanding of the morphostructures and morphostructural evolution of the study area. As a result, important morphostructures within the study area were identified, as well as some system was put into orientation of interpreted morphostructural networks and thereby determined dominant direction of the tectonic processes.
This work was supported by the Slovak Research and Development Agency under contract No. APVV-0625-11

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METHODS OF FORECASTING OF ACTIVIZATION AND THE DYNAMICS LANDSLIDES (ON THE PATTERN OF THE REPUBLIC OF ARMENIA)

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Landslides have been noticed on 2% of Armenia's 29,8 thousand square kilometres of land. Landslides take place on a total of 65,000 ha of land, of which 35,000 ha are active.
Armenia has been and remains a region of landslide activity. However, there also exist regional differences in Armenia concerning landslides. In the mid-altitude mountains of Armenia, and in the humid northeast and southern regions, landslides are especially common. There are also individual occurrences of landslides throughout Armenia.
The majority of landslides develop on the lower slopes of valleys. The majority of landslides are tied somehow or another with the above mentioned economic activities. The importance of predicting landslides and detecting groups of landslides, as well as developing defenses against them, is quite clear.
The use of modern geophysical technology and methods is necessary to receive a clearer picture of landslides. Regulated investigations will give s information concerning landslide progression and development. The following geophysical investigations were conducted in the northwest city of Dilijan. The landslide body is being studied on the southeast slopes of the Bazoom mountain range. The landslide body occupies an area of 4000 m^2, and the slope of the relief is 50 degrees. It is an active landslide. During a period of one year noticeable movement took place. The landslide currently threatens the "Dilijan" mineral water factory.
Complex and methodological geophysical electromagnetic investigations were conducted in order to follow the separation of the landslide body, and to correct the borders in the outline of the body. The selections of these methods are determined by the sharp differentials in the physical attributes (magnetic perception and specific electronic resistance) of the rocks in the region under investigation. The magnetic investigation was conducted under a regime of highly precise field work and the electric investigation using vertical electronic zond methodology (VEZ). VEZ methodology was used in order to determine the construction of the landslide body, and in the determination of the locative elements of the slide, directly upon the landslide body, as well as on points located outside of it. AB, the largest space, was 370 m, which is enough to chart the area of the slide. According to VEZ data five layers of different strengths and specific electronic resistance (ohms) were located in the geo-electric landslide profile. The first two layers are alluvial-proluvial sediments, the third layer (p_3=20 ohm.m) destroyed, water saturated tufa-brekcha, the fourth layer, root tufa-brekcha, and the fifth layer, 22 ohm.m water tight layers, or the specific electro-resistance of clay. The two layers with low electro-resistance can become the surface area of the slide for any landslide. The third layer, which is located at a depth of 4 meters from the surface, already shows that it is a surface feature of the slides, representing active landslide processes. The fifth layer is located at a depth of 21 meters. Its activation will affect a much larger area and cause much greater surface movement.
These geologic- geophysical, methods of landslide studying combined with satellite photos, as well as with landscape geomorphologic studies will allow stopping of undesired natural disasters in time, which is very actual in mountainous countries (in the Republic of Armenia) where slope processes are very active and dynamic.

DURABILITY OF THE FLOOD EFFECTS IN THE VALLEYS OF POGÓRZE SPISKO-GUBAŁOWSKIE FOOTHILLS (CENTRAL CARPHATIAN, POLAND)

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Key words: local downpour, Pogórze Spisko-Gubałowskie Foothils, mountain stream, flood

Short-duration and very heavy local downpours, cause sudden revival of processes in riverbeds and riverbanks of mountain streams. The geomorphic and economic effects of the flood caused by torrential rain in Carpathians are usually incomparably greater than during long-term activity of moderate swollen streams (Biały, Lach, 2010; Starkel, 2006).
Study area includes five streams flowing down from Magura Witowska ridge (900-1233 m a.s.l.) in Pogórze Spisko-Gubałowskie Foothills. The upper reaches of streams flow in 5-8 m deep gullies with steep slopes and narrow bottoms. Lower reaches of the streams flow through a plain terrace of the Czarny Dunajec river.
On June 28, 2009 high and intensive downpour appeared. Precipitation reached 140 mm (Długosz, 2011). Streams swelled rapidly, and their flows were more than 100 times higher than usual. Such large rise of water caused sudden and intense downcutting erosion. As a result knickpoints in the streams gradient and small plunge pools occurred. Bank erosion led to gravitational mass wasting of soil and rock from the slopes. Diluvial and colluvial deposits has been supplied abundantly to channels.
On a flat terraces of the Czarny Dunajec debris was deposited and extensive alluvial fans were formed. Deposition has proceeded beyond the old riverbed, on agricultural and built-up area. Flooding streams made new channels passing by obstacles (trees, fences, buildings). Chrobaków Potok Stream flooded six parecels. Foundations of farm buildings as well as road and channel infrastructure (culverts, bridges, canals) was destroyed. Approximately 8 -9 m^3 of debris sized up to 30 cm in diameter and up to 0.5 m thick was deposited. Before effects of the flash flood were removed, detailed documentation based on field study have been done.
After retreat of the flood a 4-year period of natural stabilization of changed channel and slope system occurred in upper reaches of streams. In lower reaches of the streams mud and debris fans have been leveled. At present area is used as meadows. New canals were marked, channels and culverts were built of stone and concrete.
In conclusion, the general rule, that the fastest and the greatest changes of relief are result of extreme events, is proved. In the period between two events long-term geomorphic processes stabilize new relief and landforms.

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AN ESTIMATION OF PRECIPITATION THRESHOLDS FOR SHALLOW LANDSLIDE INITIATION, OUTER WESTERN CARPATHIANS, CZECH REPUBLIC

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Keywords: Outer Western Carpathians, shallow landslides, total water content, threshold, snowmelt, snow water equivalent, antecedent precipitation, time-series analysis

We present an approach to the estimation of the total water content (TWC) needed for shallow landslide initiations. The methodology can be used in situations when only approximate data concerning the landslide date of occurrences exist. This was also the case for approximately 270 landslides which took place in the close vicinity of the Napajedla meteorological station in 1939 – 2010. We analyzed the time-series from this station, specifically precipitation, snow water equivalent (SWE), snow depth and the depth of new snow in order to compute TWC values.
The time series were, as a result of inhomogeneity, reconstructed on the basis of a correlation with 6 neighborhood stations. A model for SWE was computed and errors were estimated. Rainfall events with intensities >2 mm/hour were removed from the reconstructed time-series on precipitation, due to the fact that such intensities primarily cause overland flow and erosion (Starkel, 2002) and do not contribute to the TWC threshold.
7 landslide phases (1939, 1941, 1965, 1970, 1997, 2006 and 2010) were defined on the basis of the maximum number of individual landslides in a given event. A number of them were triggered solely by liquid precipitation (1939, 1965, 1997 and 2010), while the rest were, however, triggered by water from snowmelt or by a combination of both.
The total water content threshold was estimated in two steps. Firstly, for the 10-day period preceding the most probable date of landslide origins which had the best fit when compared to other time intervals. Secondly, for the month (March – July) or the "thawing season" in which the landslides took place.
The values of the TWC threshold for shallow landslides triggered by snowmelts are, as a consequence of a greater uncertainty in SWE computation, less accurate (they have wider confidence intervals) than those for landslides triggered solely by rainfall.

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A REVISION OF THE HISTORICAL CATALOGUE OF SLIDE PHENOMENA: PRELIMINARY RESULTS FROM AN ARCHIVE SOURCES SURVEY

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Keywords: Outer Western Carpathians, landslides, database, date of origin, archive

We surveyed the archive sources of selected municipalities in the Outer Western Carpathians to find records on landsliding prior to 1970. The results were subsequently compared with those published earlier in the Historical Catalogue of Slide Phenomena (Špůrek, 1972). The aim of this work was a revision of the Historical Catalogue. The results provide new data not only on dates of landside activities, but also on their locations, damage and recurrences. The information about the dates of landslide origins can be used in landslide hazard assessment or for rainfall threshold estimations.

The work began with verification of 59 landslides recorded for the respective municipalities in the Historical catalogue. This was followed by a study of additional sources including the chronicles of the villages and towns, archive written sources, daily newspapers, aerial photographs and the Internet. We also interviewed eyewitnesses in certain cases. The original set of landslides, where 2 erroneous records concerning the dates of the landslide activities were found, was supplemented by 167 newly recognized landslides.

The new set of 226 landslides was processed within GIS. It was possible to localize landslides precisely in certain cases. We therefore classified the events according to their spatial accuracy into three categories: accurate position (53 cases), approximate position (includes one or more spatial information: parcel number, part of the village, minor place-names; 65 cases) and the rough position within the village or town (including only information on the cadastral area).

An uncertainty still remains, however, as to the precise dates of the landslide origins. The exact day of occurrence was only identified for 47 events. The other 48 landslides include information on the month when the landsliding took place, 55 landslides were classified by the season of the year and the remaining 76 landslides only had information about the year of origin. Additional information included in the GIS database concerns damage due to landslides.

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SNOW-AVALANCHE HAZARD ANALYSIS IN THE KRKONOŠE MTS., CZECHIA

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Keywords: Krkonoše Mts., snow-avalanches, hazard, susceptibility, modelling

The Krkonoše Mts., with the highest peak at 1602 m, are the highest mountains in the Czech Republic. This middle-mountain range covers an area of 454 km^2 and includes 53 permanent avalanche paths. Despite its low altitude Krkonoše experience considerably high avalanche activity, even causing fatalities. Unfortunately, and so far, the local authorities do not have a professional tool for avalanche forecasting available. Within the framework of a project devoted to preparation of a tool for snow avalanche hazard forecasting an analysis of historical datasets was performed including weather and snow condition data covering more than 1100 avalanche events in the last 50 years.

HR-DEM from airborne LiDAR was used to get accurate slope and terrain characteristics, which were used for calculation of a release susceptibility map using ANN method. Afterwards and regional runout susceptibility was calculated employing Flow-R code (http://www.flow-r.org) and information from the regression analysis of avalanche runout length. This ”static“ information about avalanche hazard is then being coupled with snow distribution and stability models in order to assess the snow-avalanche hazard in near-real time. For the snow distribution modelling are being tested two models – Alpine 3D and newly developed spatial distributed HBV-ETH model.

It is planned that the forecasting system will be employed as a public avalanche alert system for the Krkonoše Mts. and consequently will be extended for the whole Czechia under the patronage of the Mountain Rescue Service, an organization responsible for the public snow-avalanche hazard forecasting. The system will use forecasted ALADIN weather data.

DEPENDENCES OF THE SPATIAL DISTRIBUTION OF CRYOGENIC LANDFORMS IN THE POHOŘSKÁ HORNATINA MTS. (NOVOHRADSKÉ HORY MTS.)

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Keywords: Pohořská hornatina Mts., cryogenic landforms, lithology, gradient of slope, orientation of slope, altitude

The geomorphological mapping with emphasis on cryogenic landforms were performed in the Pohořská hornatina Mts and the acquired positional data was further processed by statistical and cartographical methods. There were investigated dependences on distribution of cryogenic landforms on lithology, slope, orientation and altitude which were based on analysis processed in ArcGIS 9.1. Dependences of spatial distribution of cryogenic landforms are determined primarily by the index of distribution Wij = Xi / Yj, where Xi is the percentage representation of landforms in the appropriate category and Yj is the percentage ratio of this category in all studied area and secondly according to the sum (sum distribution) of the arithmetic mean and average deviation. (Křížek, Treml, Engel, 2007)
It was found that all rated cryogenic landforms are related to the presence of granite, in all cases is Wij> 1, but only tors and castle copies have above-normal occurrence on the granite. Above - normal occurrence on the granite weren´t proved in the case of frost riven cliffs and blockfields. It is caused by the occurrence of part of these landforms in places that are in the geological map marked as boulders sediments and which form closed polygons in places where is the granite.
Furthermore, the dependence of tors on the slopes with a inclination of 0-2 ° was found out. Wij is greater than 1 in this case, as well as greater than the arithmetic mean and as well as greater than the sum of the distribution. This dependence results primarily from the genesis of this landforms (French, 2007; Migon 2006; Summerfield, 1991).
In the case of slope orientation, the dependence of tors and above-normal occurence of castle copies on the plain places is evident, it is connected with genesis of these landforms (French, 2007 Migon 2006; Summerfield 1991). In the case of frost riven cliffs are obvious dependences mainly on the slopes of the warm exposure (W, S, SE), because these slopes show greater dynamics of cryogenic processes (Czudek, 1997; Czudek, 2005). That's the reason, why blockfields are also depending on the slopes of the warm exposure, especially on slopes with S and SW aspect.
Dependences and above – normal occurrences of destructive landforms (tors, frost riven cliffs, castle copies) at altitudes above 901 metres and of accumulation landforms (blockfields) at altitudes from 801 to 900 meters with relation to altitudes are consequent to genesis of landforms (French, 2007 Migon 2006; Summerfield 1991).

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KRUŠNÉ HORY MTS. AND PEATBOGS – ARCHIVES OF THE STUDY OF THE QUATERNARY NATURE

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Rašeliniště jsou historickými a palynologickými archivy, které jsou cenným materiálem pro rekonstrukci vývoje přírody. Krušné hory jsou po Šumavě druhou největší oblastí pokrytou těmito mokřady na území České republiky. Záznamy o vývoji přírody se uchovávají v průběhu času a lze v nich sledovat změny klimatu, historické změny vlivu člověka na ekosystémy, lze určit jejich rozsah a rychlost, případně i zdroje znečištění, proto jsou rašeliniště cenným zdrojem pro výzkum krajiny. Společně pylová analýza, radiokarbonové datování, datování pomocí olova ^{210}Pb, geochemické znečištění atmosféry a půd s archeologií umožňuje jejich detailní průzkum. Rašelinná jádra mohou být v případě správného použití také zdrojem cenných informací o činnosti člověka v průběhu historie. Mohou objasnit, doplnit či upřesnit údaje tam, kde chybí písemné doklady či archeologické nálezy, a přispět tak k novým poznatkům o naší historii. Průmyslová revoluce zahájila populační růst, industrializaci a vzrůstající vliv činnosti člověka na životní prostředí a na koloběh prvků na Zemi. Nejvýrazněji svou činností ovlivnil člověk právě cyklus olova. Zdroj vody, která je pro vznik a fungování rašeliniště nutná se může měnit i v průběhu jeho vývoje. Na začátku může být syceno podzemní vodou, časem průběžná akumulace rašeliny může narůst do bochníkovitého tvaru, kde nedochází ke kontaktu s podzemní vodou a rašeliniště je syceno srážkami, a tudíž není ovlivňováno charakterem podloží. Pylovou analýzu je možné použít ve všech případech, není závislá na koloběhu vody a jiných látek v rašeliništi, záleží pouze na uchování pylových zrn v sedimentech a jejich čistém odběru. K tvorbě rašeliny došlo v pozdním glaciálu a pokračovala přes celý holocén.
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STABILITY PROBLEMS AT THE TOE OF THE KRUŠNÉ HORY MTS.

Jan Burda

Key words: landslides, remediation, open-pit mining, Krušné Hory Mts., Most basin

In second half of the 20th century, the development of open-pit mining moved towards the toe of the Krušné Hory Mts. According to former studies, stability problems were expected both in crystalline rocks as well as in Tertiary sediments in the most risk area between villages of

Kundratice and Černice. Despite taken measures, these assumptions were confirmed and both mining companies and State authorities have to solve the issue of slope stabilization in this high risk zone during last decade. These redevelopment can´t be regarded as final although the total remediation sum reached up to 700 milion CZK.

TECTONIC EVOLUTION OF THE ČESKÉ STŘEDOHOŘÍ MTS. VOLCANIC COMPLEX

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The České středohoří Mts. (CS) represents an eroded Cenozoic volcanic range. It formed as a part of the Ohře/Eger Rift/Graben and its development reflects the evolution of this complicated structure of the Bohemian Massif, a part of the European Cenozoic Rift System. The pre-rift history of the region recorded many tectonic phases since the variscan orogeny, including a formation of Upper Paleozoic sedimentary basins in the area of the CS. The basal rocks of the CS Volcanic Complex flatly overlay Upper Cretaceous clastic to calcareous sediments of different age (Coniacian, Santonian) that were exposed to tectonic activity in the pre-volcanic or early volcanic period.
Cenozoic magmas of the CS are mostly primitive in their chemistry, very close to the magmas of the upper mantle. Only tectonic activity was able to allow the rapid magmatic ascent across the 30 km thick crust. The beginning of volcanic activity in the CS was related to onset of extensional tectonics during the Oligocene that formed shallow grabens and/or more sunken and water-filled areas. Basaltic magmas produced the lowest volcanic stratigraphical unit (Ústí Fm.) rocks with specific lithological content related to their formation commonly in water-saturated environments. Later, due to a possible change in the stress regime, the ascending magma was closed in the crust and magmatic evolution produced more explosive volcanism from a magmatic chamber. A large composite volcano formed in the central part of the recent volcanic range, considerably overlapping the recent extent of the CS Volcanic Complex (Děčín Fm.). The Dobrná and Štrbice Fms. represent another two episodes of tectonic remobilization that led to rapid ascent of mantle derived magmas, but their volumes were significantly less than that of the first event. This succession of events documents repeated changes of the stress regime inside the CS during the volcanic complex evolution. With regard to volcanic stratigraphy, regional faults can be viewed as as pre-, syn- and post-volcanic (Cajz and Valečka 2010).
The realistic idea of tectonic setting inside the volcanic rocks of the CS has grown from recognition of volcanostratigraphy, not a long time ago. Before, the area of the CS was believed to be nearly atectonic, or the tectonic structures detected in Cretaceous sediments were extrapolated into the Volcanic Complex. The present-day geological position of lithostratigraphical units (that are defined e.g. by changes in environment of volcanism, changes in volcanic style and chemistry of volcanics, etc.) allows us to understand the amplitude and sense of movement on faults, mainly in the vertical sense. Horizontal displacement is known as

well. The present image of the CS tectonic setting shows rhomboidal segments within this part of the rift structure (Cajz et al. 2004).

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PEDIMENTS AND CRYOPEDIMENTS OF THE MORAVIAN-SILESIAN CARPATHIANS (CZECH REPUBLIC)

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Keywords: Moravian-Silesian Carpathians, pediments, Pliocene erosion megaphase, cryopediments

Moravian-Silesian Carpathians are the westernmost member of the Western Carpathians in the southeastern part of the Czech Republic. Pediments and cryopediments in the Moravian-Silesian Carpathians are known already several tens of years. The GIS based geomorphological map „Geomorphological Conditions“ in the scale 1 : 500 000 published in the Landscape Atlas of the Czech Republic (Hrnčiarová, Mackovčin and Zvara, 2009) enabled for the first time to obtain quantitative data about the spatial distribution and territorial extent of these low-angled foot surfaces cut in flysch bedrock of the Moravian-Silesian Carpathians. Pediments have gradients less than 10^0, with most of them below 6^0. The problem is their genesis and age. The world geomorphological literature presents two main theories of origin of pediments i) pediments are regarded as a slope of transport, left by recession of the back slope, ii) pediments are formed by lateral planation by running water. Pediments in the Moravian-Silesian Carpathians developed mostly as a result of the Pliocene erosion megaphase. Pliocene erosion megaphase initiated by neotectonic movements and climatic changes individualized geomorphological units of different order (mountain ranges, basins, hills, monadnocks) and extensive low-angled foot surfaces. Apatite fission-track analysis has shown that the post-Panonian erosion reached approximately 2 km in the Moravian-Silesian Carpathians (Demek, Mackovčin, Slavík, 2011). Pediments of the Moravian-Silesian Carpathians are usually developed in two, presumably in three levels divided by a scarp. Preglacial (Lower Pleistocene) gravels were found on the pediments. The detailed geomorphological mapping has shown that the pediments were created both by backwearing of back-slopes and by lateral planation of the mountain streams.
Cryopediments (Wako, 1963) are low-angled foot Quaternary erosional surfaces developed by cryogenic processes in cold climates of the periglacial zone, mostly with presence of permafrost. Processes responsible for carving cryopediments were – frost creep, frost heaving, nivation, congelifluction (solifluction over the permafrost table), rill erosion, piping, dell formation (dells acted as main lines of material removal) and back-wearing of the back slope. Cryopediments are younger than the Lower or Middle Pleistocene river terraces. Important role played snow-drifts at

break of slopes that survived for the most of the summer. Melting of the snow-drift during the high summer supplied thaw-water necessary for the cryogenic processes on the cryopediment. Sapping of the back-scarp caused its back-wearing. Back-wearing of valley or marginal slopes was the main process of cryopediment formation. Cryopediments forms the lowest level of pediment system of the Moravian-Silesian Carpathians and in some cases are even buried by gravels of bahadas. Cryopediments are Quaternary landforms, not Pliocene pediments remodelled by cryogenic processes.

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ANTHROPOGENIC INFLUENCE OF THE FLOODPLAINS CAUSED BY THE GRAVEL EXTRACTION ON THE EXAMPLE OF SELECTED WATER STREAMS IN THE CZECH REPUBLIC

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Keywords: river network, floodplain, mining, gravel sand mining, Czech Republic

The floodplains have been influenced by many anthropogenic interventions in the past. The issue has been recently studied in the connection with flood risks (Langhammer et al., 2007, 2008; Ložek, 2003 or Lipský, 2007) or in relation with the changes of landscape structures in the period of the last 250 years (Demek, Havlíček, Mackovčin, Slavík, 2011 and Demek, Havlíček, Chrudina, Mackovčin, 2008). Specific issue about anthropogenic influence on floodplains is the extraction of gravel sands. During the extraction of large volumes of stone, changes happen to the hydrological regime. This is manifested in floods. They represent the risk of natural hazards for inhabited areas in the neighbourhood of the flooded areas and fundamentally affect fluvial processes (Collins, Dunne, 1990; Chang, 1988 or Kondolf, 1997). This paper focuses on the analysis of anthropogenic impacts on floodplains caused by the gravel extraction in selected river basins in the Czech Republic. The intensity of anthropogenic processes influencing the floodplains is documented on the examples of the rivers Dřevnice, Orlice and Morava in the geomorphological unit Mohelnická brázda. There is also comparison of the historical use of floodplains and their condition in the last 20 years.

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NEW METHOD FOR ASSESSING THE POTENTIAL HAZARDOUSNESS OF GLACIAL LAKES IN THE CORDILLERA BLANCA, PERU

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Keywords: GLOF, potential hazardousness, glacial lakes, Cordillera Blanca

This contribution presents a new and easily repeatable objective method for assessing the potential hazardousness of glacial lakes within the Peruvian region of Cordillera Blanca (excluding ice-dammed lakes, which do not reach significant volumes in this region). The presented method was designed to meet four basic principles, which we considered as being crucial. These are: (a) principle of regional focus; (b) principle of objectivity; (c) principle of repeatability; and (d) principle of multiple results. Potential hazardousness is assessed based on a combination of decision trees for clarity and numerical calculation for objectivity. A total of seventeen assessed characteristics are used, of which seven have yet to be used in this context before. Also, several ratios and calculations are defined for the first time. We assume that it is not relevant to represent the overall potential hazardousness of a particular lake by one result (number), thus the potential hazardousness is described in the presented method by five separate results (representing five different glacial lake outburst flood scenarios). These are potentials for: (a) dam overtopping resulting from a dynamic slope movement into the lake; (b) dam overtopping following the flood wave originating in a lake situated upstream; (c) dam failure

resulting from a dynamic slope movement into the lake; (d) dam failure following the flood wave originating in a lake situated upstream; and (e) dam failure following a heavy earthquake. All of these potentials theoretically range from 0 to 1. The presented method was verified on the basis of assessing the pre-flood conditions of seven lakes which have produced ten glacial lake outburst floods in the past and ten lakes which have not. A comparison of these results showed that the presented method successfully identifies the potentially hazardous lakes.

HISTORICAL AND RECENT HUMAN ACTIVITY IN THE CATCHMENT AREAS IN GORCE AND BIESZCZADY MTS.

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Key words: historical human impact, catchment area

The historical documentation shows that during the last 1000 years occurred at least two phases of an intensive deforestation of upper San river basin: mature - in initial period colonization agricultural (16th-17th centuries) and younger - related to the development the wood processing industry in the 19th-20th centuries. Deforestation in older phase were a more sustainable and cover mainly zone valleys, more favorable settlement and agricultural crops. The shortages forests at the upper limit forests were necessitated by agistment increasingly larger flocks cattle and sheep. Mass tree clipping in the beginning of 16th century caused deforestation and change composition of tree species.

In the second phase, particularly in the late 19th/20th century, increased the pressure in addition to the wooded area, since wood has become a raw material intensive processing (mills, coopery) and trade (exports by rail from Bieszczady). Then from areas have been so far poorly used area, and the available for forestry rail. After Second World War when Bieszczady were depopulated, we can observe secondary heritable there landscape. In present day excessive tree clipping is carried on for the acquisition of charcoal and also construction purpose.

Pastoral economy flourished in the Gorce mountains, was launched at the turn of the 14th and 15th century, with the arrival of Balkan origin population-of. The most important of their settlement is considered Ochotnica (Kurzeja 2006). Vlachs shepherds who ridges of the Carpathians mountain range from the Balkans region came in with flocks of sheep and goats in search of pasture, played an important role in settlement behavior (Bucała 2009). The economy flourished of livestock grazing in Ochotnica probably fell on the 16th and 17th centuries (Adamczyk 1996). Under the influence of demographic pressures, the population began to transform the meadows on the glades in the fields. This phenomenon has already occurred at the end of the 17th century, and the evolution of this passed the first clearings to settlements (Dobrowolski, 1936).

With the increase of population and enlarge the cultivated areas, forest areas constantly raised and at the beginning of the 20th century in Gorce mountains, at an altitude of about 800 m above sea level, in the valley of the Ochotnica reached 958 m above sea level. From 1787 over the next 100 years, the forest area in the village of Ochotnica decreased by 1/3 with over 1500 ha

(Chwistek 2006). A similar situation took place in the area of the massif of Pilsk (1557 m above sea level), where the scale of anthropogenic landscape transformations has reached the maximum at the turn of the 19th and 20th centuries (Łajczak 2005). At that time the border of agro-forest reached the highest position and in many areas was close to the pastoral halls on the slopes of the mountain range (Bucała 2009).

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HUMAN IMPACT IN THE CATCHMENT AREAS IN GORCE AND BIESZCZADY MTS.-COMPARATIVE STUDIES

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Key words: human impact, large wood debris, channel mapping, catchment area

The most destructive human activity on the GNP and Bieszczady Mts. is the road network. Their construction or redevelopment could undermine the existing balance of the slopes, undercutting or excessive load on the wall, which in turn leads to the formation of landslides. In the case of the undercutting of slopes and the formation of artificial slopes you can change the balance of water conditions (dehydration). In certain cases of maintenance or construction of roads can run undesirable erosion. Strengthening the banks of creeks, along which lead the way, as well as the

building of bridges can disrupt the natural processes of erosion and the accumulation of the river, and the acquisition of gravels to the surface can destroy the natural form of accumulation. Because of the road maintenance treatments it is impossible to completely eliminate should be used carefully and in consultation with the geologists and geomorphologists. A positive example of repair and maintenance of roads in the GNP treatments can be taken after the ravages of the flood in 1997. An important action to avoid the risks and conflict situations is constant control, and how to use, records of the changes and possibly quick removal. Pavement maintenance use only local material supplied with the least possible. Bringing material from areas outside the GNP may disrupt the natural image of the composition of the river gravels and, in the case of a research result in improper assessment of geological structure in the mountain range.
The primary threat is the desire to economic intervention and infrastructure changes in the GPN and its immediate vicinity. Little can be affected also included treatments and adopted in the plan. A second source of threat is developing tourism within the Park, and especially certain forms of recreation or sports, even about the extent of protected areas.
Improperly carried out downloading wood (even using horses) may damage the plating and the top layer of soil, and subsequently cause erosion. Branches after cleaning the stems should be completely removed from the supply pipes. Left in greater quantities in unnaturally stop excessive amounts of gravels. So that accumulation can cause filling the hallway and natural rock outcrops to a height of even a few meters away, and after the branch of the may flood period to be run and, in the form of violent runoff move down the hallway, creating places a smaller decline in heaps and cones, bombarding the trough, roads, changing trend and resulting in unnatural changes in the processes of erosion and the accumulation of the river. A lot so created accumulations and run out from the upper sections of the pipes during floods in 1997. Removing them in a partially restored the original balance, but where else was the cause of being buried under and the destruction of roads.

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See previous abstract.

THE ARTIFICIAL BOULDER STEPS AS A MODERN CONTROL WORKS STRUCTURE IN MOUNTAIN STREAMS

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Keywords: Moravskoslezské Beskydy Mts, mountain stream, step-pool, stream restoration

Torrent and gully control (currently regulated by ČSN 75 2106) in the Czech Republic landscape has influenced mountain streams since the 19th century. Mainly traditional control works are implemented, particularly staircase-like sequences of concrete check dams or bed sills. The main objective is to reduce the channel slope, inhibit erosion of the channel bed and banks and limit

sediment transport into the lower parts of the basin. Modern trends of control works abroad tend to conservation of natural channel morphology. In last two decades, sequences of artificial boulder steps alternating with pools are widely used in mountain streams restoration. Natural step and pool systems in mountain streams show high values of flow resistance reducing sediment transport and they does not affect the channel connectivity and stream ecology by contrast to artificial check-dams. Often regulated stepped-bed channels in the Moravskoslezské Beskydy Mts. are characterized by lower size of bed sediments fraction, high transport capacity and bed incision. The natural stream morphology is usually presented by disordered channel bed with frequently alternating channel units such as cascades, steps, pools and bedrock.
An experiment of manual rebuilding of the channel bed was performed in the Malá Ráztoka stream. The 40 m channel reach (channel slope 0.09 m/m) created by disorganized cascade and step units, was rebuilt to regularly alternating units of steps and pools. Designated dimensions of step high H (0.44 m) and step spacing L (4.1 m) were calculated according to suggestions of foreign studies and considering the local channel slope S: $1<H/L/S>2$ (Abrahamas et. al. 1995; Lenzi, 2002). Only boulders available in the channel or deposited along the banks were used for the steps construction. The key stones in boulder steps exceed 0.4 m and this corresponds to stability for the flood event $>Q_{20}$ (Galia and Hradecký 2012). The rebuilt reach will be subjected to a detailed long-term monitoring focusing on effects of flood flows on sediment transport and changes in channel geometry (step and pool geometry). Construction of several other sections and starting their monitoring is planned for spring 2014.

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MORPHOLOGICAL PATTERNS AND LONGITUDINAL CONNECTIVITY IN BESKYDIAN HEADWATER CHANNELS

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Keywords: Moravskoslezské Beskydy Mts, mountain stream, bedload transport, bed sediments, hillslope-channel coupling

Mountain headwater streams are the interface between hillslope and fluvial processes and the suppliers of water and sediment to downstream fluvial networks (Kavage-Adams, Spotila 2005). Our contribution summarizes investigations in small flysch-based mountain streams of

Moravskoslezské Beskydy Mts. Continuity in channel-reach morphologies were assessed in longitudinal stream profiles with respect to intensity of bedload transport and thus, (dis)equilibrium between potential sediment supply and transport capacity during flood events. Parameters of observed channel-reach morphologies were statistically evaluated by PCA analysis to obtain leading predispositing factors. Bedload transport was evaluated by simulations in 1D transport model TOMSED and by observations of marked particle movement (Galia – Hradecký 2012). Moreover, measurements of largest boulders occurred in channels gave information about competence of stream power during flood events to transport this coarsest fraction.
There was evident that streams under low sediment-supply or high transport capacity were prone to occurrence of bedrock, bedrock-cascade and also step-pool morphology on the lower gradients. On the other hand, cascades and step-rapids without well-developed step-pool morphology were rather typical for high sediment-supply conditions. Differences in sizes of coarsest sediment fraction were assessed in longitudinal profiles under past debris-flow events and under prevailing fluvial processes. Occurrence of past debris-flows indicated much higher sizes of largest boulders related to transport potential of these colluvial events. Longitudinal profiles without debris-flow evidence in some cases indicated changes in boulder size trends with respect to fluvial processes, especially to erosion (coarsening) and deposition (fining). Nevertheless, this fact was not evident in all investigated stream profiles. In addition, role of stream power during bankfull flows was not important at all, when we did not observed any dependence between computed stream power and size of largest boulders. Some dependence was observed for fluvially dominated channels when higher magnitude discharges (e.g., Q_{20}) were considered.

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VERTICAL CHANGES OF THE VISTULA CHANNEL IN THE FORELAND OF THE CARPATIAN MOUNTAINS DUE TO RIVER REGULATION (1840-2012)

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Key words: Vistula, channel regulation, fluvial processes, floods

The regulation of the Vistula in the Carpathian foreland had been started in the first half of the 19th century and then continued with varying intensity in 20th century. It consisted of straightening the river channel with ditches cutting off meanders, its narrowing by means of stone

spurs and protecting the edges with stone bands. There were also built flood embankments, water dams and barrages, as well as lateral canals. As a result of those works, the channel that was meandering, braided and sinusoidal in character has undergone shortening, narrowing and deepening.

The increase of the channel's inclination stimulated its deepening which covered almost entire course. Only in the short section of the river in the Oświęcimska Basin and in other section of the river between Zawichost and Puławy, the channel does not deepen itself, and even undergoes shallowing. The next element of vertical changes of the Vistula channel is increasing height of the river banks. This is not only the result of the channel's deepening, but also the increase in thickness of the alluvia in the area of the channel with spurs and floodplain area limited with flood embankments. The average thickness of the alluvial sediments deposited there has been estimated at 2 m. Generally, the height of the Vistula banks in the Carpathian foreland has increased as a result of the channel's deepening and extension of its banks on average by 3,5 m and even more than 4 m in shorter sections.

The hydrological effects of the vertical changes in the channel of the analyzed Vistula section are large differences in duration of overbankfull water stages along the longitudinal profile of the river. On average, the sections within the aggrading channel remain underwater per annum even several times longer than the sections within the most deepened channel, what means that the greatest risk of flooding occurs directly upstream the Vistula gorge through the Polish Highlands (surroundings of Sandomierz), and especially in that gorge. The direct evidence for that was the Vistula Valley long-term flood of May 2010 nearby Sandomierz and in the Chodelska Basin.

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SUDETIC MARGINAL FAULT KINEMATICS BASED ON 3D INTERPRETATION OF RESISTIVITY SURVEY AND PALEOSEISMIC TRENCHING (BÍLÁ VODA SITE)

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Keywords: ERT profiling, 3D ERT, Voxler, fault kinematics, trenching, Sudetic Marginal Fault

Sudetic Marginal Fault is one of the most prominent tectonic structures, limiting Bohemian Massif on the NE. This fault can be traced both in the morphology and in geological structures and spans more than 140 km from Hrubý Jeseník Mts. towards NW.
Recently, an extensive systematic research has been launched, aiming particularly to understanding the faulting history with possible implications to the potential future hazard. The fault and its vicinity was studied directly by trenching, however, it was impossible to cover area large enough to track the position of different geological units, forming the surroundings of the fault.
The ERT was used to extrapolate the knowledge on lithology distribution around the trenching site, covering approximately area 600 x 300 m. Altogether, 25 ERT profiles using Wenner-Schlumberger array were measured in an irregular network, with the highest density around the trenching site. The measured profiles were inverted using Res2DInv64 software by Geotomo.
The 3D compilation of more than 30 000 measured resistivity points, forming one of the largest ERT datasets in such a small area, was processed in Voxler 2, using a 3D interpolation algorithm. As a result, an interactive blockdiagram of resistivity distribution was created and visualised, showing the 3D distribution of lithological units around the fault. The two main units, weathered crystalline rocks and Miocene clays have suitably very different resistivity (200-800 Ωm vs. 10-80 Ωm). Another unit important for interpretation consisted of rather high-resistivity (>1500 Ωm) alluvial deposits, covering the bedrock under thin layer of soil.
Due to that significant resistivity response difference, it was possible to trace the fault within the modelled block. Furthermore, the fault-cut and displaced alluvial deposits allowed, together with absolute dating and the results of the trenching, to reconstruct the offset amount and slip rate of the late Pleistocene/Holocene faultings.

THE OLD CLAY PITS AND THEIR CURRENT USE (HODONÍN DISTRICT)

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Key words: clay pits, Hodonín district, topographic maps, current use

Approximately 60 clay pits have been identified in the Hodonín district, based on the research of topographical maps from 1836-1991. In the second half of 19th century, clay pits and smaller brickyards were found in the vicinity of nearly every village of the region. Smaller brickyards gradually perished due to concentration of brick making into two largest facilities in Hodonín and Bzenec-Přívoz. Decline of former use of these anthropogenic forms was pronounced namely in the second half of 20th century. Present use of old clay pits varies greatly. Some localities became parts of protected areas thanks to their geological profiles and specific natural conditions. Some localities were incorporated into residential areas or areas with wine cellars, typical for the region. Some localities started to serve as dump wastes. In rare cases, the clay pit serves as a recreational area. Some old clay pits represent mine brownfields and are still to be reused. Some old clay pits have not been preserved since their original forms were completely transformed by e.g. agricultural modifications (e.g. creation of agrarian terraces).

LANDFORM EVOLUTION - KEY TO THE KNOWLEDGE OF PALAEOENVIRONMENTAL CONDITIONS (TALES FROM THE OUTER WESTERN CARPATHIANS)

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Keywords: landform evolution, landslides, floodplains, palaeoenvironmental record, Outer Western Carpathians

Landform evolution represents an inseparable part of landscape evolution. Georelief is a very sensitive part of landscape and reflects changes in landscape variables. Presented paper summarizes some feedbacks between landform occurrence in the landscape and changes of other landscape components during the Quaternary history of Outer Western Carpathians. (I) Case study of mountain floodplain evolution: We present here a detailed study of the sedimentary archive within a landslide-controlled impounded floodplain (Smrdutá site, Czech Flysch Carpathians) using geochronological (^{14}C and ^{137}Cs), sedimentological and pollen evidence. A sedimentary sequence deposited above the landslide dam points to three highly discontinuous and instantaneous depositional events dated to 4.6 and 2.0 cal. ka BP, whereas the last cycle started approximately in the 17–18th centuries and has continued to recent times. (II) Case study of

mountain ridge disruption: One of famous examples of spreading of a mountain ride is located on the elevation of Čertův Mlýn Mt. in the highest part of the Moravskoslezské Beskydy Mts. Besides typical displays of double ridges, crevice-type caves, counter-scarp slopes and shallow landslides there are huge tectono-gravitational block deformations. Some manifestations of gravitational spreading were dated to the period of quite young Holocene (Subboreal-Subatlantic). (III) Case study of landslide reactivations: Complex flow-like landslides (CFLLs) are important geomorphic agents of Late Quaternary mountain evolution in the Flysch Belt of the Outer Western Carpathians. Radiocarbon dating of organic matter incorporated into landslide debris or related deposits suggests that most of the CFLLs collapsed repeatedly throughout the Holocene.

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COMPARISON OF THE CHARACTERISTICS OF THE PLEISTOCENE LOAMS AND LOAMS OCCURRING ON NEOGENE SEDIMENT IN THE ORAVA BASIN (WESTERN CARPHATIANS)

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Keywords: loams, Orava Basin, Neogene sediments

In the intra-montane Orava Basin loams are common deposits forming a cover on glaciofluvial fans and terraces of the Czarny Dunajec River (Pleistocene cover) and on outcrops of Neogene bedrock of the Orava Basin. Loams overlying Neogene claystone represent freshwater sediment (e.g. L. Watycha, 1976) however, no detailed analysis has been performed to determine the origin of the loams on the fans and terraces. This study compares the characteristics of the Pleistocene loams and loams occurring on Neogene sediment outcrops to determine their possible origin. The differences in loam composition were determined by comparison of grain-size distribution parameters according to Folk and Ward (1957): mean grain size, skewness, kurtosis and standard deviation. The field study indicated that the thickness of the Pleistocene loams within the basin is

non-uniform. The boundary between underlying gravels and the Pleistocene loams is very clear but it is not erosive in character. Single pebbles occurring occasionally within the Pleistocene loams possibly come from the gravelly surface below (e.g.bed armouring). On the Czarny Dunajec and Orava terraces they exhibit some stratification and layers of material differing in grain-size can be distinguished. Detailed analysis of silty-mud Neogene deposits showed they are characterized by high homogeneity of the grain size composition and a narrow spectrum of mineral composition (Wiewióra A., Wyrwicki R., 1980). In the north-western part of basin (Lipnica Wielka and Chyżne) deposits of this type are dominant in the Neogene series. In the south – eastern part of the Orava Basin silty-mud sediments are divided with layers of gravelly material. Outcrops of Neogene sediment are covered by weathered loams, which are macroscopically similar to the Pleistocene loams occurring on the terraces of the Czarny Dunajec glacifluvial fans. Loams from glacifluvial fans differ considerably when they are analyzed with laboratory methods. Grain-size analysis indicated that the deposits are composed mainly of fine clay material, and the deposit is polimodal and poorly sorted. Mean grain size varies from 4,5 phi to 6,3 phi. Mineral composition of the Pleistocene loams indicates they are derived from the rocks of the Tatra massif. Variability of vertical profile and lateral sedimentary structures, petrographic composition and the thickness of the study loams indicates changes in local environmental conditions during loam deposition. The features of the Pleistocene loams reflect their complex origin: fluvial (normal sequence of the grain size, loams covering the surface of glacifluvial - alluvial fans), weathering (unclear boundary between underlying gravels and overlying weathered material, similarity of the mineral composition of bedrock and loams), aeolian (homogenic, very fine material). Without detailed field (analysis of the outcrops, drills) and laboratory studies differentiation of the Pleistocene loamy fan covers from the weathered Neogene clay covers is difficult.

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NATURAL TRANSFORMATION OF FORMS AND QUATERNARY SEDIMENTS IN THE WESTERN TATRA MOUNTAINS AND THEIR FORELAND

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Keywords: slope roads, riverbank erosion, multigelation, loam fracturing, Tatra massif

Today's mountain relief is a complex of forms formed by natural processes operating with different intensity over a long period of time. Only the youngest elements of landscape show

connection with human activity and the anthropogenic landforms are of minor importance in the overall shape of the mountains. At present, the Tatra Mountains and their northern foreland (Podhale) are the most intensely shaped by fluvial and slope processes. High activity of those processes is enhanced by periodic occurrence of heavy rainfall and oscillations of water- and ground temperature around 0˚C. With locally thick debris- and silty slope covers and high slope gradients, conducive to rapid runoff, several landforms are subject to significant modification. Within the Tatra Mountains, some slope roads used in the past as access roads to ore mines, are rapidly disappearing. The exploitation of the roads ceased around 150-200 years ago and are currently overgrown with trees (in the forest zone) or dwarf pine (above timberline). In some locations on the forested slopes (e.g. on Kopa Magury, 1704 m asl, Western Tatra Mts.) their only remains are narrow gullies or a slope flattening with a less dense forest. In several sections of these roads, the artificial gullies became incised or covered with gravelly-silty material delivered by streams running across the roads. In the subalpine zone, traces of the old roads can only be found among a dense system of dwarf-pine branches covering slope surface. On the rocky slopes of Magura (Skupniów Upłaz) the course of the old roads is invisible as they became covered by debris and rock rubble.

In the Tatra foreland, especially fast transformation concerns river channels. River beds are subject to erosion, and banks retreat due to undercutting by floodwaters. During winters, unvegetated banks are also eroded due to the activity of frost processes. On the banks of locally exposed banks of the Czarny Dunajec River and its tributaries in the Orava Basin, repeated multigelation in only one half-year of 2011/2012 caused bank retreat of 3.5-12.5 m that is 100 m² of bank surface. Particularly intense retreat was recorded on banks built of fine and silty alluvium (Augustowski K., Chmielowska D., i.in., 2012). Quaternary sediments and landform transformation in this region also occurs as a result of active endogenic processes. For example, the 1995, 2004 and 2007 earthquakes in the Orava Basin caused fracturing of the loamy deposits in the area of Domanski Wierch. The cracks and fissures, with significant and multi-directional dip, enlarge with depth from the surface, intersect or connect. Their strike is within two range groups (30-55° and 150-175°) indicating the direction of stress. The cracks enable penetration of water into the ground and increase weathering rates. In the vicinity of Chyżne, fine weathered material on the Pleistocene alluvial fans was locally eroded exposing Neogene sediments of the Orava Basin. The examples of natural transformation of young landforms and sediments presented above confirm the common pattern of continuous relief evolution.

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TOWARDS THE FLOODPLAIN AND RIVER LANDSCAPE DEFINITION

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Keywords: floodplain delineation, river landscape, small watercourse, water management

The flat areas lining the hydrographic network of landscape typically represent very attractive sites for realization of human activities. Study of the fundamental landscape functions providing to human society constitutes already significantly developed topic, addressed by a number of domestic authors (e.g. Květ 1997 or Ložek 2011). Developing knowledge about the potential of the landscape along watercourses is directly related to the temporal evolution of landscape ecosystems and particularly their spatial delimitation.
The traditional and probably the most frequent approach is to determine the extent of an area on the basis of geomorphological characteristics (Demek 1988) as well as soil parameters which are however partly dependent on geomorphological and geological variables. Quite usually there are also other approaches – for example delimitation based on the flooding boundaries (hydrological approach, e.g. Hugett 2003) or on the basis of geobotanical and landscape-ecological indicators. All of these methods are targeted to definition of the "floodplain", which is partly reflected to the legislation concerning the nature and landscape protection (recently such as MŽP 2007). Within the issues discussed is increasingly occurring the term "river landscape" (Štěrba et al. 2008), which almost identical area defined from a different point of view, partially using the approaches outlined above.
The aim of this contribution is to show the existing approaches to definition of this landscape phenomenon and using appropriate analytical tools to evaluate the potential of each method. An important parameter is their usefulness for application of the legal standards in practice, and also their overall effectiveness with regard to the principles of sustainable development in the field of water and floodplain management. Applying the acquired knowledge can be seen also in the proposals and implementation of natural flood control measures on watercourses, in order to reduce the risk of flooding. The contribution points out the differences between various approaches to the delimitation of floodplain, resp. river landscape, reflected particularly in an environment of the small streams where the correct interpretation is often conditioned by the detailed field survey.

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DIRECTIONS OF VALLEY AXES IN RELATIONSHIP TO GEOLOGICAL STRUCTURE-ELEMENT ORIENTATION IN THE STŘÍBRNÉ HORY AREA IN THE BOHEMIAN-MORAVIAN HIGHLANDS (CZECH REPUBLIC)

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Keywords: Bohemian-Moravian Uplands, Stříbrné Hory, tectonics, foliations, joints, valleys

The goal of this paper is an evaluation of the directions of valley axes in a relationship to the geological structures (foliations and joints) in the area of the village Stříbrné Hory in the Bohemian-Moravian Uplands. The structures and the lithology control a degree of the fragmentation of the landscape, final type and density of valley net. They shape distribution of slopes, width of valley, power of stream and accessibility of material for supplying to flow (Fryirs and Fryirs 2005). The researched area is predominantly formed by migmatitised sillimanite-biotite paragneisses. Tectonic phenomenon is deep-seated fault near Přibyslav of the N–S direction and crossing faults (Štěpánek et al. 2008).
The database of the azimuth and the dip of foliations and joints were taken from the report of detailed geological mapping by Lukášová (1961). The data were evaluated in the program Spheristat. The tectonograms were constructed on equal area (Schmidt net) on the lower hemisphere using axial data type. The foliations are predominantly oriented in the direction NNE−SSW to NE−SW dipped 75° to ESE−SE. The joints are directed into three trends: NW−SE dipped 25° to the SE, WSW−ENE dipped 75° to the NNW and NNE–SSW dipped 70° to WNW. All foliations and joints, especially also steep joints, were sorted by the frequency of the azimuth and the strike in rose diagrams constructed in Excel.
Valley axes were constructed on a scale 1:25.000 with the interval of contour line 5 m. All valley axes were determined by the azimuth and the length in the program Autocad. Valley axes were classified by total length in decimal intervals 0–359° according to the azimuth and the directions. Valley axes are mostly directed in the NW−SE, W−E and SSW−NNE and dipped to the SE, SSW and W.
As foliations and joints as valley axes were consequently anaylsed by a construction of rose diagrams. Similar trends were visually investigated on a base of the comparison of peaks in the charts. The trends of geological structures are in a correspondency with the directions of valley axes in the NNE–SSW, SE, E–W, NW and WNW. The directions of valleys coincide with the system of the foliations and steep joints.

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VECTOR ANALYSIS OF VALLEY AXES IN CONCORDANCE TO GEOLOGICAL STRUCTURES

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Keywords: Bohemian-Moravian Uplands, valley axes, vector, foliations, joints, azimuth, dip

The paper describes the methodology of evaluating geological structures by the vector analysis of valley axes. Both geological structures and valley axes were determined by the azimuth and the dip which corresponds with the angle of the slope. The determination of the dip of valley axes has formed a base for the quantitative classification of valley axes analogous to geological structures. The following five types of valley axes were distinguished: sub-horizontal, gently inclined, moderately inclined, steeply inclined and sub-vertical.
The model area was chosen in the Cihlářský Brook catchment area near the town Havličkův Brod in the Bohemian-Moravian Uplands in the central Czech Republic. The landscape is characterized by hilly land to upland with planation surfaces in water-sheds and mostly gently inclined slopes. The researched area is predominantly formed by Paleozoic paragneisses, amphibolites and Holocene fluvial and deluvial deposits.
The orientations by the azimuth and the dip of both the valley axes and the geological structures were evaluated by the construction of outline diagrams in the programme Spheristat usually being used for analyses of geological structures or another structural research (eg Barbosa & Lagoeiro, 2012; Benito-Calvo et al., 2011).
The outline diagram shows a maximum of orientations of points oriented in the strike NE–SW about the dip 1–3° to SE or NW. The outline diagram of foliations is characterized by the maximum in the strike NNE–SSW with the dip 30–50° to ESE. An outline diagram of joints shows the central maximum about the strike W–E dipped 10–20° to N.
The directions of valley axes were compared with geological structures by the statistical relationship using the χ^2-test. A parameter p is statistically extremely significant between the directions of valley axes and the azimuth of foliations in contrast to the azimuth of joints which is insignificant in the model area. The valley axes usually correspond with the sub-horizontal class of the quantitative classification of valley systems in the researched area.
The evaluation of geological structures by the vector analysis of valley axes is applicable in all kinds of landscape. All valley axes can be classified by the azimuth and the angle of slope (dip). The quantitative evaluation of geological structures by vector analysis of valley axes should

cover all kinds of structures (foliations, joints, lineations, folds, faults) in the specific researched area.

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NEW DATA ABOUT THE LATE GLACIAL AND HOLOCENE EVOLUTION OF VALLEYS IN HOLY CROSS MOUNTAIN REGION (CENTRAL POLAND)

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Keywords: Holy Cross Mountain, river valleys, Late Glacial and Holocene evolution

Valleys of Holy Cross Mountain belong to Vistula River drainage basin. Extraordinary radial pattern of river valleys developed during the Tertiary (Kowalski 2002). Present knowledge of the Late Glacial and Holocene evolution of these valleys was insufficient and fragmentary (Kowalski 2002, Ludwikowska-Kędzia 2000) and concentrated mainly on river valleys of 4th order (Lubrzanka, Belnianka). Therefore since 2008 systematic studies on this phase of valley evolution in Holy Cross region have been conducted. Research was focused on valleys of 3rd order of Czarna Nida (Krupa 2014), Biała Nida, Kamionka (Przepióra et al. 2013) and 2nd order of Kamienna (Barwicka, Kalicki 2012) and Czarna (Zieliński et al. 2013). Some alluvial bodies of different age occur in one morphological level of valley bottoms. These cut-fill series have been formed by rivers of various channel patterns – macromeanders (Late Glacial) and small meanders (Holocene). Multichannel systems (anabranching) from the Eoholocene and Subatlantic have been found in Czarna Nida valley. Regional trends of the Late Glacial-Holocene erosional-accumulation cycle follow the same patterns as in other valleys in Central Europe like incision in limit of the Young Plenniglacial and Late Glacial, Younger Dryas straitening and braiding of river channels and some Holocene phases of an increase of fluvial activity. Except supraregional phases i.e. in the Mezoholocene, local catastrophic events occurred in Czarna Nida valley which played important role in morphodynamic of small basins. Traces of Prehistoric human activity (iron smelting) have not been fund in Czarna Nida Valley. Since Middle Ages a pronunced increase of sedimentation rate in Czarna Nida and Kamienna valleys occured.

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FLOODPLAIN AND IN-CHANNEL LANDFORMS GEOMORHIC STRUCTURAL CONNECTIVITY

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Keywords: the Belá River, connectivity, channel morphology, flood events

Temporal and spatial connectivity that has characterised braidplain and channel behaviour will give crucial information about the evolution and management decisions of this type of rivers. The aim of the contribution is to understand how the spatial connectivity has developed on the Belá River (244.3 km^2, 23.6 km); evaluate how time-spatial linkages of channel and floodplain landforms have been affected by recent large flood events and local factors. Four geomorphological coupling levels of the structural connectivity for seven time periods, using aerial photography (1949–2009) have been investigated: i. valley slope/low terraces–braidplain; ii. channel–channel level; iii. channel–bank level; iiii. bar–channel bed level. Each time horizon has been selected to be representative for estimation linkages changes after large flood event. The development of geomorphological structural connectivity is examined by documenting sequential changes in braidplain width, channel planform (braided and wandering indices), bar and bank attached erosion/accretion areas as parameters reflecting four types of connectivity. The changes in the structural connectivity is expressed in the three-point ordinal scale (1. increasing; 2. unchanging; 3. decreasing) as well as in the map expression of river reaches zonation. Generally, the width of braidplain with decreasing trend refers to long term decoupling valley slope/terraces–braidplain linkages. This trend is prove also by decreasing of the braidplain area. The values of braided indices across years decrease contrary to the number of wandering ones exhibit rising tendency which indicates the increasing trend of channel-channel connectivity. The channel-bank type of connectivity exhibits temporal alternation. In some time periods increasing one dominates conditioned either by erosion or deposition processes but there are periods characterized also by decreasing or unchanging this type of connectivity. The interpretation of the bar-channel bed level connectivity by erosion/ accretion areas allow us to make conclusions that during the period 1949–1973 both processes generate unchanging but intensive connectivity. On the contrary, the period 1986–2003 can be understand as decreasing and less intensive. The

period 2003–2009 is considered as increasing one when the predominance of intensive deposition processes is clearly exhibited.
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TO THE KNOWLEDGE OF EROSIONAL SYSTEM IN THE BOSONOŽSKÝ HÁJEK AREA WESTWARD OF BRNO

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Keywords: Brno region, the Bosonožský hájek area, unique gully erosion, relief evolution

Západně od Brna na východních svazích Bobravské vrchoviny se ve sprašových pokryvech vyvinuly jednotlivé strže i stržové systémy. Jedinečný stržový systém se nachází v Bosonožském hájku asi 1,1 km JV od brněnské městské části Žebětín. Podle rozšíření a morfologie byly stržové systémy rozděleny do tří oblastí výskytu. Součet přibližných délek všech zjištěných strží je 18 354 m. Hustota stržových zářezů činí v rámci zájmového území 39,25 km.km^{-2}, což představuje lokalitu s nejvyšší hustotou strží na jižní Moravě (Münster 2007). V současnosti jsou strže relativně stabilizovány, nejsou periodicky protékány vodou. Místy se projevuje působení povrchového ploužení a ojediněle sesouvání. Lokálně destruktivně se projevují antropogenní vlivy (průjezdy motocyklů, umělé jeskyně).
Nejmohutnější stržový systém je vyvinut ve střední části zájmového území. Vytvořil se v mocném sprašovém pokryvu a zasahuje i do podložních biotitických granodioritů brněnského masivu. Délka hlavní strže činí 515 m, převýšení 62 m, max. zahloubení až 12 m.
Výzkumné aktivity (Kirchner, Münster, Máčka 2011) směrovaly k poznání vzniku a stáří stržových systémů, byly formulovány možné hypotézy. V posledním období byly v zájmové oblasti uskutečněny vrtné práce a využita metoda elektrické odporové tomografie k ověření mocnosti sedimentů ve dně hlavní strže ve střední části území.
Dle stávajících poznatků je zřejmé, že v zájmové oblasti se vyskytují jak staré strže přírodní geneze, tak rozsáhlé mladší strže podmíněné antropogenně. K dalšímu prohloubení poznatků o stáří a vývoji strží v Bosonožském hájku bude nezbytné nalézt podklady, umožňující přímé datování erozních událostí.

The aim of paper is a gully erosion in the eastern part of Bobravská vrchovina Highlands. There is a unique gully network in Bosonožský hájek, which is located 1.1 km south-east from city district Brno Žebětín. Three types of gully networks can be recognized according to an extension and morphology. The approximate length of whole network is about 18 354 m and the density is about 39.25 km.km^{-2}. This area has the highest density of gully networks in south Moravia (Münster 2007). Nowadays, an evolution of a relief of the locality is stabilized and isn't

influenced by periodic water flow. There are signs of creep, very rare landslides and local anthropogenic disturbances (motorcycle rides, artificial caves). The main gully is situated in the middle of the area of interest. It is developed in Pleistocene loess deposits and included within the underlying granitoid bedrock. The length of main gully is 515 m, difference of heights is 62 m, countersink 12 m. The research activities (Kirchner, M Münster, Máčka 2011) were focused on the absolute dating and on hypothesis generation. Currently, the research was expanded with drilling and geophysical survey to determine the thickness of deposits in the main gully.

The first results indicated a presence of old gully networks of natural genesis and younger networks influenced by human activities. It is necessary to find a sample for dating of the erosion events for better understanding of relief development in locality Bosonožský hájek.
The work took use of the long-term conceptual development support of research organisations RVO: 68145535

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HEADWATER AREAS TRANSFORMATION UNDER HUMAN IMPACT; ODRA RIVER TRIBUTARY, SILESIAN UPLAND, POLAND

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Keywords: Upper Silesia Upland, headwater area, human impact, fluvial processes.

In the northern foreland of the Moravian Gate, the western edge of Silesia Upland is dissected by headwaters of Odra river tributaries. This region, with a complicated geology of older structures, was covered by the Tertiary sediments a few hundred meters thick (Hassing 2003). During the Quaternary the glacigenic deposits, related to a two-time transgression of the Scandinavian ice-sheets, have been deposited. During the last glacial period it was smoothed by periglacial processes. The Holocene climate amelioration resulted in a succession of forest communities. This transformed the hydrological regime of local rivers. Odra river tributaries draining the Silesia Upland resulted in a meandering channel pattern.

Downstream the confluence of the Bierawka river with source streams, the traces of fossilized long-existing alder forest have been identified. The stamps and roots were dated between 1120±60 to 3670±40 years BP. This indicated the stability of natural environment in the upper part of Bierawka drainage basin.

The archaeological traces of Neolithic human penetration of this area are rare. The Slavic tribes settled the Silesia Upland between 5-7 c., earlier - the loess plateau in the Sudetes northern foreland, and later - the discussed headwaters dissecting the Silesia Upland western margin (Klimek 2007). The Bierawka river headwaters with the prevailing S or SW oriented slopes, the dense pattern of groundwater sources and streams, not frozen during winter time, offered favourable conditions to location of the settlements. The traces of Early Medieval settlements are very frequent here despite written documents informing about first settlements since the first half of 13th century (Panic 1992). This stimulated the soil erosion on the formed slopes sloping 20-30m/km.
In the mid-14th c. the population density here reached 7 to 15 inhabitants/km^2 and, later, in the second half of 18th century - 30-40 inhabitants/km^2 (Ładogórski 1956). After heavy rainfalls or especially intensive snow-melting period, the farming lands were eroded very intensively. Also, the bog ore exploitation and, later, the Miocene siderites exploitation from open cast small mines and smelting resulted in an increase in the sediment supply to the local streams transported to the Bierawka river. The Bierawka river periodically overloaded with suspended and bead load, which resulted in the formation of anatomizing channel pattern. These events and, later, the hard coal mining since 19th century further transformed the geochemical properties of alluvia.

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LANDSLIDES IN MORAINE SEDIMENTS, CORDILLERA BLANCA, PERU

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Keywords: Landslide susceptibility, Slope stability, Moraines, Cordillera Blanca

Landslides of different types are widespread in the Andean region including Cordillera Blanca Mts. in Peru. The most devastating landslides occurring are rock/ice avalanches, which claimed

thousands of lives in 1962 and 1970. Apart of earthquakes, their triggering mechanisms are being largely unexplored because they usually origin close to very high glaciated peaks where no permanent monitoring is applied. These avalanches have been strongly localized to the north peak of Huascaran Mt., but some recent events, like avalanche to the Lake 513, suggest possibly more widespread future occurrence of this phenomenon. Other hazardous landslide types are landslides in moraine material which represent usually small scale slips or flows originating on the steep slopes of terminal moraines. Often, these landslides may fall to the glacial lakes causing dangerous outburst floods. Other examples of landslides in moraine material are deep-seated deformations related to the activity of the Cordillera Blanca normal fault. We present in depth study of the first group of landslides. Landslide from the left lateral moraine of the Palcacocha Lake has been studied in depth using field mapping, geotechnical and geophysical investigations. Acquired data enabled us to estimate volumes of possible future landslides, which may fall into the lake. This information will be used for hydrograph modeling of the overtopping wave which will result from the landslide impact to the lake and may cause glacial lake outburst flood. Detailed research also enabled us to describe its slope stability conditions, which may be applied on other sites within the Cordillera Blanca with similar morphological, sedimentological and geological conditions.

THE GEOCHEMISTRY OF BACKGROUND AND SURFICIAL LAYERS OF HOUSE GARDEN IN KIELCE. THE COMPARATIVE STUDY

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Keywords: background, house garden, anthropogenic soils, geochemistry

With the development of civilization the changes in solum became more visible. Currently the soil features which is left to human influences could different from properties of natural soils, significantly. In this connection in Polish Soils Taxonomy (1989) distinguished the separate section of the anthropogenic soils. There are belong this units whose genesis is closely connected with human activities, while its degree of conversion – it casued by intensity and character of anthropogenic actions. In this way the observable changes could be characterized by positive or negative notes. At first case soils from culturesol are developing. Culturesol was changed by intensive agriculture. The negative line of anthropogenic soils is called industrisol and urbisol. Disturbances which observe for phisical, chemical and morphological properties of this soils due to strong industry impact and nearness of urban-industrial building (Mocek et al. 1997).
The aim of this research is presentation of basic geochemical features of house garden surficial layers in Kielce (on Baranówek estate) and comparision with the most accepted values of backgrounds and with the individual research results of scientists group. The topsoil (to 20 cm) because of direct contact with anthropogenic environment indicate changes the strongest which happen in modern times. Therefore, not without reason, the human is one of soil-forming factor in soil-science lists – next to climate, relief, water, time and organisms activity. In case of anthropogenic soils human factor correspond with this changes the most.

On this research made sampling from three sites. Two first samples is from place of home cultivation of vegatables (potatoes, cucumbers), while third sample has been taken from non-cultivated area, near fruit trees. The samples was air-dried by about three weeks in laboratory room. The first experiences included basic soil-science studies. After grain size analysis by sieve method was marked: pH in H_2O and KCl by potentiometric method, hydrolytic acidity H_h and the sum of exchangeable bases by Kappen methods, the percentage content of carbonates $CaCO_3$ by Scheibler method, exchangeable acidity H_w and mobile aluminium Al^{3+} by Sokołow method, the percentage content of organic carbon $C_{org.}$ (humus) by combustion method and water capacity by flood method. The next experiments concerned the determination of selected trace elements, it means Cd, Cu, Fe, Mn, Ni, Pb, Zn using IPC-MS spectrometer.
Considering on the postion of garden and character of realized works could classify the tested soils to section of the anthropogenic soils and to type of hortisol, it means garden soils. Especially it is visible in case of samples collected from cultivated area actually where conduct a litlle agritechnical measures connected with digging over and vegetables planting annually. Probably the site from which took the third sample was subjected to similar treatments earlier. In all of these samples was present strange materials that could be introduced unconsciously to solum. It was for example: pieces of debris and building materials, litlle metal elements, styrofoam globules, pieces of wood. Besides this elements was found remains of living organism, it means fragments of bones, snail shells to few milimeters size and tree twigs.

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THE IMPACT OF FOREST MANAGEMENT ON CHANNEL MORPHOLOGY AND SEDIMENTS IN THE HEADWATERS OF SMALL FLYSCH VALLEYS IN WESTERN CARPATHIANS

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Keywords: forest management, Carpathians, mountainous streams, stream channels

One of the forms of human activity that influences the morphology of the watercourse channels in mountains and the sediments deposited in valley bottoms is forest management. The author aims to determine how intensively developing since the mid-19th century forest management has led to changes in the shape of channels as well as the nature of sediments in the selected headwater sections of streams in the Beskid Żywiecki (the Western Carpathians). The formation of these streams' channels is affected by a dense network of forest roads. The rate at which water flows from slopes to channels as well as the size of weathering supply may be faster or slower, depending on the inclination and length of these roads, and whether they are connected with the

streams. According to studies conducted in other parts of the Polish Beskids, it is known that dirt and forest roads provide even up to 80% of suspended load transported by the mountain streams (Krzemień, 2012). Over more than 150 years of the functioning of forest roads, there have been significant changes in the water cycle occurring in the headwater catchment areas of the Beskid streams, which result in the altered morphology of channels as well as the altered nature of sediments deposited in the valley bottoms, and – what is the most important – the increased flood risk, including the headwater sections of watercourses in the mountains. Related to forest management is also the construction of the 19th-century earth-fill dams in the headwater sections of streams in the Beskids, intended for interim storage of water needed for timber floating. There were built wooden splash dams as well. When lifted, they caused a sudden rapid flow of water what, in turn, allowed waterway transportation of timber logs along the stream. This frequently repeated procedure over many years, until the '20s or '30s of the 20th century, has caused considerable changes in the morphology of the streams' channels and valleys' bottoms. In the past, there were miniature water reservoirs above the dams, where large amounts of chiefly silt loam materials were accumulated. Below the dams, the streams' channels have undergone deepening through frequently generated "artificial floods". In spite of having discontinued that sort of forest management for more than 80 years, the geomorphological and sedimentological results are still visible. One of the aims of the author's study is to determine the accumulation rate of material in the former miniature water reservoirs, what indirectly indicates the size of suspended load transportation. The initial studies on the granulometry of these sediments show that suspension load transportation dominates even in the headwater areas of the Beskid streams, although their channels are built of coarse-grained material (Łajczak, 2011). The author's study will contribute to a better understanding of the functioning of channels belonging to the headwater sections of streams in the Beskids – the issue to which no one has paid enough attention so far.

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MICROTEXTURAL CHARACTERISTICS OF GLACIOFLUVIAL SEDIMENTS FROM HIGH TATRAS

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Keywords: glaciofluvial sediment, exoscopy, quartz grain micromorphology

Microtextures of glacial and fluvial origin are development on quartz grains of recent glaciofluvial sediments. This paper deals with main microtextural characteristics of relict glaciofluvial sediments of the High Tatras.

Samples were collected in August 2013 from two glaciofluvial outcrops at the foot of High Tatras. The first outcrop was located in the bed of Studený potok Brook, where the samples were taken from two sections (three samples from each section. Second series of samples were collected from "Velká žľtá stena" Wall near Tatranská Poliank
All samples had similar frequencies of microtextures except roundness. Samples from glacifluvial accumulations near Studený potok Brook, were more rounded than samples from Velká žľtá stena" Wall. Typical glacial microtextures as conchoidal fractures, fracture faces and grinding features were not abundant. V-shaped pits and dish-shaped pits as typical fluvial microtextures occurred at a lower frequency. There are appeared only pronounced microtextures as straight steps and grooves, parallel striations and meandering ridges on the surface of quartz grains. These microtextures were probably resistant to weathering and it is possible, that other impact microtextures were covered by silica pellicle or filled with silica globules.
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GEOMORPHOSITE ASSESSMENT FOR GEOTOURISM PURPOSES

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Keywords: geodiversity, geotourism, geomorphosite, assessment methods and criteria

Geotourism can be understood in a broader sense as geographical tourism sustaining *environment, culture, aesthetics, heritage, and the well-being of residents* of a place (National Geographic Society, 2005) or in a more restricted sense as a form of nature tourism that specifically focuses on landscape and geology (Dowling, Newsome eds., 2010).
Geodiversity, respectively geological, geomorphological and pedological sites are the most important resource for the geotourism activities. It is evident that not every site can be used for geotourism purposes. To find out which sites can be used, it is necessary to identify, describe and assess various sites using a suitable assessment methodology.
Based on the analysis of the definitions and key features of geotourism and other approaches to geotourism and coming out from assessment methods already used for geomorphosite assessment (e. g. Panizza, 2001, Pralong, 2005, Pereira et al., 2007), five groups of assessment criteria are proposed: 1) criteria which consider an assessment of the scientific and intrinsic values (diversity and importance of the features and processes, the scientific knowledge of the site), 2) criteria which consider an assessment of the exemplarity and pedagogical potential of the site (clarity and visibility of the features and processes, the availability of the products that support education), 3) criteria which consider an assessment of accessibility and visibility of the site and the presence of tourist infrastructure (transport, local products), 4) criteria which consider an assessment of the existing threats and risks, assessing conservation activities or existing legislative protection of the site, 5) criteria which consider an assessment of the added values (ecological and biological value, cultural, historical, artistic value of a site, aesthetic and scenic value).

The proposed method can serve to identify geotouristic potential of geomorphosites. Although the proposed method is numerical which should reduce the subjectivity, there is always a degree of subjectivity due to the fact that the real value of some criteria cannot be measured and it depends on assessor's experience, knowledge and preferences. Nevertheless, the procedure needs to be improved, refined and more thoroughly validated as the list of assessment criteria is not complete and it is a subject to further discussions.

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EVOLUTION OF THE RIO COLCA VALLEY RELIEF IN LACUSTRINE SEDIMENTS (ANDES, PERU)

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Keywords: lacustrine deposits, relief, Rio Colca Valley, Andes

The Rio Colca river belongs to Pacific basin and drains Central Andes in southern Peru. The river is 520 km long, its springs are located on the plateau of Altiplano. The Rio Colca flows through Western Andes, where incises one of the deepest canyon on Earth. In lower reaches the Rio Colca flows through Atacama Desert. Above the canyon the valley is incised in lacustrine sediments at a distance of approx. 50 km. Slopes and bottom of the valley, built of these sediments, are incised to a depth of nearly 350 m. The top parts of the slopes reache elevation of 3600 m a.s.l.

Direct cause of intensive erosion and denudation processes in the valley was probably capture of lake water. One of the rivers, which flowed into the Pacific Ocean, had eroded headward through Western Andes, reached the lake and captured its water along with the entire catchment area.

Incising and downwcutting erosion of sediments began and alluvium were transported towards the Ocean.
5-6 levels of aggradational and degradational terraces show, that incising within the lake sediments ran periodically. Geological structure of lower terraces levels proves, that periods of thick gravel and periods of fine-grained depositions occurred. Gravel deposition can be explained by climatic changes (higher humidity, cool climate, El Ninõ). Deposition of sandy and dust sediments are related with pyroclasts originated from the catchment area and transported by low flows.
Along with deepening of the valley mass wasting processes, especially landslides began to act. Frequent earthquakes in the region, steep slopes of high level terraces and poor cohesion of a rock and soil are the major driving forces for a landslide to occur. The most extensive and deep landslides are located in a fault zone which intersects the western part of lacustrine sediments (area of Mac-Madrigal-Lari). Landsides were several times reactivated during subsequent seismic events. Large rotational landslide is located in the village of Ichupampa. Its colluvium moved down the lower terrace is 15 m thick.
Efermal and perennial tributaries of the Rio Colca also incised deep canyons in soft lacustrine sediments. Numerous of them are located in lower reaches of the rivers. Their gradients are very steep.
Relief of the Rio Colca valley is partially modified by the human. The system of agricultural terraces on the slopes is the most visible effect of human impact in the landscape. Construction of slope roads did not affected the relief of the valley.
At present, evolution of the relief follows most intensively within the river channel (lateral and bank erosion) and on the slopes (landslides). The Rio Colca river still did not incised the floor of lacustrine deposits on its almost entire length.

AUTOMATIC EXTRACTION OF LINEAMENTS IN THE MAIN ETHIOPIAN RIFT AND THE ETHIOPIAN HIGHLAND

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Key words: lineaments, morphometry, Main Ethiopean Rift

The Main Ethiopian Rift and the Ethiopian highland have diverse geological history, e.g. repeated sea transgression and regression, Tertiary and Quaternary volcanism, uplift of Ethiopian highland (in the last 29 million years) and opening of Main Ethiopian Rift (in the last 18 million years), which caused the formation of faults and cracks (Kazmin, 1975; Pik et al., 2003; Gani et al., 2009).
This paper deals with the functions that can automatically extract lineaments in programs ArcGIS and PCI Geomatica. The initial data were SRTM digital elevation model with resolution 90 m on equator (CGIAR-CSI, 2014).

Two maps of lineaments were created: 1) map A was created from a combination of shadow relief with solar azimuth 0°, 45°, 95° and 135°; 2) map B was created from a combination of shadow relief with solar azimuth 180°, 225°, 270° and 315° (Abdullah et al., 2010; Muhammad, Awdal, 2012).

Map of lineaments A and B were compared visually and also with use of morphometric characteristics: 1) the "number of lineaments"; 2) the "total lengths of lineaments"; 3) the "average lengths of lineaments"; 4) the "morphotectonics networks´density"; 5) the "morphotectonics networks´ frequency"; and 6) the "azimuth of lineaments".

Morphotectonic network near the Ethiopian Rift consisted of 14 940 lineaments (map A), or 14 938 lineaments (map B), the most common length of lineaments was 38,1–39 km. In the case of visual evaluation, map A and B showed differences, the values of morphometric characteristics were almost identical. After extraction of morphotectonic network of lineaments B compared with A: 1) decreased the "number of lineaments" about 0,013 %, 2) extended the "total length of lineaments" about 0,061 %, 3) extended the "average length of lineaments" about 0,077 %, 4) increased the "morphotectonic network´s density" about 0,062 % and 5) decreased the "morphotectonic network´s frequency " about 0,0008 %.

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CHANGES IN RELIEF OF THE AZAU VALLEY IN CENTRAL CAUCASUS MTS RESULTING FROM IMPACT OF VOLCANIC ACTIVITY AND GLACIER OSCILLATIONS DURING THE LAST CA. 1100 YEARS

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Keywords: Azau Valley, Caucasus Mts, volcanic activity, glacier oscillations, jökulhlaup effect, Little Ice Age, rampart moraine erosion

The subject of this paper are changes in the relief of the partly glaciated Azau Valley in the Central Caucasus, neighbouring to Elbrus volcanic cone (5643 m a.s.l.) resulting from intensification of volcanic activity and valley glaciers' oscillations during the last 1100 years. Field research, analysis of topographic maps and photographs from the last 140 years as well as information in literature were the basis for my work. I identified the most important geomorphological processes modelling the valley: a lava flow, floods of *jökulhlaup* type, glaciers' transgressions and recessions, erosion of moraines and mass movements on the slopes. I distinguished eight sections of the Azau Valley varied in their relief and being under the differentiated influence of the listed geomorphological processes. The valley under question, represents the Alpine type area of typical cascade like transfer of waste material from the slope to the valley systems and further along its floor. Hanging tributary valleys on the Azau Valley slopes are valleys exporting waste material while the main valley functions as the valley importing waste material. In the period of absence of visible volcanic activity of Elbrus, the fastest changes in the Azau Valley relief take place during the recession of the valley and slope glaciers and of ice cap on this volcano. Findings proof interdependence of intensity of material aggradation in the valley and the amount of moraine deposits which can quickly erode and be transported to the stream channel, easily accessible weathered material derived from marginal ice-free areas as well as on the volume of ice melting water discharging great loads of sediment.

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WATER CIRCULATION AND CHEMICAL DENUDATION IN THE UPPER SKAWICA RIVER FLYSCH CATCHMENT (NORTHERN SLOPE OF BABIA GÓRA MASSIF, WESTERN CARPATHIAN MOUNTAINS)

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Keywords: Skawica River, Babia Góra massif, Western Carpathian Mountains, flysch rocks, landslide morphology, chemical denudation

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 $mg \cdot s^{-1} \cdot km^{-2}$), 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 $tons \cdot yr^{-1} \cdot km^{-2}$, 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.

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TIMBERLINE AT MT. BABIA GÓRA AS A REFLECTION OF THE DIFFERENT RATES OF SLOPE PROCESSES

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Keywords: Babia Góra massif, Western Carpathian Mountains, flysch rocks, slope processes, landslide morphology, timberline

Geomorphologists have recently been shifting their focus increasingly to the timberline seen as a boundary of two differently functioning mountain geoecosystems. There are two types of timberline, i.e. climatic and empirical. The variable altitude of the latter depends to the greatest extent on rates of slope processes, but also on the local climate and human activity. The climatic timberline is determined by certain annual isotherms (2°C at Mt. Babia Góra). Timberline itself is defined as the boundary of a continuous forest, above which it becomes sparser (and ends at a forest line) and further still there are only isolate dwarf tress (bound by a treeline). The Babia Góra massif (1725 m a.s.l.), where the research is conducted, is an asymmetrical ridge with a precipitous northern slope and a gentler southern slope. On the northern slope the timberline is shaped by snow avalanches and the block cover creep, as well as, but less frequently, by landslides and debris flows. Herding has played a role in the determination of the current timberline. Most of the highest section of the northern slope has never been used for herding, but the entire southern slope, including its summit section, has seen sheep and cattle herding, which has produced numerous and large forest clearings that reach up to the timberline. Even now, 60 years after the establishment of the Babia Góra National Park and a related forest expansion, the pastoral frontier around the former clearings, now overgrown with trees, is still visible and can be even 100 m lower than the natural timberline in adjacent sections of the slope. This fact suggests a need for a particularly careful approach to timberline analysis on the southern slope of Mt. Babia Góra. The authors measured the intensity of geomorphological processes influencing the timberline at Mt. Babia Góra by determining the distance, by which the empirical timberline (measured using GPS) was lower than the climatic timberline, which was identified on average at 1380 m a.s.l. This approach is a new contribution to the body of research on this massif. The results confirm general patterns of timberlines, such as these found in the Tatra Mts and Karkonosze Mts, whereby it tends to be higher on slopes that are gentler, exposed to the south, upwind or convex and that it is lower a.s.l. below gullies, paths of avalanches, mobile slopes covered by rock rubble and below former herding clearings affected by snow avalanches. Another new contribution to the science of natural influences on the timberline includes findings about a landslide impact. Landslides developing above the timberline have been found to send large volumes of rubble into forests, while landslides developing below the timberline continue to edge upward thus gradually eliminating the forest and exposing much longer sections of slopes to avalanches. The shape of the slope and the rate of slope processes at Mt. Babia Góra combine to produce timberline altitude differences up to 400 m.

RIVER TRAINING VS. FLOOD RISK IN THE PIEDMONT SECTION OF THE VISTULA, POLAND

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Keywords: Vistula River, piedmont section of the Vistula, river training, flood risk

Flood risk is the possibility of a river overflowing its banks due to weather conditions and temporarily inundating a flood plain. The flow of floodwaters results in economic losses and the loss of human life. The magnitude of flood risk depends on the duration of elevated water stages, the height of elevated water stages and the resulting extent of flooding across a flood plain. However, actual losses caused by floods are determined by land use in each given area. Well-planned human activity across valley floors and in river channels can lead to a reduction in flood risk. Poor planning, on the other hand, can increase flood risk and lead to substantial losses in populated river valleys. One form of human activity that has not yet been fully evaluated with respect to flood risk is river channelization. The construction of levees makes the inundation zone much more narrow, increases high water levels in rivers during major floods and increases the rate of floodwater flow. This makes it easier to breach levees and inundate large areas outside levees. Dams serve to reduce the height of flood waves. However, when the rate of flood wave formation is significant, a reservoir may help generate an even larger flood wave further downstream. Channelized rivers are usually a little shorter, less sinuous, deeper and more narrow. This results in flood waves that concentrate more quickly and move faster. In addition, the extent of the flood is different as is the height of the peak wave. The acceleration of the flood wave is one of the stated goals of river channelization, which is designed to reduce flood risk. Channelization efforts systematically make the river channel deeper along shortened sections with a large gradient, although downstream sections with a smaller gradient become more shallow. In general, this leads to a higher rate of river flow. The construction of levees yields larger fluctuations in water levels. Increasingly deeper river channels are characterized by ever shorter durations of elevated water levels. Shallower downstream sections of rivers with a small inter-levee zone experience increased flood risk due to higher upstream flood wave intensities and larger fluctuations in water levels. Existing river channelization methods have becoming objects of scrutiny in recent years. Some researchers argue that channelization does not really decrease flood risk, which actually increases along shallow sections of river, where groundwater levels increase and saturate flood plains for longer periods of time. A good example of a river channelized since the middle of the 19th century is the Piedmont section of the Vistula in southern Poland. This section of the Vistula is characterized by variable flood risk, variable geometric parameters and variable dimensions of the inter-levee zone. The purpose of the presentation is to: (1) describe the current state of flood risk along this stretch of river, (2) describe the rate of river flow, and (3) describe changes in flood risk since the start of channelization efforts with respect to changing channel geometry and changing rates of river flow reflecting the effects of channelization work.

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COLLAPSES OF THE ABANDONED MINES IN THE NÍZKÝ JESENÍK MTS.

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Keywords: abandoned mines, Nízký Jeseník Mts., clayey shale, collapses

The hilly landscape of the Nízký Jeseník Mts. is interlaced with the tens of the underground clayey shale mines of the various age and length. Many of these mines have been quarried since 18th century and some of them are still in the operation. The largest mine works reach a few kilometres length and they are tens of meters deep. Some of them have been mined in two or three levels. The steeply inclined clayey shale flags were mined by the battery breast. Huge underground chambers and pillars remained after this method of the mining. Over the time when the mines are abandoned the chambers started to be unstable and the collapses of the walls and the ceilings destabilize the superficial terrain above the mine works. The paper discusses the current state of the mines and describes the most important collapsed localities.

MONITORING OF THE LANDSLIDE AREA NEAR TŘEBENICE, ČESKÉ STŘEDOHOŘÍ MTS.

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Keywords: České středohoří Mts., slope deformation, above-average precipitation, landslide monitoring

This paper presents the first findings of current surveys and monitoring of the slope deformation which is located near Třebenice town, on the southeast edge of the České středohoří Mts. The landslide is situated near the border of the České středohoří volcanic complex and sedimentary Bohemian Cretaceous Basin. Landslide area has a character of the extensive shallow slope deformation in clayey and sediment rocks. This area was several times reactived in the past (last large reactivation was in 80´s of the last century). We observe the partial reactivations in connection with above-average precipitation in May and June 2013. These reactivations are particularly evident on the recent deformation of the road surface in the landslide area. The road surface and its recent deformation are newly monitored by geodetic methods. The other landslide activity is monitored by long-term control measurement of groundwater level and by extensometric tape for measurement of surface deformation. This data can be correlated with climate information (especially precipitation) from a nearby permanent meteorological station of IRSM CAS p.r.i.

TRANSFORMATION OF THE LANDSCAPE STRUCTURE IN THE ŚLEPOTKA RIVER CATCHMENT AREA (UPPER SILESIA, POLAND) SITUATED ON TERRAIN SUBJECTED TO STRONG ANTHROPOGENIC PRESSURES

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Keywords: anthropogenic pressure, landscape metrics, landscape structure, Ślepotka river, Katowice, Upper Silesian Coal Basin

The area of Upper Silesian Coal Basin is the most important underground mining exploitation district in Poland. The hard bituminous coal mines, thriving in that area since the XVIII century,

contributed to enormous transformations of the natural environment in the form of its pollution, landform changes and through landscape structure modification. The river valleys situated within the reach of intensive exploitation activity undergo strong transformations. On the regional scale the Ślepotka river catchment constitutes an interesting example of flow transformations as well as the area adjacent to it. Ślepotka is a left-bank tributary of Kłodnica which belongs to the river basin of Odra. Ślepotka has its sources in the forest which is situated on the borders of two districts of Katowice, i.e. Murcki and Ochojec. The flow measures 8 km and flows, e.g., through a nature reserve Ochojec, and its catchment has 14 km^2 (Mapa hydrograficzna Polski 1:50 000, 2001).

The diagnosis included the time from the year 1930 to 1994. These years coincide with the period when another hard bituminous coal mines were built, the existing industries joined into larger conglomerates and the exploitation of materials was led on the largest scale. However, the 1990s carried the restructuring of industry in Poland. Essential changes were observed in the participation of particular covering types and land usage in the research area during about six decades. In the analyzed period the river changed its course both naturally, and through human activity. It resulted in creating overflow areas and flooding in fluvial terraces. Marshy lands and bogs developed and vanished. Progressing urbanization and technological development contributed to a significant transformation of the landscape structure in the area discussed, as well as increasing human pressure affected the condition of river Ślepotka pollution (http://reuris-f.gig.eu/pilot/4073/index.html).

Using landscape metrics is an objective proof of progressing changes – presenting suitable factors which depict the process of landscape structure transformation in a vivid way (Roo-Zielińska E., Solon J., Degórski M. 2007). The method mentioned above enables to determine the quantitative and surface participation as well as mutual relations between individual types of surface usage, such as: residential areas, agricultural areas, wooded areas, naturally valuable areas and highly transformed areas (Forman R.T.T., Godron M., 1986). Presentation of the problem with appropriate measure's help allows determining the range of the changes. A tabular list of the results and the landscape structure presentation of the studied catchment in a graphic form depict the full transformation of the natural environment.

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THE RIVER CHANNEL PATTERN TRANSFORMATION AND RECENT DYNAMICS OF THE CHANNEL-FLOODPLAIN SYSTEM OF THE VÁH RIVER, SLOVAKIA

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Keywords: fluvial geomorphology, channel pattern, river dynamics, river training, Slovakia, the Váh River

The Váh River, the longest river of Slovakia (403 km), has been a subject of long-term human modification. Starting with the first regulations at the beginning of the 19th Century, the river training process has eventuated into the construction of the "Váh Cascade" system in the 20th Century, consisting of 22 dams and hydropower plants. Important parts of this system are also five river reaches with diverged (by-passed) channel, by total length of 140 km (more than 1/3 of whole river length).
The aim of our research is to analyse the changes of the channel-floodplain system, caused by such strong anthropogenic modification of the river. In this contribution, we are comparing two river reaches, the first one, between Púchov and Trenčín and the second one between Piešťany and Sereď (both ca. 35 long). Spatial-temporal analysis has been based on comparison of several time horizons (1938 – topographic maps, 1949, 1985 – aerial photos and 2003 – orthophotomaps). Data obtained, including channel width changes, bank line movements and area of channel bars changes, have been evaluated statistically.
The results allow demonstrating, quantifying and classifying of the fluvial system changes (e.g. Hooke and Yorke 2011). Reconstruction of the channel pattern evolution can be useful for the restoration projects or for prediction of the future behaviour of the river system (e.g. Hohensinner et al. 2008, James et al. 2009).

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ASSESSMENT OF FLOOD IMPACT IN FLOODPLAIN OF A CHOSEN STREAM – GEOMORPHOLOGICAL EXAMPLES IN TEACHING GEOGRAPHY

Markéta Pluháčková

The aim of the poster is to present some geomorphological examples from an educational project. The project deals with geomorphological transformation of the floodplain after a flood. Fluvial forms in the floodplain of the river Úslava in the south-eastern part of the town Pilsen that were created after the flood in 2002 were specified and characterized within this project. These forms were used as an example for didactical transformation of the topic "floods and its consequences on the floodplain" within the teaching geography. There was created a project focusing on fluvial forms. Google Earth application is used to deal with the problematic. The poster presents: target group of the project, studied area and examples of tasks (determination of the fluvial forms, assignment of its photos to layers in Google Earth, delimitation of flooded area and development of flow line during floods).

BUILDING A REGIONAL HISTORICAL LANDSLIDE DATABASE FOR ÚSTÍ NAD LABEM REGION: PRINCIPLES, CONSTRAINTS AND PRACTICAL IMPLICATIONS

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Keywords: documentary data, landslide, rock fall, database, N Czechia

During the past few decades, increasing attention was devoted to creation of historical landslide databases across the World (e.g., Guzzetti et al. 1994; Ibsen, Brunsden 1996) as they enable to study the varying occurrence and causes of landslides, including their relation to fluctuation of other proxy time-series (such as precipitation patterns), as well as changing vulnerability of society through time. Moreover, the historical landslide databases have been used to calibrate and evaluate the reliability of landslide susceptibility maps. The creation of historical landslide databases is prevailingly based on documentary data analysis (Glade et al. 2001; Raška e al. 2014) as the morphologic effects of historical landslides can be currently hardly recognized due to subsequent landscape evolution and human activity. In addition, the documentary data are the only source that can give information about social impacts of and recovery after the historical landslides. In this paper, we present a historical landslide database of the Ústí nad Labem region for the period of 18th Century to 1940s (preceding World War II), which is concurrently being created (Raška et al., in press) using different types of documentary data. Until now, tens of historical landslides have been identified from protoscientific and scientific records, newspaper articles, old photos and maps, and official investigation protocols and reports. The occurrence of these landslides is analysed together with precision of their location and completeness of the data about social impacts and recovery measures after the landslide. The results are then used to raise a question about suitability of documentary data for site-specific management of historical

landslide location, about (in) sufficiency of research devoted to social dimension of landslide recognition and management, and new challenges for collection, conservation and dissemination of data about historical landslide, such as web online services and crowd sourcing.

Acknowledgements:
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1916 CATASTROPHIC FLOOD FOLLOWING DESNÁ DAM FAILURE: A ROLE OF HISTORICAL DATA SOURCES IN RECONSTRUCTION OF ITS GEOMORPHOLOGICAL AND LANDSCAPE IMPACTS

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Keywords: man-made dam failure, documentary data, catastrophic flood, Desná, N Czechia

Hundreds of catastrophical floods resulting from man-made dam failures were recorded across the globe (e.g. Costa 1985), including the Czech Republic. This specific type of floods is characterised by extreme discharges frequently exceeding maximal flow rates of natural hydrometeorological floods several times. Presented paper provides reconstruction of geomorphological and landscape impacts of the most catastrophic flood from man-made dam failure within the territory of today's Czech Republic – Bílá Desná dam failure in 1916 (Žák 1996). Due to the significant transformation of the Bílá Desná catchment realised during

following almost hundred years after the flood event, the field research performed in summer and fall 2013 had to be supported with extensive search in regional archives for documentary data (Glade et al. 2001; Raška et al. 2014). Various available historical data types and sources, such as court investigation notes, investigation reports for insurance companies, old maps and old photos, video and recorded testimonies of survivors were used in order to reconstruct magnitude of the flood and its impacts on channel morphology and landscape. According to the reconstruction of dam failure, which was caused by internal erosion of the dam, peak discharge was calculated between 406.8 and 1300.8 $m^3.s^{-1}$ and exceeded the mean flow rate at Bílá Desná River more than eight hundred times. The river channel immediately upstream and downstream the dam get back to its former meandering pattern with higher sinuosity and new gravel point bars and irregular bars have been formed. Moreover, the river channel immediately below the dam has been shifted by up to 30 m following the flood wave. The most significant flood impacts were apparent in the Desná town, where the flood wave together with transported boulders (up to 2 m in diameter) and logs from upstream sawmills killed 62 inhabitants and damaged or destructed tens of buildings. The reconstructed flood wave in the town of Desná and Tanvald exceeded the bankfull water level twice with the width ranging between ca. 50-250 m in contrast to average channel width of about few meters.

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MORPHOLOGIC DIVERSITY OF AGRARIAN LANDFORMS IN THE ČESKÉ STŘEDOHOŘÍ MTS. AND KRUŠNÉ HORY MTS.

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Keywords: agrarian landforms, geodiversity, N Czechia

The landforms originated as a result of land cultivation belong among the most important and representative anthropogenic landforms. The most common in Czechia are agrarian terraces, levees and accumulations. Agrarian terraces are steps on slopes, which are represented by narrow long plateau and steep marginal slope, frequently made of stones (stony wall). Agrarian levees are linear landforms that were created as the stones from field were collected and accumulated at

the borders of field. Similar origin is typical of some non-linear agrarian accumulations (mounds).

The territorial distribution of agrarian landforms in Czechia is connected with hilly and mountainous areas, especially in the mountain ranges of Šumava, Krkonoše, Jeseníky, Krušné hory, Českomoravská vrchovina and Beskydy. The natural factors that predispose the origin, quantity and character of agrarian landforms in these areas include high share of coarse particles in soils, slope inclination and lithological conditions. The factors of social and economic nature include overcrowding of mountainous areas leading to high pressure on land use (primarily high share of arable land) and resulting in a necessity to collect the stones from field in order to facilitate their cultivation and increase their productivity. The origin of clayey agrarian landforms is a result of long-term cultivation of field and meadows on slopes, where the borders of the parcels lead approximately parallel to the contour. Contrarily, there is significantly higher share of agrarian stony terraces (at former vineyards and orchards, etc.) in the areas with a climate favourable for agriculture. These landforms can be found primarily in southern Moravia (Šobes, Znojmo, Hustopečsko, Dolní Dunajovice), and in certain parts of Bohemia (Mělník and the České středohoří mts.). In respect of the above mentioned the Krušné hory mts. and the České středohoří mts. are examples of both mountainous areas and areas with favourable climate, thus representing broad spectre of agrarian landforms. Moreover, these areas differ in terms of lithology, land use and other factors resulting in diversity of agrarian landforms.

Based on our field survey, we have detected high occurrence and diversity of landforms represented by: a - type of agrarian landform (stony and clayey agrarian terraces, spontaneous and stony agrarian levees and agrarian mounds), b – size of the landform (width in metres, maximally reaching 12 metres, height up to 5 meters in clayey landforms and 3 m in stony landforms), c – lithology – size of clasts (from cm to boulders of 1.5 m, shape and roundness of clasts). Agrarian landforms increase geodiversity, i.e. edaphic and morphologic diversity of a certain area. This holds also for the studied areas, where the historical agriculture accounts for major anthropogenic transformation of the Earth surface. The origin of new agrarian landforms in a present-day landscape is not so common, but the historical landforms gain various functions. They represent a biotope for several flora and fauna species. Together with their vegetation, they influence the overall secondary landscape and its character.

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GEOMORPHOLOGY OF THE DYJE-SVRATKA BASIN: FOCUSED ON INDICATORS OF NEOTECTONIC EVOLUTION

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Keywords: Dyje-Svratka Basin, neotectonics, Quaternary, linear landform, fluvial system, alluvial fan

The Dyje-Svratka Basin represents a specific depression of subdued topography within the Miocene Carpathian Foredeep (Molasse Zone) largely covered by Quaternary fluvial, slope and aeolian deposits, adjoining to higher and much more tectonically and erosionally dissected Foredeep segments (Vyškov Gate and western Weinviertel in the Czech Republic and Austria, respectively). Three extensive flat alluvial fan levels dominantly consisting of voluminous remnants of Lower Quaternary gravel sands are typical landforms there. They are located in a markedly higher topographic position above surrounding basin floors, commonly with an apparent spatial discrepancy to current main streams.
A general topographic and sedimentological research has especially been carried out in the region to reveal some features indicating relevant neotectonic impulses in its geomorphological image, omitted so far also due to their prevalent hidden or indirect nature. Except for a lot of regional fluvial system anomalies, an occurrence of discrepantly uneven distribution of gravel sands, numerous linear, frequently fan-limiting landforms being many times repeated in en echelon or sub-parallel patterns, and distinct lower topographic segments in distant parts of the fans with steps, saddles or isolated ridges are among the most significant such proving phenomena. Commonly, landforms of various types are associated within pronounced morpho(tectonic) zone areas, usually trending in NW–SE, WNW–ESE to W–E, or N–S directions.
Present-day data point to the early Middle Pleistocene as the main period of recent tectonic-related features evolution; these, however, being afterwards largely modified by various later periglacial processes.

TWO DIFFERENT PHASES OF CONTEMPORARY CHANNEL MIGRATION AND BANK EROSION RISK

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Keywords: channel migration, bank erosion, risk, flood impact, the Topľa River

Successful and sustainable management of rivers requires awareness of which river reaches are prone to bank destruction and the subsequent lateral shift. The aim of this paper is to identify bank erosion, geomorphological and financial effects of channel migration in the riparian zone of

the 39 km long channel of the Topľa River (Eastern Slovakia). The Topľa River eroded in total area of 85.2 ha and 60.1 ha were deposited. The average channel shift per year doubled from 0.8 m/year (1987 – 2002) to 1.6 m/year (2002 - 2009). The most eroded category in the riparian zone is floodplain forest, followed by arable land, grasslands and pastures and shrubs. From the economic point of view, large destructed farmland areas (arable land and grassland) are negative phenomena (€ 29,924.02 in total). Increase of bank erosion in the studied reach after 2002 is obvious. In the first period, the rate of erosion and deposition were in approximate balance with the slight prevalence of deposition. It was due to the response of the channel to flood events (1987 and 1989) when it narrowed from the average width of 31.4 m to 28.7 m and stabilized. Small discharges with recurrence interval 1 or 2-year which occurred in reach between 1989 and 2000 did not exert larger destructive effects. On the contrary, in accord with Corenblit et al. (2007) or Ward et al. (2002), their effect was constructive and contributed to the stabilization of the system. On the other side, high magnitude and frequent floods after 2002 (and especially in 2004, 2006 and 2008) intensified erosion processes – the area of erosion compared to the area of deposition increased by 3.6-fold. High magnitude floods lead to sudden and significant bank erosion, destruction of the planform and to partial or total rejuvenation of the stream accompanied by channel and gravel bars expansion, destruction of old and formation of new stands for the vegetation. For the overall management of streams it is important to be aware of instable reaches. It is also necessary to bear in mind that bank erosion is a natural process in stream channels. "green" approach is now preferred worldwide which avoids technical interventions into the channels and the rivers are left to meander in the certain area or in certain reaches freely. Piegay et al. (1997) also point out that active restrictive interventions in channels are expensive and result in a spiral effect leading to degradation of streams and increased flood risk. But the effects of bank erosion and bank destruction are not given much attention in Slovakia. This research was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences; 02/0106/12.

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CONTEMPORARY STATE AND RIVER PROCESSES OF THE OLŠE RIVER CHANNEL (OUTER WESTERN CARPATHIAN, CZECH REPUBLIC)

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Keywords: incision, unit stream power, channel change, Olše River, Flysch Carpathians

In the last decades, intense and temporally variable anthropogenic disturbances in the Czech Carpathians basins continuously adjusted new constrains of rivers. Especially afforestation and bank stabilisation caused reduction of sediment supply. Originally gravel-bed character of rivers with high amount of transportable material was changed. The effect of hungry waters (Kondolf 1997) induced progressive channel transformation. Present-day state of channels shows a tendency towards the acceleration of processes linked with river bed deepening. Focusing on the Olše River in the Czech part of flysch Carpathians, the paper summarizes results of energetic potential aspects of contemporary Carpathian river channels. New internal conditions of channels have been affecting acceleration of erosion processes. The main cause is an adjustment of flow dynamics. The unit stream power values (after Bagnold 1966) increased two or three times between the years from 1960 to 2003. Other characteristics, used for evaluation of factors identifying the energetic potential of channels (as hydraulic radius etc.), show increase of values in the year 2003 compared with the year 1960. Contemporary state of the Olše River channel predicts that future development will lead to progressive incision.

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THE MORPHOTECTONIC VIEW OF VYDRICA VALLEY EVOLUTION AND ITS SEDIMENTOLOGICAL RESPONSE

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Keywords: morphostructure analysis, valley evolution, sedimentological response, Vydrica, Malé Karpaty Mts.

The aim of this article is to contribute to knowledge of the Vydrica valley evolution and its infill and also morphostructure evolution of the southern part of Malé Karpaty Mts. We used the methods of morphostructure, morphometric analyzes of georelief and also geophysical methods. Although the Malé Karpaty Mts. was the aim of the several geomorphological and geological studies, detailed research into the Vydrica valley in the context of the development of its sedimentary infill has not been realized yet. The Vydrica Valley is a distinct S- shaped morphological landform in general direction of NNE-SSW which extends in the middle of the southern part of the Malé Karpaty Mts. This contribution is a part of the first phase of ongoing research aimed at morphostructure analysis and analysis of geophysical profiles realized by the ERT (Electrical Resistive Tomography). Till now we have realized four (ERT) cross sections in the upper part of Vydrica catchment. These cross sections point to relatively thick (up to 25 m) fluvial sediments of varying granularity. Next stage of research will be lead into two directions. The first one is to clarify the older evolution of Vydrica valley in the context of neotectonic evolution of the southern part of the Malé Karpaty Mts. In this case, according to the works of e.g. Lukniš (1956) or Urbánek (1992), we can consider that an upper part of Vydrica valley was formed by valley piracy. In present the nearby stream – Stupavský potok – is drained westward probably in the place where its old valley was drained southward into present Vydrica catchement. Nowadays, there are two separate river basins. At the place where presumed valley piracy was occured the Stupavský potok creek changes its direction from NNE-SSE direction to WNW direction and is drained into the Záhorska nížina lowland. The valley of Vydrica changes direction from ENE to SSW. At present, height difference between the bottoms of the valleys is about 100 m. These two catchments are divided by shallow and wide saddle which is about 130 m above the Stupavský potok creek, while the slope into the valley of Stupavský potok creek has a gradient of 36°. Because the present valleys are based in different lithological conditions – Vydrica valley in granitoid massif and valley of Stupavský potok creek in carbonates – finding carbonates originating from the basin of Stupavský potok creek into Vydrica valley would be possible confirmation of valley piracy in the past. The second direction of research is to clarify the development of valley bottom, respectively its sedimentary infill in the relatively near past. By analysis of bottom sediments of the Vydrica valley we want to point the connectivity between climate changes and economic activity in the valley and their influence to sediment response and processes.

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ANALYSIS OF RAINFALL THRESHOLDS OF DEBRIS FLOW IN SMĚDAVA, THE JIZERSKÉ MOUNTAINS

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Keywords: debris flow, rainfall, tresholds, Jizerské Mountains

In August 2010 extreme precipitation affected the north of Bohemia and caused regional floods and slope deformations. Three torrential debris flows originated in the Jizerské Mountains., close to Bílý Potok on the north slope of Smědavská mountain. The rainfall situation which caused the shallow debris flows, was analysed and compared with the rainfall situation in 1958, when the debris flows were moulded there too.
The rainfall data was obtained from rain gauges of the Czech Hydrometeorological Institute. Four rain gauges were chosen close to Smědavská mountain with data of daily amounts from 1983 to 2013 and 10 minutes intensity or hourly amounts from the specific period. The data from 1958 was available from three different rain gauges (only daily amounts). The data series were not complete, so it was necessary to interpolate them using linear regression.
A number of analysis was carried out, for instance, daily precipitation, two-day/three-day moving average, antecedent precipitation index of 5/10/30 days, 10 minutes intensity, hourly amounts, etc. and the trigger factor of rainfall of origin of debris flow in the study area was investigated.

WHAT DOES THE GEOPORTAL SOWAC-GIS OFFER?

Jana Smolíková[1)] – Hana Kristenová[1)] – Věra Váňová[1)] – Ivana Pírková[1)] – Jiří Kapička[1)] – – Daniel Žížala[1)] – Vítězslav Vlček[1)] – Luboš Chlubna[1)] – Vladimír Papaj[1)] – Ivan Novotný[1)]

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Keywords: soil, erosion, map, GIS

Geoportal SOWAC-GIS managed by Research Institute for Soil and Water Conservation is thematically focused on the protection of soil, water and landscape of the Czech Republic. It offers information in the form of digital maps, specialized map applications, metadata, soil database, expert text and legislation. The presented data can be used and acquired by all users, ranging from the academic and scientific community, students, representatives of state and local governments to general public. The specialized map applications available to general public are, for example: Monitoring of Erosion and Slope Deformation on Agricultural Land in the Czech Republic, Statistical Yearbook, Erosion Calculator, eCatalog BPEJ (Evaluated Soil Ecological Unit), RESTEP, etc.

Monitoring of Erosion and Slope Deformation on Agricultural Land in the Czech Republic is intended for recording erosion events and slope deformations on agricultural land and their evaluation. It is a spatial database which is a source of data for assessing and modelling erosion processes and designing preventive measures. Statistical Yearbook offers statistical data related to water and wind erosion and basic soil characteristics based on the BPEJ code in the form of maps, tables and graphs at different levels of the administrative structure of the country. Erosion Calculator provides quick, easy and efficient calculation of the erosion vulnerability. In addition, this tool proposes control measures. ECatalog of the BPEJ is instrumental in reading and understanding the code. RESTEP – Regional Sustainable Energy Policy is the application of the interactive map of renewable energy for sustainable regional planning in the energy sector, etc.

Finally, SOWAC-GIS provides scanned data of the comprehensive soil survey, maps of the basic morphometric analysis and shares spatial data in the Internet environment by web map service (wms).

METHOD SELECTION INFLUENCE ON THE COARSE SEDIMENT SIZE PARAMETERS OF MOUNTAIN HEADWATER STREAMS IN FLYSCH

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Keywords: headwater streams, fluvial accumulations, grain-size parameters, wet sieving, Digital Gravelometer, macrogranulometric analysis, Outer Western Carpathians

Mountain headwater streams are narrow and relatively steep channels with stream gradient higher than 0.01 m/m (Thompson et al. 2006). Headwater streams are characterised by coarse sediments with variable share of gravel and boulder fraction (Montgomery, Buffington 1997) and, in the area of Outer Western Carpathians, by strong fluctuation of the bedload size distribution in the longitudinal profile (Škarpich et al. 2010). Granulometric analysis is a standard tool in the research of fluvial system dynamics and transformation of channel forms. Quantitative grain-size parameters are one of the fundamental information about sediment source, transport history and conditions during accumulation. Resulting grain-size parameter values can be influenced by selected method of granulometric measurement. For the variability determination of the coarse-sediment grain-size parameters in the longitudinal profile of 4 selected headwater streams in flysch Outer Western Carpathians we performed granulometric analysis of channel bars and bedload material by 3 different methods: wet sieving, optical granulometry (digital photoanalysis) and direct clast measurements using Wolman (1954) sampling method. Moreover, on 2 of the studied streams, method of 5 largest boulders (Galia, Škarpich 2013) was applied to verify ability of this tool to assess the channel-forming processes and to detect the (dis)connectivity in coarse sediment transport.
As compared with results from wet sieving and Wolman (1954) sampling, results obtained by optical granulometry are not variable enough to correctly identify the influence of particular factors (e.g. influence of claystone ratio in bed sediments, character of sediment inputs or human interventions) on the fluctuation of the sediment grain-size parameters in the longitudinal profile. Thus, optical granulometry is not a proper tool for the grain-size analysis of the fluvial sediments in the flysch mountain headwater streams.

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OH LAKE, WHERE ART THOU?

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Keywords: landscape changes, proglacial stream, river pattern, ice-dammed lake, Nordenskiöldbreen, central Svalbard

Terminoglacial area of the Nordenskiöldbreen glacier is characteristic by abrupt landscape changes caused by recent recession of the glacier and melt-water release. Post-LIA proglacial river system on the right flank of the glacier passed several flow-pattern changes. According to aerial orthophotos and our field survey, a series of changes from braided to vertically incised channels and vice versa can be recognized. During the ablation season of 2012, the river piracy caused the abandonment of former braided stream and formation of new channel in direction perpendicular towards the glacier snout. Blocking of melt-water stream by glacier body caused the formation of up to 30 m deep ice-dammed lake. The sedimentary sequences documented in the field support the hypothesis of a river prograding into the lake with rising level. The sudden subglacial drainage of the lake was followed by vertical incision of a new high-energetic stream several meters into the glaciofluvial and glaciolacustrine sediments and bedrock. Large amounts of fresh, unconsolidated glacigenic, glaciofluvial and glaciolacustrine material in the vicinity of the glacier allowed an excellent sedimentological and geomorphological preservation of these events.

LATE HOLOCENE CLIMATE AND LAND-USE CHANGES RECORDED IN THE BEČVA RIVER FLOODPLAIN

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Keywords: environmental change, river pattern, sedimentology, geophysics, alluvium, Bečva River

To reconstruct the geomorphic and sedimentary imprint of the Late Holocene anthropogenic and natural environmental changes in the erosion prone catchment, we studied the alluvial record of the Bečva River floodplain (Outer Western Carpathians, Czech Republic). Coring, geophysical sounding (ERT, GPR and SSR methods) and lithological analyses of floodplain deposits supported by AMS dating of charcoal fragments, subfossil seeds and trunks enabled the establishment of the main stages of Late Holocene floodplain evolution. During the Late Atlantic and Early Subboreal periods, gravel aggradation and braided environments occurred in the

studied floodplain. The Late Subboreal and Early Subatlantic are characterised by overbank sedimentation, and the Middle Subatlantic is marked by the recurrence of gravel aggradation. A major incision phase took place during the Medieval Warm Period (10–11th centuries). The onset of overbank sedimentation in the 15th century correlated with ongoing deforestation of the lower parts of catchment, and colonisation (so called Wallachian) of the mountain ridges during the 16–17th centuries further accelerated this process. During the 20th century, reforestation of mountains and river-channel training resulted in a significant incision phase. Our data suggest that climate fluctuations were major driving factors for the morpho-sedimentary evolution of the floodplain approximately up to the 12th century, whereas in the latter evolution period, land-use changes superseded natural factors. This transition occurred more than one millennium later than in other Central and Western European catchments.

NEW APPROACHES IN THE RESEARCH OF THE SILTATION DYNAMICS OF THE MLADOTICKÉ (ODLEZELSKÉ) LAKE BASIN

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Keywords: lake basin morphology, siltation dynamics, suspended sediments, Mladotické (Odlezelské) Lake

The study area of the presented research is the Mladotické (Odlezelské) Lake catchment. The Mladotice Lake (4.7 ha) is situated in the western part of Bohemia in the Czech Republic. In May 1872 a landslide as a result of extreme rainfall event blocked the Mladotický stream valley and has created the Mladotice Lake. Due to the exactly known date of its genesis the Mladotice Lake catchment area represents a unique research locality. There is a very dynamic evolution in the lake basin mostly aggradations and siltation. Over 4 meters of fine grained sediments are deposited on the lake bottom. Uninterrupted sedimentary records in the lake basin can improve knowledge about the impact of recent climate changes, flood events variation and land use changes which have happened during the 20th and the beginning of 21st century. The lake catchment area is 46.5 km² and about 50% of this area is being intensively farmed. The aim of the current study is based on the evaluation of sediments transport in the relationship to the lake basin siltation. The actual research develops previous results mostly related to the lake bathymetry mapping and the lake sediments stratigraphy and geochemistry analysis (Janský et al., 2010, Schulte et al., 2006). The first bathymetric mapping from 1972 and the second one from 2003 are followed for comparison with a new measurement which was made in spring 2013. The new bathymetric mapping (10 year after last measurement) was measured by modern technology SonTek Flow Tracker and SonTek ADCP River Surveyor and by mobile Leica total geodetic station (TCRP 1202 with Smart Station). Using the ADCP gave us more than 20000 depth measurements with GPS tracking which were used for creating a new bathymetric map. The evaluation of the sediments transport has been realized by continuous measurement of turbidity by multiparametric sound ISY since 2012. The water samples from the automatic water

sampler ISCO are used for evaluation of important flood events and for assessment of relationship between turbidity and suspended sediments concentration (observed since 2012 as well). The monitoring of the discharge and precipitation is undertaken by the network of digital automatic ultrasonic and pressure water level gauges and the fully automatic meteorological station has used the remote data transmission via the GSM/GPRS network in Mladotice Lake catchment area since 2006. Due to these studies and measurement results it is possible to specify yearly sediment inflow to the lake and predeterminate the siltation evolution in the future. These results will be used for compilation of erosion-sedimentation modeling in the relationship of land use and climate changes.

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GRAVEL-BED VERSUS SAND-BED ANABRANCHING RIVERS SEDIMENTATION EXAMPLES FROM DANUBE AND VISTULA RIVERS' FLOODPLAIN DEPOSITS

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Keywords:, anabranching river, sediment analysis, overbank deposits, Danube & Vistula river

The assessment of the conditions of overbank deposit sedimentation on the two different multichannel river valley was the purpose of the study. After Rosgen (1994) the classification of natural rivers we classified as follows: (1) the Danube river system in Bratislava represents the gravel-bed, anatomizing stream. (2) the lower Vistula river system is an example of the sand-bed anatomizing stream. For this reason we chose the overbank deposits of these two rivers for the analysis of selected hydrodynamical parameters (flow regime, the maximum shear velocitie) and the lithodynamical conditions of fluvial transport environment, importance share of traction, saltation and suspension loads in the deposition of alluvia. The analyses we conducted using Passega (1964), Visher (1969), Viarda and Breyera (1979) and Sly et al. (1983) methods.

Overbank deposit of both rivers were accumulated mainly in low flow regime condition, but some of the Danube river deposits (5%) were deposited in the high flow regime condition. Maximal shear velocity registered in the Danube river overbank alluvia calculated based on C=-8,5 phi was ca 6 ms^{-1}. While the shear velocity in the Vistula river overbank deposits estimated from C=-3,3 phi was 1,7 ms^{-1}. Based on analyses of distribution of the samples on the CM diagram (Passega 1964) alluvia, we concluded that graded and uniform suspension had a dominated role in the deposition of the overbank alluvia. However, ca 6% of grain of the Danube river overbank alluvia were deposited from traction. Whereas, the analyses of cumulative curves of grain size composition (Visher 1969; Viarda and Breyera 1979) of samples from the both rivers show that independedly from the type of sediments, generally overbank alluvia were accumulated from saltation and intermitted suspension. Moreover, the Danube river overbank deposits differ from the Vistula river in the accumulation with the higher content of the traction and the bigger grain size in each type of the transport.
Typical structure representing a flood flow changes during a single flood episode is the flood cyclothem in the Danube river floodplain and the flood rhythmite in the Vistula river floodplain.

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INFLUENCE OF DAM ON RIVER CHANNELS PATTERN CHANGES CASE STUDY FROM WLOCLAWEK RESERVOIR ON VISTULA RIVER

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Keywords: river channel pattern, fluvial geomorphology, remote sensing, lower Vistula river

The lower Vistula river represents a multiple-channels fluvial system. Its channel pattern consist of the main channel of braided river type and side channels of single straight or meandering type. According to the Smith and Smith (1980) theory of a fluvial system evolution the lower Vistula river system is in the transition phase from a braided river to a anastomosing river. Contemporary, this transformation takes place with a large influence of anthropopression caused by the construction of the Wloclawek reservoir in 1970 and its functioning during the last 40 years.

We analysed two about 10 km fragments of the valley: (1) 10 km downstream from the dam and (2) 70-80 km upstream from the dam, in the area of the reservoir backwater. Changes in the river channel pattern, as well as the types and sizes of inter-channels forms, we traced on a series of aerial photographs from before the dam construction and over 30 years after it. We carried out the geomorphometric analysis of the channel pattern and the inter-channel forms with the use of the Brice (1975) and the Brice and Blodgett (1978) methods.
On that base we concluded: (1) in both fragments, upstream and downstream from the dam, the number of inter-channel forms (island and inter-channel areas) declined; (2) simultaneously the number and size of channel forms (central bars) decreased; (3) sandy bars were transformed to islands solidified by vegetation; (4) islands with established vegetation increased their surface area by evolving towards the inter-channel areas; (5) extensive inter-channel areas were turned into the floodplain as a result of the disappearance of side channels; (6) surprisingly, the main channel upstream from the dam reduced its width whereas the one downstream from the dam widened the main channel
Finally, functioning of the Wloclawek reservoir accelerated forming of the multiple channels fluvial system similar to the anabranching sand-dominated island river system (Nanson, Knighton 1996).

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CHRONOLOGY OF PROCESSES IN HIGH-GRADIENT CHANNELS OF MEDIUM-HIGH MOUNTAINS AND THEIR INFLUENCE ON THE PROPERTIES OF ALLUVIAL FANS

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Keywords: dendrogeomorphology, alluvial fan, debris flow, flood, the Moravskoslezské Beskydy Mts

High-gradient channels are the locations of the greatest geomorphological activity in medium-high mountains. The channels' frequency and character influence the contemporary morphology and morphometry of alluvial fans. There is currently no detailed information regarding the frequency of these processes in high-gradient channels and the evolution of alluvial fans in

medium-high mountains in Central Europe. This study in the Moravskoslezské Beskydy Mts. analysed 22 alluvial fans (10 debris flow fans and 12 fluvial fans). The processes occurring on the fans were dated using dendrogeomorphological methods. A total of 748 increment cores were taken from 374 trees to reconstruct 153 geomorphological process events (60 debris flow and 93 floods). The frequency of the processes has been considerably increasing in the last four decades, which can be related to extensive tree cutting since the 1970s. Processes in high-gradient channels in the region (affecting the alluvial fans across the mountain range) are predominantly controlled by cyclonal activity during the warm periods of the year. Probable triggers of local events are heavy downpours in the summer. In addition, spring snowmelt has been identified as occasionally important. This study of the relations affecting the type and frequency of the processes and their effect on the properties of alluvial fans led to the creation of a universal framework for the medium-high flysch mountains of Central Europe. The framework particularly reflects the influence of the character of hydrometeorological extremes on the frequency and type of processes and their reflection in the properties of alluvial fans.

MONITORING OF A COMPLEX SLOPE DEFORMATION ČEŘENIŠTĚ USING A TIME-LAPSE RESISTIVITY PROFILING

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Keywords: ERT profiling, time-lapse monitoring, hydroclimatic monitoring, geodetic monitoring, Čeřeniště complex slope deformation

Studies of complex landslides bring us a knowledge on structure and behaviour of individual parts of such slope deformation which can differ in several aspects. In case of Čeřeniště complex slope deformation (České Středohoří Mts.) we can distinguish upper part close to the headwall which is affected by deep-seated gravitational processes such as spreading and block subsidence of basalt blocks and tuffites. Central part is formed by flat block (platform) which is followed by active landslide built by pyroclastics and tuffites.
This study is aimed to the distal, recently active part of the slope deformation. After the ERT survey along the whole deformation (2012), in 2013 resistivity monitoring of active colluvial lobe was implemented in form of a transversal profile. The profile is 189 m long, of which first and last 40 m reach surrounding slopes. Electrode stepping was 3 m, altogether 64 electrodes were used in Wenner-Schlumberger array. Also, Wenner Alpha and Dipole-dipole arrays were tested.
Repeated resistivity measurements with one month period together with the monitoring of precipitation, air and soil temperature and with soil moisture gauges are aimed to bring valuable and detailed information on conditions in the moving earthflow.

Furthermore, using the monitoring of movement velocity based on repeated geodetic measurements and laser scanning we shall be able to determine the causal connection between precipitation, soil saturation and (re)activation of mass movements. The time-lapse resistivity survey would serve as an effective tool which can yield information on subsurface water saturation and its changes and, also, it could help to reveal relations within the system „precipitation – subsurface saturation – mass movement activation".
The permanent profile was also used as the testing site for other resistivity techniques, such as vertical electrical soundings (VES) and resistivity profiling (RP).

MULTIDISCIPLINARY GEOPHYSICAL SURVEY OF DEEP-SEATED GRAVITATIONAL SLOPE DEFORMATIONS (CASE STUDIES FROM THE FLYSCH OUTER WESTERN CARPATHIANS)

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Keywords: multidisciplinary survey, electrical resistivity tomography, ground penetrating radar, seismic tomography, microgravimetry, deep-seated gravitational slope deformations, crevice-type caves, flysch, Outer Western Carpathians.

The phenomenon of the deep-seated gravitational slope deformations (DSGSD) is well-known from the flysch Outer Western Carpathians. The majority of the slopes in this area is affected by DSGSD with several stages of its development. The presented study is dealing with morphologically very well pronounced ridge disintegration with typical scarps, block movements and trenches or crevice-type caves, and prevailing processes of spreading, toppling and rotational sliding. Multiple geophysical methods were applied in investigation of DSGSD in the Moravskoslezské Beskydy Mts., namely at Záryje site (Radhošť Massif, 1129 m a.s.l.) and on Ropice Mt. (1083 m a.s.l.). Both localities are formed by sandstone dominated, thick-bedded flysch rocks of the Godula Member (Silesian Unit).
The multidisciplinary geophysical survey of DSGSD combined the methods of electrical resistivity tomography (ERT), ground penetrating radar (GPR), seismic refraction (SR) and microgravimetric measurement, all based on the previous geomorphological and speleological investigation.
Basic survey method, ERT, revealed high resistivity anomalies (> 10 000 ohm.m), which are usually caused by the opened crevices, tension cracks or even caves (the typical indications of disrupted zones within the rock massif). Moreover, these anomalies correspond to morphological evidence of ridge disintegration, such as near-scarp trenches or toppled counter-scarp blocks.

Similarly, the results of microgravimetric measurements display significant gravity anomalies situated in the subsurface, which are closely related to the toppled blocks. The georadar (GPR) measurements, despite the limited penetration depth, offered useful information on signal attenuation of the near-surface layers. It confirmed low and high conductive zones within the heterogeneous anisotropic flysch colluvium and these results correspond to the resistivity models. The shallow seismic refraction method confirmed very complex geological structure, which is furthermore highly affected by tectonics (faults, crevices), mass movements and weathering. Results of SR reveal very strong attenuation of the seismic waves and, thus, the registered signal was very week and noisy. However, even such results brought very useful information: i) the studied disrupted flysch rocks are very complex and heterogeneous; ii) interpretation of geophysical data and models might be very complicated, and requires more additional information (on lithology, structure, geomorphic or speleological conditions); iii) microgravimetry and ERT have good potential to reveal strong anomalies even in such complicated situation; iv) wavefield-based geophysical methods (GPR, SR) have only limited applicability, namely due to a strong signal attenuation and heterogeneity (and also anisotropy) of the subsurface enviroment.
The application of the multidisciplinary geophysical survey offered very useful and complex information on the subsurface within the investigated DSGSD. Geophysical measurements brought valuable information not only on geological structures or lithology, but also confirmed some hypotheses of the slope development. Last but not least, the performed survey brought very useful information on applicability of each geophysical method as well as on applicability of the whole geophysical complex.

ORIGIN, TRIGGERS AND SPATIO-TEMPORAL VARIABILITY OF DEBRIS FLOWS IN HIGH-GRADIENT CHANNELS (A CASE STUDY FROM THE CULMINATION PART OF THE MORAVSKOSLEZSKÉ BESKYDY MTS.; CZECH REPUBLIC)

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Keywords: debris flow, high-gradient channel, dendrogeomorphology, granulometric analysis, the Moravskoslezské Beskydy Mts.

High-gradient channels are integral parts of fluvial system in medium-high mountains and concentrate large amount of energy to origin of mass-wasting processes, such as debris flows. This study from the Moravskoslezské Beskydy Mts. tries to give a comprehensive view on debris flow initiation, spatio-temporal variability and potential triggers of these rapid channel processes. Main approach was dendrogeomorphic dating of affected trees supported by granulometric analysis of sedimentary fill and basin morphometric analysis. Geomorphological mapping revealed the most active zones of debris flow occurrence. Accurate tree-ring series dating of 55 samples (both deciduous and coniferous species) with growth disturbances showed 9 different debris flow events during the last 75 years with the highest peak in 1997. Meteorological

conditions (extreme daily precipitation or spring melting of snow) allowed origin of debris flows despite the fact that recent sediment source areas occur sporadically. This leads to argument that reactivation of older deposits is the main process of recent debris flows origin. On the other hand, between 1950s and 1980s, when both basins were less covered by trees, there was possibility of higher slope and channel coupling and supplying sediments so debris flows should initiated even in less extreme meteorological conditions.

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BLOCK FIELDS OF THE EASTERN SUDETES: A GEOMORPHOMETRIC APPROACH

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Keywords: Block fields, Periglacial covers, Geomorphometry, GIS, Sudetes Mts.

Block fields are characteristic elements of an inherited Pleistocene periglacial landscape of the Sudetes Mts. (Migoń, Traczyk 2003). The currently non-vegetated block field occur in the Karkonosze Mountains and the Jizera Mountains, but are also common in the highest parts of the Eastern Sudetes in the Śnieżnik Massif (1425 m) and Hruby Jeseník Mts (1491 m).
Utilizing an orthophotomap published in Google Maps and using on-screen vectorization method, as many as 124 block fields in the Śnieżnik Mssif and 258 fields in Hruby Jesnik Mts. were identified and mapped.
Geomorphometric parameters of the study area were determined on the basis of a DEM produced using Copernicus data and information funded by the European Union - EU-DEM layers (EU-DEM). The EU-DEM is a 3D raster dataset with elevations captured at 1 arc second postings i.e. about every 30 metre. Based on this DEM, the following primary and secondary parameters of relief were calculated using SAGA GIS software: Slope, Aspect, SAGA Wetness Index (SWI), Curvature Classification, Potential Direct Insolation (PDI). In the next step, using the QGIS

program (QGIS Development Team, 2014) and Zonal Statistics method of parameters defined above were calculated for each field block.
The results of the analysis show that the majority (45%) of block fields in the Śnieżnik Massif is located at the altitude above 1300 m a.s.l., on convex-linear (VL) slopes (31%). Over 60% of block fields has an inclination from 15 to 25º. In the Śnieżnik Massif block field located on slopes with an eastern aspect (35%) dominate. SWI and PDI parameters indicate that 87% of block fields are situated on relatively dry slopes (SWI <10) and 66% of them occur on surfaces that receive high direct solar radiation dose (PDI from 3.5 to 5 kWh/m2). In the Hrubý Jeseník Mts block fields are distributed uniformly from 800 to 1400 m a.s.l. In each 100 m altitude interval 16 to 20% of block fields occur. As in the Śnieżnik Massif, most of the block fields has an inclination from 20 to 25º (36%). They are situated mainly on the western (29%) and south-eastern (23%) slopes. In contrast to the Śnieżnik Massif, block fields in the Hrubý Jeseník Mts. occupy mainly linear (LL - 23%) or linear-convex (LV – 22%) slopes. Block fields in the Hrubý Jeseník Mts. are located on dry (SWI <10 – 66%) and low damp slopes (10-11 SWI - 26%) and typically (22%) on slope surfaces that receiving moderate doses of surfaces direct radiation (PDI from 3 to 3.5 kWh/m2).
In conclusion, the main factors to determine the formation of block fields in the Eastern Sudetes are the shape and inclination of slope, while the role of slope aspect and altitude are minor. In addition, a relationship between moisture and insolation, and the frequency of appearance of block fields is observed.

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SORTED PATTERNED GROUND IN THE PETUNIABUKTA, BILLEFJORDEN, CENTRAL SVALBARD

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Keywords: sorted patterned ground, frost sorting, morphometry, Svalbard

Sorted patterned ground is one of the most characteristic features in the periglacial landscape of the Svalbard archipelago. Its distribution and morphology is controlled by local freeze-thaw

regime that is influenced by topography, ground material, hydrology, snow cover and vegetation. Geomorphological mapping, morphometrical measurements, ground thermal monitoring and sedimentological analyses of active permafrost-related sorted patterned ground are therefore conducted in order to improve the understanding of genesis, process dynamics and environmental constraints of these periglacial landforms as well as to obtain the basis for comparative study with its relict equivalents in mountainous areas of Central Europe.
Here, the preliminary results of the morphometric analysis of sorted patterned ground from the western part of the Petuniabukta, Billefjorden, Central Svalbard (79° N), are presented. Well developed large-scale sorted patterned ground, including circles, nets, polygons and stripes, is mainly found on the raised marine terraces and adjacent flat-topped mountain ridges. Glacier forelands deposited since the Little Ice Age are occupied by rare small-scale and poorly developed patterns. The sorted patterned ground consists of a center of fine-grained material, which is surrounded by coarse borders of open-work fabric. The diameters of the studied landforms range from several decimeters to up to ~5 m. Their heights reach up to ~0.5 m.

Acknowledgement
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GEOMORPHOLOGIC RESEARCH IN PERU – CORDILLERA BLANCA AND MACHU PICCHU

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Key words: natural hazards, risk, landslides, Cordillera Blanca, Machu Picchu

Geomorphological research in Peru has been oriented towards two areas of interest: Machu Picchu, where topics of slope movement were studied and the Cordillera Blanca which is the focus of our interest since 1996. The main objective of the Machu Picchu studies was to monitor and subsequently interpret slope movements inside the archaeological site. Without any earthquake the archaeological site seems to be rather stable, on the other hand several other types of slope deformations were identified in the close surrounding - e.g. rockfalls, debris flows (Vilímek et al., 2006 and 2007). Our field research in the Cordillera Blanca was focused on the geomorphological effects of neotectonic movements along the main Cordillera Blanca fault (Vilímek and Zapata, 1998) where a TM-71 optical-mechanical crack gauge was installed. Evaluation of various types of natural hazards was done using the database of DesInventar, where landslides were identified as the main hazardous process. Later, we identified a prehistoric

avalanche under Mt. Huascarán (Klimeš et al., 2009) and clarified the triggering factors for a landslide near Rampac Grande (Klimeš and Vilímek, 2011). Our first GLOF study (Glacial Lake Outburst Flood) was done for Lake Palcacocha (Vilímek et al. 2005) whereas our most recent work is oriented towards GLOF modelling and hazard evaluation methods (Klimeš et al., 2014; Emmer and Vilímek, 2013). Currently, we are continuing to work on new methodology for hazard evaluation, on international networking (e.g. Vilímek et al., 2014) and on identification of potentially dangerous glaciers/lakes connected with ongoing deglaciation.

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Excursion guide

State of geomorphological research in the year 2014

Exkurzní průvodce

Stav geomorfologických výzkumů v roce 2014

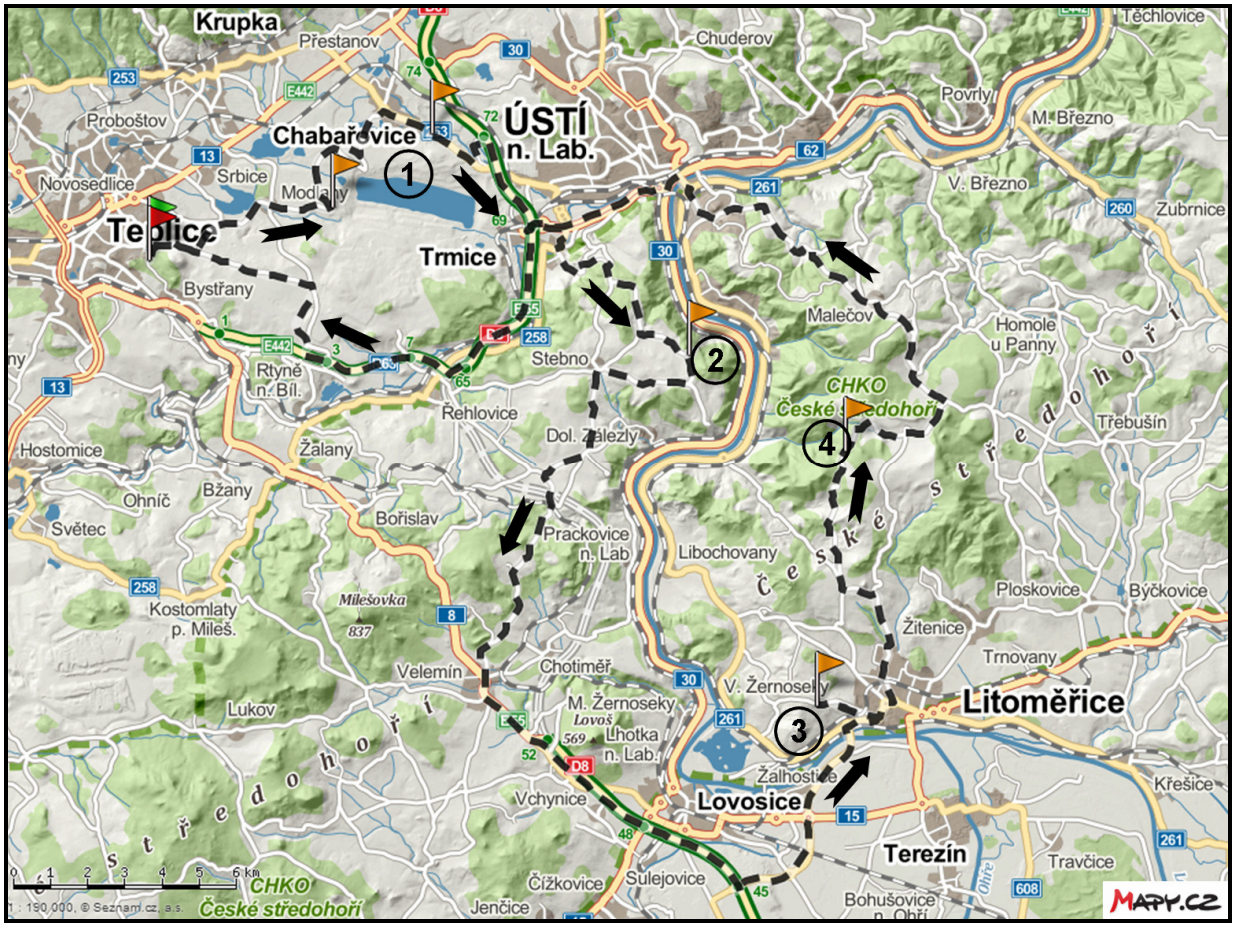
Authors

Autoři

Pavel Raška – Jan Klimeš – Petr Tábořík – Filip Hartvich – Tomáš Marek

Ústí nad Labem – Praha – Teplice 2014

Excursion trip and stops



Stop No. 1: Chabařovice open-cast brown coal mine and the Spolchemie waste dump

1.1 Coal mine pit

The Chabařovice basin is part of the N Bohemian brown coal basin, developed during the young Caenozoic tectonic activity (Saxonian tectonic phase) as a response to Alpine orogeny. As a result of subsequent limnic sedimentation, the area stretching from the Sokolov basin in the W to the easternmost margin at the excursion site is rich of brown coal deposits. These have been subject to mining at least since the 17thj century, but the intensity and area of mining gradually increased especially since the mid-19th Century and after the World War II, leaving huge devastated or degraded area behind along with various environmental pollutants (e.g., dust particles, pollutions from brown coal power plants and industry connected with brown coal mining). The Chabařovice mine was closed in 1997.

The brown coal deposits in the Chabařovice basin are characteristics of high quality (low sulphur volume) and were subject to mining during 1977–1994 (total volume of 61 M tonnes have been extracted). After then, the plan for restoration has been launched – in 2010, the Milada lake has an area of 210 hectares. The restoration effort was constrainted by landsliding at the S part of the area, i.e. N slope of the Rovný hill. The hill is built by basaltic rocks of the Ústí formation and is surrounded by basin sediments and loess deposits. The oldest recorded landslide occurred in the vanished Rabenov village during the extreme rainfalls at the end of the 19th Century. In 1960s, during the construction of the highway connecting the Teplice and Ústí nad Labem city, the S part of the hill was subject to detailed geomorphologic mapping aimed at blocky slope deformation near the historical community of Stadice. After the restoration plan has been launched, the largest landslides affected the N slope of the hill following to the former open-cast mine. Three inclinometric probes were installed with a depth of 24 m and detailed geodetic monitoring has been launched. These works resulted in change of the restoration plan and construction of the retailing walls at the slope.

Afterwards, it was decided that the „wet“ mine re-cultivation will be most suitable, and after insulation of the area against underground waters the lake of 247 hectares with maximum water depth of 25 m and volume of 35 mil. m^3 was filled in years 2001–2010, when it reached designed level of 145.7 m. There is, however, a serious disadvantage of this method - accumulation of rather porous soils at the slope foot. Water can easily accumulate in this porous material and also subsidence can be expected. In short, it can be said that application of not always optimal stabilisation methods complicated the present day slope geometry adjustments.

There are therefore significant problems with the stability of the slopes around the lake. Already during the mining, it was noted that in the Chabařovice open mine pit up to one half of the slopes suffered from landsliding (Pichler 1998). This was mainly due to aquifer body on the contact of permeable Quaternary and overburden clays. The impermeable clays caused the water outflows into the upper stripping cut. Therefore, frontal slides developed along almost whole width of the first cut. From this fact the mining often benefited, for by controlled lowering of the cut stability artificial slides were induced and thus the clayey material was brought closer to the mining machine (Kůrka et al., 2001).

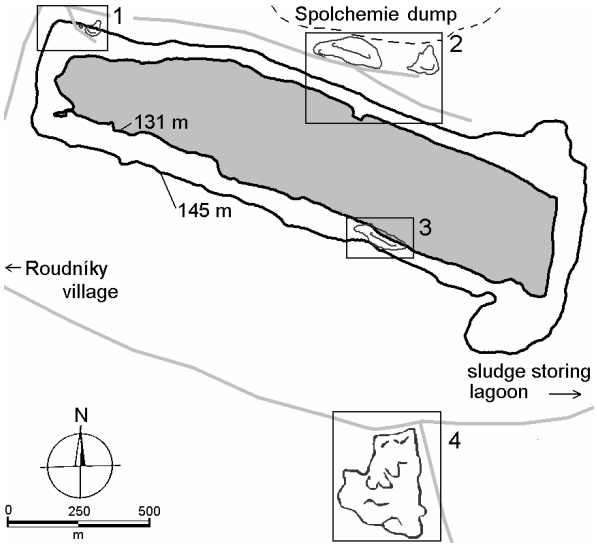


Fig. 1: Position of landslide sites Chabařovice mine pit.

The field mapping of landslides in the former Chabařovice open mine pit was performed in several campaigns during the years 2003 and 2005. Thus it was possible to observe not only the rearrangements of the terrain due to recultivation, but also the behaviour and changes of the landslides. During the first mapping campaign in July 2003, several landslides of various size were discovered (Fig. 1). All of them occurred in the deposits of barren material, cleared from the mine.

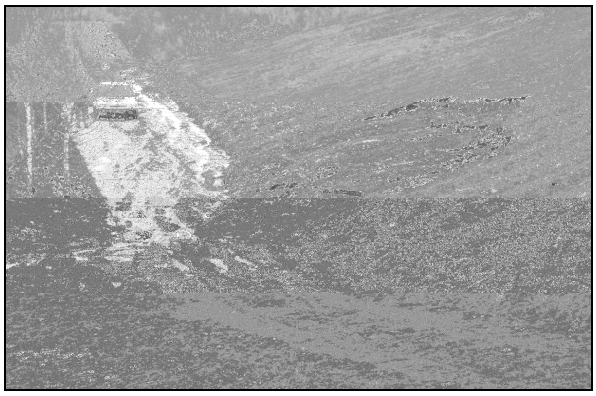


Fig. 2: Small reactivated landslide on the site No. 1 (February 2004).

Based on topographical map 1: 10 000 and CAD *dxf file of the mine (kindly provided by PKU corp.), field mapping information (water springs, landslides, bedrock material composition), 2 different DEMs (data by courtesy of PKU), finer for nearest vicinity of the lake and the other for wider surroundings, GPS documentation points and additional parameters from mine pit documentation, hazard maps were created.

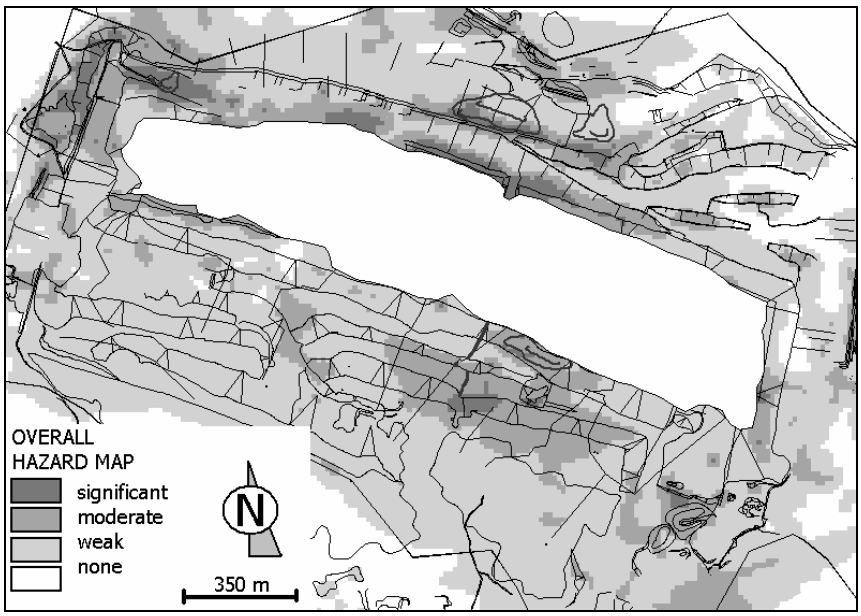


Fig. 3: Map overall hazard.

The overall hazard map (Fig. 3) indicates several zones of increased slope movements hazard, each for specific reasons. The northwestern corner of the pit has very steep slopes (exceeding the effective inner friction angle). Aside from that, there are water springs and repeated sliding has already occurred here. Continuing reshaping of the slopes during recultivation might deal with an important factor of hazard, the steep slope. Two separated strips approximately in the middle of the northern slope are both zones of steeper slope as well, but in each the hazard is escalated by different cause. Lower belt, situated on the very shore of the lake, is exposed to intensive abrasion due to its aspect and long wave fetch distance. Upper belt coincides with the former landslides and water springs.

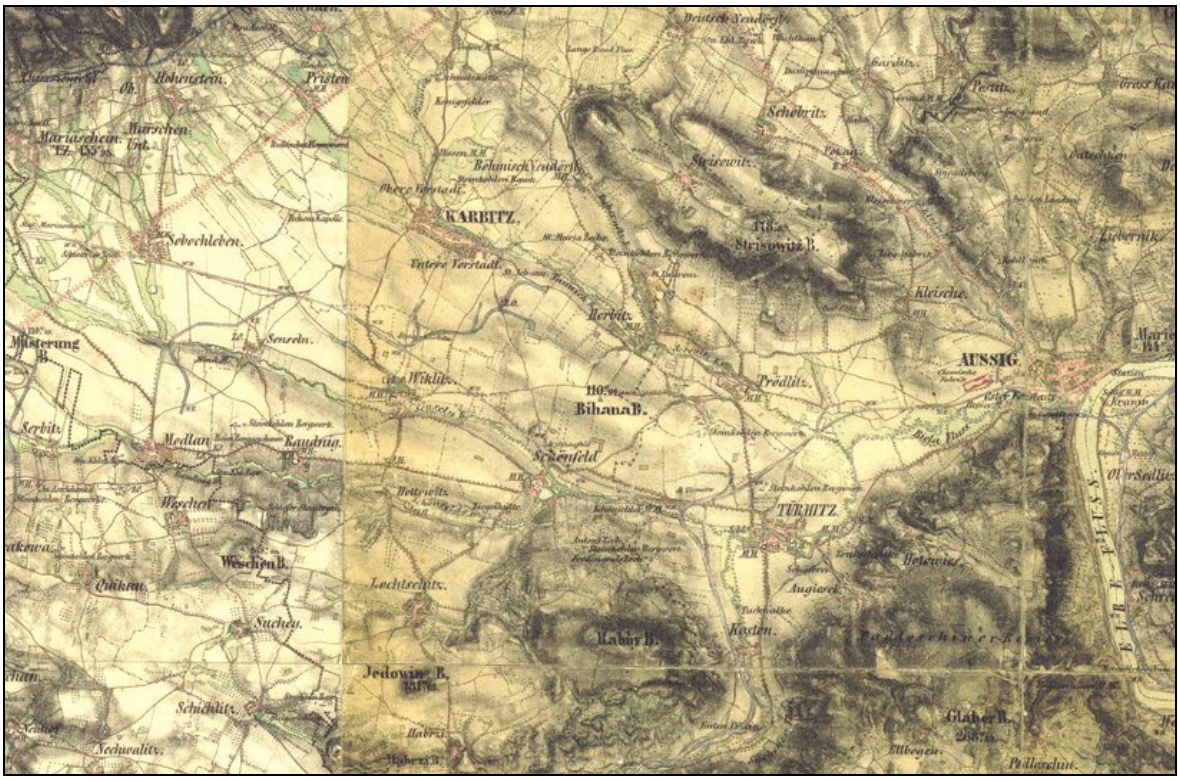


Fig. 4: II. Military map from the mid-19th Century (oldmaps.geolab.cz) of the Chabařovice area.

1.2 Spolchemie dump

Bordering to the open mine pit of Chabařovice on the NE, is situated a recultivated waste dump, owned by Spolchemie. a.s. The dump was active already since 19 th century, and was used for various waste materials, including dangerous or highly toxic (particularly in 1970ies), such as cans of hexachlorbenzen. The process of recultivation lasted from 2000 till 2008, when the water sewage system and treatment reservoirs were put into operation. The surface of the dump was insulated by layers of clay, loess soil and equipped with petexdrain network. However, due to formation of too steep slopes, particularly in the SW part of the dump (over 25°), the clayey insulation, layered parallel to the steep slope of the surface, repeatedly caused development of shallow landslides/landflows. Although there were efforts to stabilize the area with gabion walls, the slope deformations are still continuing to develop, particularly after heavy rains. The area was studied using geodetic and geophysical methods, and repeated surface mapping occurs every spring. The differential maps were constructed, for the period 2006–2012 and 2012–2013.

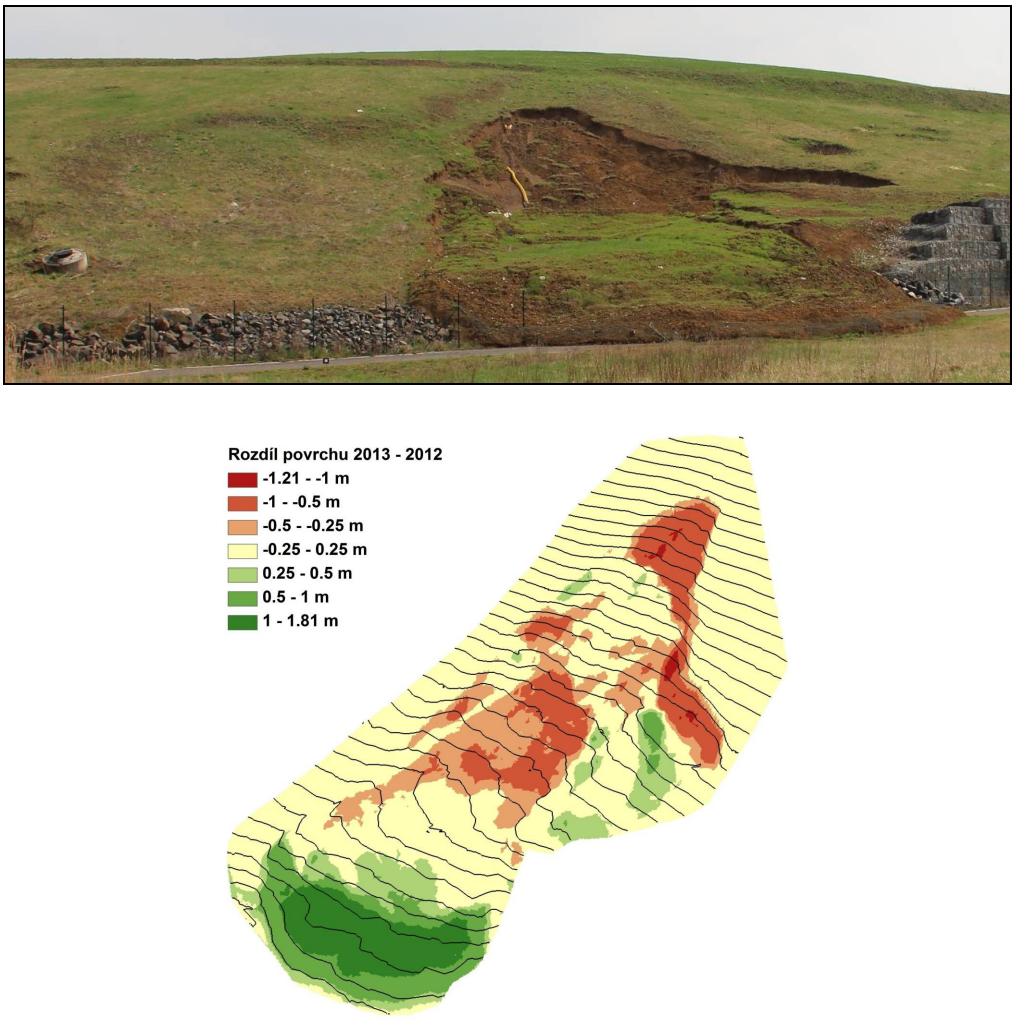


Fig. 5: Photo and differential model of the changes of the landslide on SW slope of the Chabarovice dump (2012–2013).

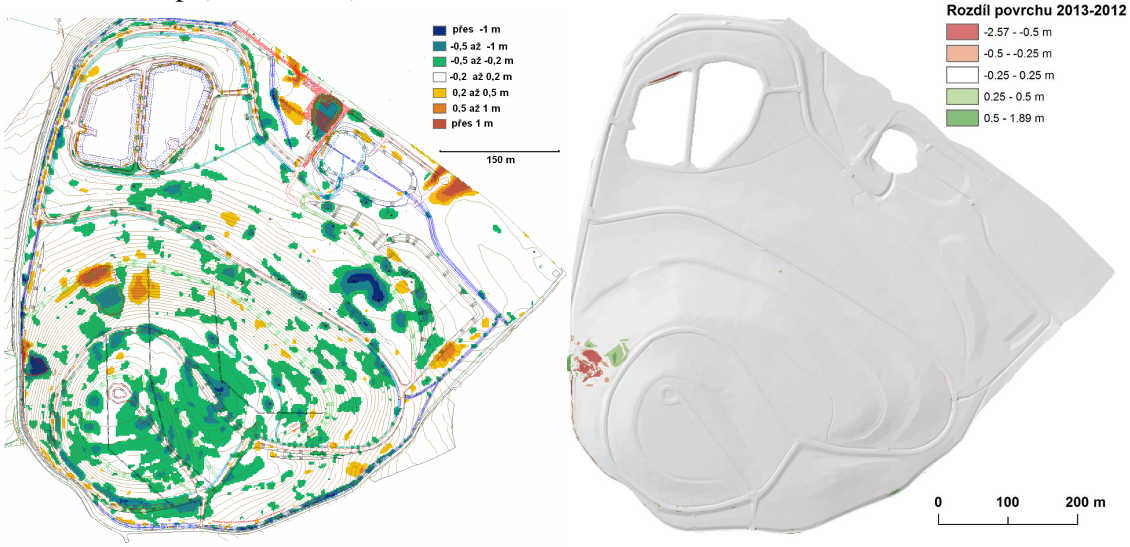


Fig. 6: Differential maps of the surface altitude changes between 2006–2012 (left) and 2012–2013 (right).

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Stop No. 2: Podlešínská pláň - The Čertovka landslide

The central part of the Labe/Elbe River valley (LRV) in the neovolcanic range of the České středohoří Mts. is a deep erosional structure that evolved due to consequent erosion of the Labe River into the uplifting terrain of the range during the Late Cenozoic. Tectonically induced erosion generated steep slopes frequently exceeding the angle of 30°. These slopes are formed by several superimposed volcanic bodies of different lithologies: basaltic rocks, volcanic breccias and volcaniclastic material. Underlying Cretaceous sediments of the Březno and Merboltice Formations (Coniacian to Santonian) are exposed in some segments of the valley. This structural and topographic setting results in a significant mass wasting. The predisposing conditions and triggering factors of landslides have been studied from the viewpoint of landscape evolution research and landslide susceptibility mapping

The Čertovka landslide at Vaňov south of Ústí nad Labem, Czech Republic, is developed in a steep slope of the Labe River Valley (LRV) (Fig. 7). A major episode of landsliding occurred in the first months of 1995, and the slope at Vaňov has been subjected to geological and geomorphological investigation since then. The landslide was found to be initiated at the boundary between Late Eocene to Oligocene basaltic lavas above and volcaniclastics below, with bedding dipping against the slope (anaclinal slope). The underlying volcaniclastics show tendency to argillization and have a much lower rock strength, which acts as an important factor of slope instability at the site. The Čertovka landslide is a complex slope deformation consisting of several landslides and flowslides, with boulder streams merging into a boulder accumulation further downslope. The headscarp area of the landslide developed at one of the structural levels built by basaltic lavas and forming step-like morphology of the valley slope. The headscarp coincides with the course of a regional E–W-striking Vaňov Fault which underwent multiple tectonic history and is associated with a dense fracture system including smooth slickensides on the headscarp (Fig. 8). Possible future landsliding will be initiated at structural levels of basaltic rocks, with the headscarps developed along fractures parallel to the Vaňov Fault. The probable gradual retreat of headscarps at the individual structural levels along the slope profile denotes a retrogressive landslide style.

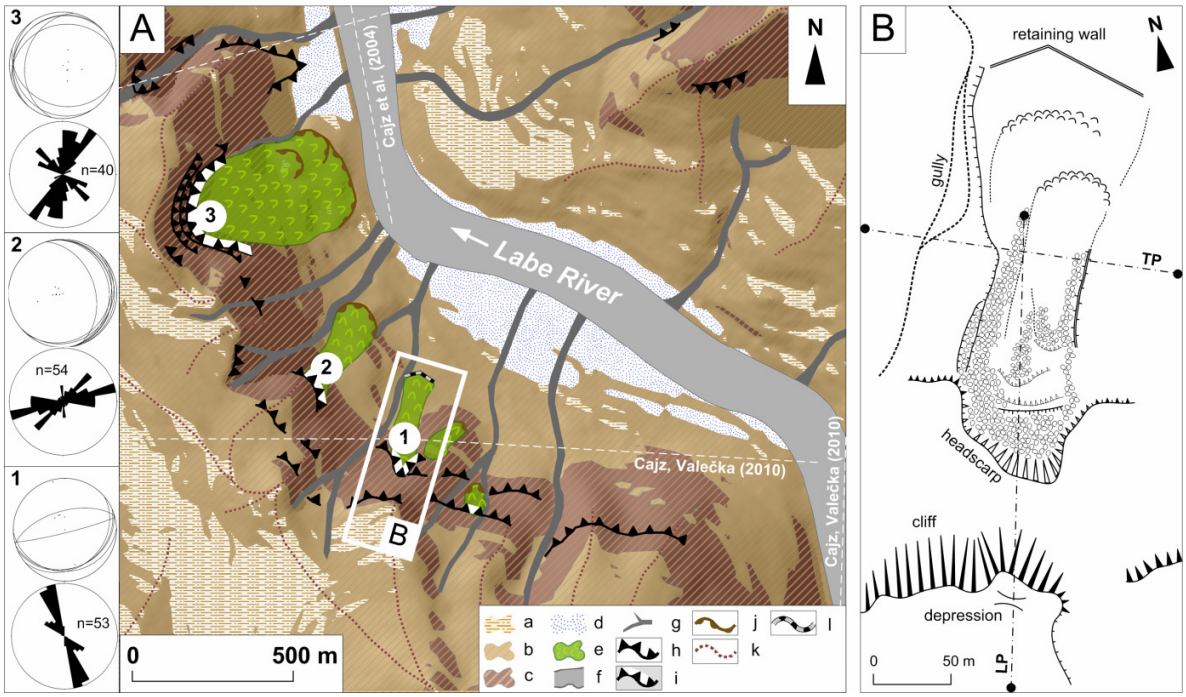

Fig. 7: Geomorphological sketch of the landslide complex at Ústí nad Labem – Vaňov.

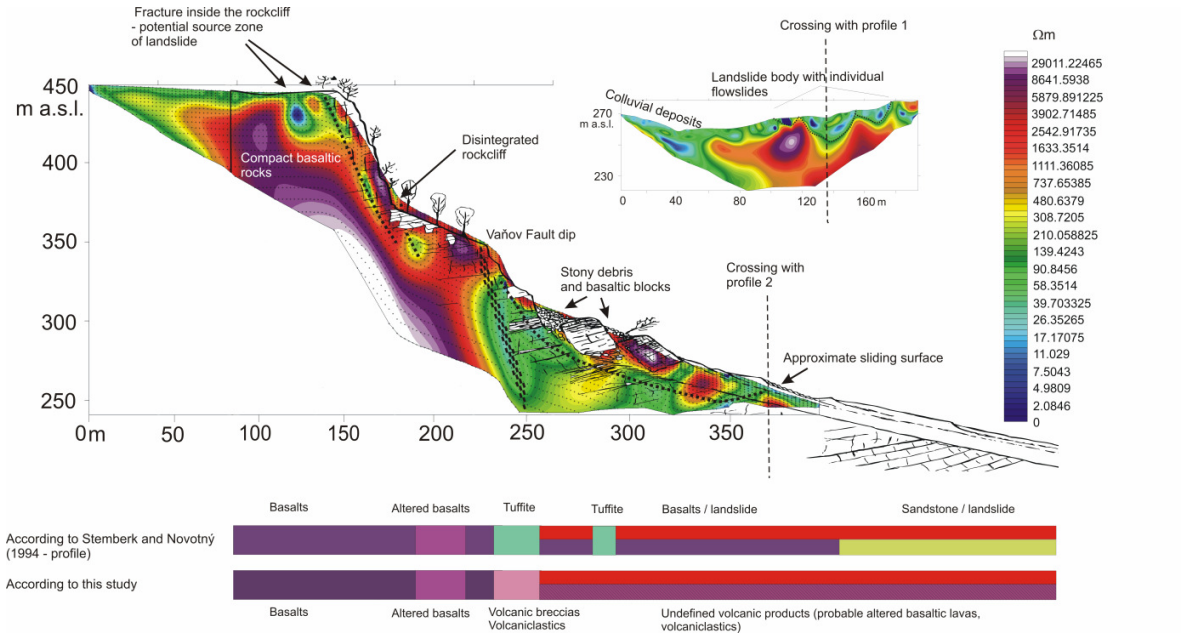

Fig. 8: ERT longitudinal profile at the Čertovka landslide.

Reference:

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Stop No. 3: Radobýl – Quarrying and it´s ecologicaleffects

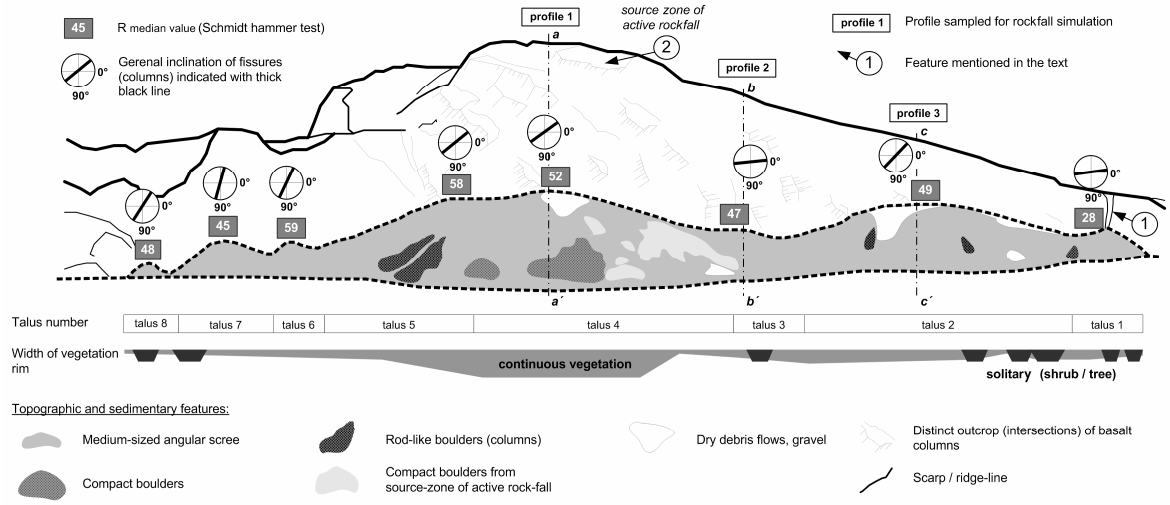
The neovolcanic mountain range of the Ceske stredohori Mts. has a unique natural value in the European context. At the same time, however, it has been a centre of basalt quarrying in the Czech Republic since at least the 19th century, with more than 150 abandoned quarries currently present in the area, 80 of them still well visible in a landscape (Table 1).

Table 1: Number and area of quarries in the České středohoří Mts.

Year	Number of quarries	AAQ (m^2)	TAQ (km^2)
1840s	80	2999	0.2
1953	55	17919	1.0
2007	37	59350	2.2

Explanation: *numbers refer to those quarries that were visible in a certain year; AAQ – average area of a quarry; TAQ – total area of quarries.

Radobyl Hill (399 m a.s.l.; 50° 31´ 47´´ N, 14° 5´ 31´´ E) is located 5 km from the town of Litomerice. The hill itself is composed of basalt exposed by a long period of quarrying. There are no existing reports on the quarrying activities at the site within the archive of the Czech Geological Survey or Regional historical archives, however, the first maps showing the quarry were from the III Military survey (1877–1880). The quarry was no longer in operation after World War II and was established as a natural reserve in 1963. The previous quarrying of the three stages has exposed high rockwalls that display the unique structure of basalt. The importance of this volcanic outcrop is illustrated by the fact that Radobyl Hill represents one of the comparative examples cited in the document that nominated the Giant´s Causeway for inclusion on the UNESCO natural heritage list. Apart from its geologic significance, the abandoned quarry is important because the characteristics of the ecosystem allow several species to occur at the site. For this ecological reason, the site is protected under NATURA 2000.



Among the interesting geomorphic features, the pseudocarst cavity at the quarry margin must be mentioned. The cavity is a result of deep-seated gravitional slope deformation

predisposed probably by tectonic conditions. Using the determination of osteological material in the loess sediments at the cavity ceiling, the age of the cavity was set to ca. 42 ky BP (Pokorný, Vrabec 2011).

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Stop No. 4: Čeřeniště landslide – Deep-seated gravitational slope deformation

Deep-seated gravitational slope deformation (DSGSD) is situated on the right bank of the Labe River, on the west slope of Kupa Hill (635 m a.s.l.). Length of the deformation is 1050 m and width 700 m.

Upper part of the slope is compound of rigid basalt layers up to several tens of meters thick intercallated with thinner layers of tuffs. Middle part of the slope is build by tuffs.

Main scarp of the DSGSD is up to 40 m high and 600 m wide. There is an extension trench dividing the main scarp from highly fractured basalt block, which is 400 m long and 200 m wide. Two of the widely opened tranches, which developed sub-parallel with the main scarp, are monitored with TM71 crack gauges since 1998 (13 on Fig. 9). Further down slope, there is gently counter slope dipping platform separated from the upper part of the DSGSD with high and steep slope. This slope starts with 15 m deep crack and has been monitored with extensometer tape since August 2013 (14 on Fig. 9). Lower part of the DSGSD bellow the platform is compound mainly of weathered basalts and tuffs, which are periodically subject to relatively shallow landslides. Distinct tilting of the trees confirms ongoing slope deformations. In 2010, landslide with assumed depth of shear plane of 5 m and total length of 500 m occurred there. This landslide has been monitored since December 2013 with geodetical and geophysical methods aiming on describing relationship between its movement and water saturation (15 on Fig. 9).

Ongoing monitoring of the DSGSD:

1/ Results of the TM71 crack gauge monitoring

Upper part of the DSGSD shows creep movement (0.5 mm/year), which vertical component accelerated during 2010 reflecting extreme precipitations. After several months of accelerated movements, the activity returned to the creep.

2/ Results of extensometer tape monitoring

Total length of the monitored slope is 90 m. The results show clear extension, which reached up to 5.5 mm on the steepest part of the slope. The opening of the 15 m deep crack was 2 mm since the beginning of the measurements (August 2013) until February 2014.

3/ Results of geodetical and geophysical monitoring

Repeating electric resistivity tomography measurements describe water saturation of the weathered mantle in relation to precipitations, which are monitored by nearby meteorological

station. Geodetical measurements describe movements of the landslide, which can be explained by changing hydrological conditions.

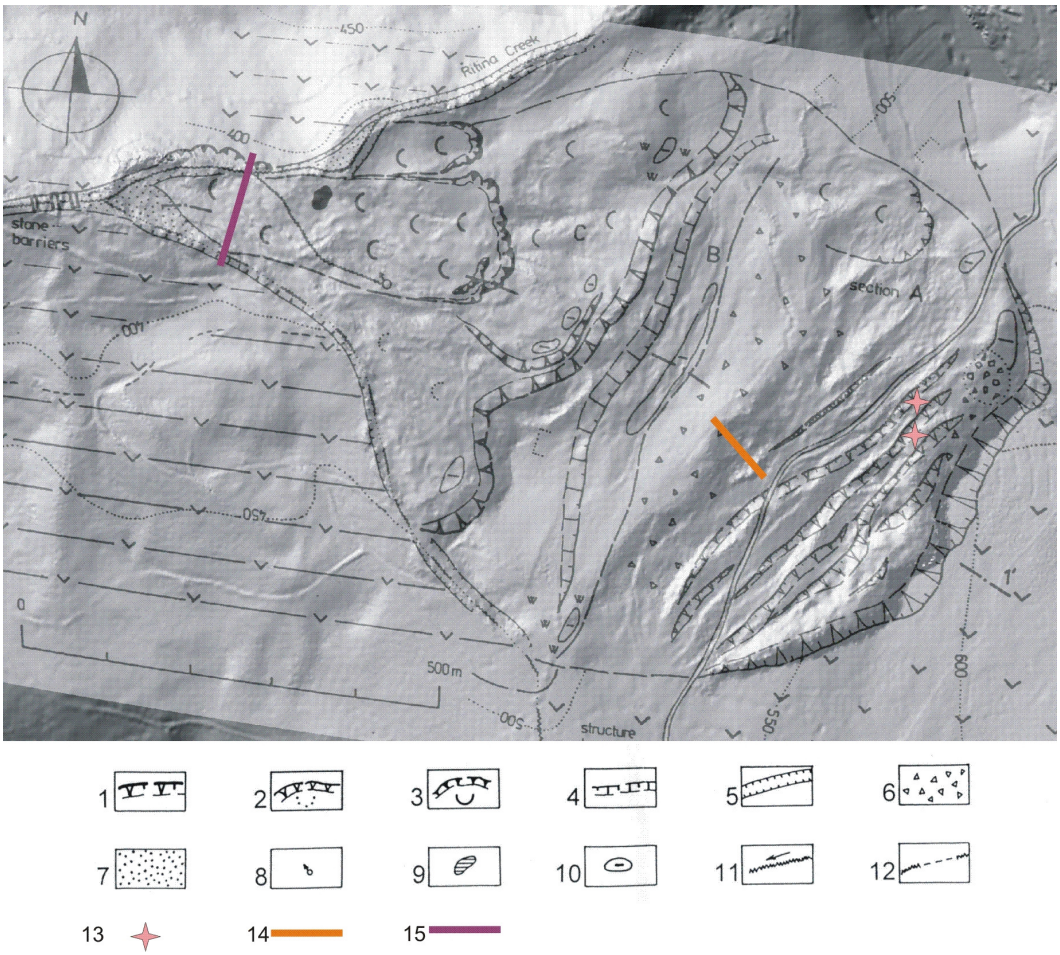

Fig. 9: 1 – main scarp of the DSGSD; 2 – main scarp of temporarily inactive landslide; 3 – main scarp of active landslide; 4 – scarp; 5 – gully; 6 – scree; 7 – alluvial sediments; 8 – spring; 9 – lake; 10 – depression; 11 – stream; 12 – temporary stream; 13 – TM71 crack gauge; 14 – extensometer profile; 15 – geodetic and geophysical monitoring profile.

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