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CENTRE OF BIOLOGY, GEOSCIENCE
AND ENVIRONMENTAL EDUCATION

ROLE OF FIELDWORK IN GEOMORPHOLOGY

ABSTRACTS

(Extended version)

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Association of Geomorphologists**

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Editoři: Pavel Mentlík, Václav Stacke

WELCOME TO PLZEŇ – THE HEART OF THE WESTERN BOHEMIA

Welcome to the 15. Czech Association of Geomorphologist's annual international conference. The meeting will focus on the role of fieldwork in geomorphology. We would like to stress importance and irreplaceability of fieldwork now in the time of extensive use of sophisticated data sources, tools and devices. Traditionally, a broad range of geomorphologic topics is covered by the conference agenda. However, the following key themes underpin the meeting:

I am become death, destroyer of the worlds. – Man as a creator and victim of landscape changes.

Once upon a time, there was an ice age. – Glacial and periglacial processes and landforms.

Water, water, every where! – Fluvial geomorphosystems on the roof of Europe.

We need to go deeper! – Tectonic and structural geomorphology.

Yes, how many years can a mountain exist, before it is washed to the sea? – Slope processes and slope-channel coupling.

Quo vadis? – Section opened for the geomorphology students and graduates.

We hope that you are stimulated by excellent talks and interesting posters and you enjoy the meeting.

Pavel Mentlík and Václav Stacke,
Markéta Pluháčková, Klára Vočadlova, Pavel Rak
and Michal Mergl (excursion guide)

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THE SUSCEPTIBILITY OF THE WIELKI ROGOŹNIK RIVERBANKS (PODHALE REGION) ON THE FROST PROCESSES

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Keywords: frost actions, multigelation, riverbanks, Podhale region

Riverbanks on the Podhale region (the border between Central and External Carpathians) are built with different types of material. In the southern part of the region (Gubałówka Hills) riverbanks are mostly rocky, in the northern part (Orava – Nowy Targ Basin) riverbanks are cut mainly in own alluvium, rarely reaching the rocky ground.

A classic example of a river with a large variation between the material building up the riverbanks is Wielki Rogoźnik River. It dehydrates Gubałówka Hills, Pieniny Klippen Belt and flows into the Dunajec River in the Orava – Nowy Targ Basin. Below the Dunajec River Gorge river bed is winding and has small longitudinal decrease (2.5 ‰). On both sides of the Wielki Rogoźnik river bed, there are different ages terraces, locally undercutting. It's important for the stability of riverbanks, that each terraces are composed of various deposits. It's influences on the different rates of destructive processes on riverbanks.

Terraces of Wielki Rogoźnik River are built with: 1 - coarse gravels of crystalline rocks with sand; 2 - coarse and medium gravels of sandstones with sand; 3 - fine gravels with sand; 4 - loamy-sand material. Sediments: 2 and 3 have a locally varying degrees of cementation, higher for older alluvial or greater content of limestone particles in fine-material cementing gravels. Sediments 4 are located on all terraces as cover with thickness 0.6-1.5 m.

The research is currently investigating how the above-mentioned types of sediments are susceptible to frost actions, and which of these sediments is resistant to these processes. For this purpose, on the above-mentioned types of sediments that build the riverbanks of Wielki Rogoźnik River erosion pins were installed. These were installed on the active sections of the riverbanks, where banks are devoid of turf. After each period of multigelation (oscillation of the ground temperature round 0°C) some defects in the riverbanks of the surface can be noticed.

As the current studies have shown the processes of frost actions of the marginal areas are most damaging for the clay, regardless of their layered or random structure. It is possible that it's influenced not only by the biggest moisturizing and largest sediment and silty mineral content (supported by frost having). It seems to be important that their position by the top of the bank where the freezing of sediments is the highest, because runs in two directions - from horizontal and lateral surfaces. The effect of freezing the clay tracks is the creation of numerous slots (horizontal and vertical) and

the front surface of the riverbank. On the upper surface of the riverbank (terraces) deep slit are formed parallel to the riverbank edge. The shattered parts of the shore (usually hoods turf) were displaced along these slits during the gravitational displacement.

Resistance of the riverbanks made of fine gravels packed in the sand is greater, especially when the cementing is strong. Frost processes penetrate deeper into the banks, but during the thawing the losses of the surface of riverbanks are relatively small.

The results of field studies indicate that frost action takes place in two stages. First, freezing the soil and its binding to the ice, and during the second step the effects of freezing are revealed. During the thawing of ice it comes to debris loosening from the surface of individual banks and their subsequent gravitational transfer to the foot of these banks.

DELINEATION OF BASIC MORPHOMETRIC – MORPHOSTRUCTURAL INDIVIDUALS OF THE WESTERN CARPATHIANS USING OBJECT-BASED IMAGE ANALYSIS

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Keywords: Western Carpathians, morphometric-morphostructural individuals, Object-based image analysis (OBIA), multi-resolution segmentation

Following the trends in contemporary geomorphology, demanding objective and reproducible methodological approaches, possibility of using principles of object-based image analysis (OBIA) for automated delineation of basic terrain units (or basic morphostructures) within the Western Carpathians region is proposed. Even though only morphometric characteristics (or land-surface variables) are used for objects delineation, since the active morphostructures are well-reflected in terrain morphology, these terrain units can be marked not only as morphometric but rather as morphometric-morphostructural individuals. First, DTMs of two land-surface variables representing terrain roughness were derived from SRTM DEM (Jarvis et al., 2008) resampled to spatial resolution of 80 meters and smoothed with r.denoise algorithm implemented in GRASS GIS (Stevenson et al., 2010). Slope gradient raster was computed using Characteristic scale script implemented in Landserf (Wood, 2009), and vertical dissection of terrain raster was computed as the standard deviation of elevation using focal statistics. To avoid skewed frequency distribution affecting further analysis, both input layers were transformed (normalized) using a tool developed by Csillik et al. (2015). Delineation of objects representing morphometric-morphostructural individuals was performed using multi-resolution segmentation (Baatz and Schäpe, 2000) implemented in the eCognition® Developer software. The values of segmentation parameters were picked relatively objectively using automated tool called ESP2 (Dragut et al., 2014). As an input into the segmentation, we considered individual layers as well as their combination. Several settings of objects hierarchy were tested, too. As a result of segmentation, relatively homogeneous objects in terms of terrain roughness were delineated. These objects clearly divide terrain not only into basic and simple block structures represented as mountain ranges and intermountain basins but in some cases also into their smaller parts. Moreover, the preliminary accuracy and significance assessment of the delineated objects was done by visual comparison and calculation of some of the quality measures suggested by (Heipke et al., 1997), against boundaries of the reference polygons – traditional expert-made (manually drawn) geomorphological regions of the study area as compiled by Minár et al. (2011). According to both visual comparison, and quality assessment, course of

both boundaries is in most cases fairly similar. Most of the mismatch between them is due to subjective decisions of the authors, using not only morphometric variables but also geology or geomorphological development as input, and using different mapping scale. Nevertheless, further work on object delineation (segmentation), as well as quantitative accuracy assessment of their boundaries is needed. However, using object-based approach, we should be able to provide more detailed alternative for this traditional regions and thus to create more objective input object basis for further analyses.

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APPLICATION OF LOW-COST UAV IN GEOMORPHOLOGICAL STUDIES IN THE ARCTIC

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Keywords: *low-cost UAV, photogrammetry, mapping, Arctic, Svalbard, Petuniabukta, Hornsund*

Usage of Unmanned Aerial Vehicles (UAVs) is constantly increasing during last years. Nowadays, they are available not only to the specialists in the field of aerial photogrammetry, but also for regular non-expert users. Their costs are also lowering, allowing acquiring basic ready-to-fly set for less than 1000 EUR. By using UAVs, scientists are able to map quickly and with high resolution large areas (up to several km²) and at very low cost, compared to airplane or helicopter surveys. UAVs can carry different types of sensors. Including most widely applied RGB cameras, NIR cameras, thermal, multispectral or even LiDAR sensors. The results are usually used for preparing orthophotomaps or digital surface/terrain models (DSM, DTM). Precision of UAV photogrammetry varies from several cm and is able to cover area from hundreds to tens of thousands m².

In this study we tested a low-cost ready-to-fly UAV DJI Phantom with a HERO3 Black outdoor camera attached. DJI Phantom is a quadcopter with a take-off weight of less than 1000g. A popular rugged outdoor camera HERO3 was mounted on a stabilized gimbal under the copter. We applied the UAV on four locations in Svalbard in order to obtain orthophotomaps and/or precise DTMs of the area. All four areas were surveyed during summer field season in 2014, two of them in the vicinity of the Czech field station in Petuniabukta and two nearby Polish Polar station in Hornsund. On each of the surveyed locations a minimum of 4 ground control points (GCP) was set up and measured. To obtain absolute geographic coordinates a dGPS Topcon HiPer+ was used in Petuniabukta and hand-held Garmin GPSMAP64s was used in Hornsund. Resulting images were processed in the lab using Agisoft PhotoScan Professional – Educational license (Agisoft 2014) software, an easy-to-use and affordable commercial solution.

For each surveyed area an orthophotomosaic was produced and DEM interpolated from a dense point cloud. For each area the resulting products were analysed and interpreted, including calculation of errors in the GCP positions.

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RE-ASSESSMENT OF PERMANENT SNOW-AVALANCHE PATHS IN THE KRKONOŠE MTS. BASED ON NUMERICAL RUN-OUT MODELLING

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Keywords: *snow avalanches, Krkonoše Mts., run-out modelling, RAMMS, hazard mapping*

Snow avalanche run-out modelling is a crucial issue in determining hazard areas and rescue operations in mountain areas. Within an applied project focused on snow avalanche hazard prediction in Czech mountains a re-assessment of permanent snow avalanche paths was performed in three Czech mountain ranges with recurrent snow avalanche activity: Krkonoše, Jeseníky and Kralický Sněžník. For the purpose of the study, two main data sources were used: i) LiDAR-derived DTM provided Krkonoše National Park administration and Czech Cadastral Office respectively; and ii) extensive statistical data about snow avalanches covering period from 1961/62 till present. DTM data was used to calculate run-out statistics for each permanent snow avalanche path according to the methodology proposed by Lied and Bakkehöi (1980) and McClung and Mears (1991)

The data were applied to RAMMS modelling code (Christen et al. 2010) and for each permanent path four different return periods were calculated (10, 30, 100 and 300 years). As a result an updated footprint of permanent snow avalanche paths was made. Including information about the hazard with different return periods.

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ORE MTS AND HUMAN IMPACT

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Keywords: palynology, geology, stratigraphy, human impact, Ore Mts, Quaternary

The Krušné hory Mts (Ore Mts) are an area very rich in peat-bog complexes, the Boží Dar peat-bog complex belonging to the largest ones. Two peat bogs in this complex were the subject of palynological research (Břízová 2014). There are the localities Boží Dar-V rezervaci, Boží Dar and Oceán. The Boží Dar peat bog is an upland moor and two analysed profiles of Boží Dar (V rezervaci, thickness 2.9-3 m) and Boží Dar (thickness 0.32 m) represent vegetational evolution since the Late Glacial period until today (Břízová 1995). Pollen analysis of the upper layers of the Oceán peat bog depicts the situation since 17th century (Břízová 1997; thickness 0.38 m). Localities Hora Sv. Šebestiána, Novodomské rašeliniště (Načetín) and Polské bažiny pertain to the Šebestián peat bog complex. Now several peat bogs in this complex are the subject of palynological investigation too. There are the localities Hora Sv. Šebestiána (HŠŠ, HŠŠ-2- Na Výsluní, HŠŠ-3, HŠŠ-4, HŠŠ-5, HŠŠ-6, HŠŠ-7), Polské bažiny, Novodomské rašeliniště-Načetín (NDR, NDR-2) and Načetín-rybník (NAR). Several samples of these localities was radiocarbon – dated (see tab.; Gd: Radiocarbon Laboratory Silesian Technical University, Gliwice; Hv: ¹⁴C und ³H - Laboratorium, Niedersächsisches Landesamt für Bodenforschung, Hannover). New localities Kovářská and Brandov are the subject of palynological and geochemical investigations too.

The bedrock of the peat bog consists of muddy talus deposits derived from weathering of the substrate composed of phyllites and nephelinites.

The vegetational sequence obtained from pollen diagrams for the peat bogs and the Krušné hory Mts is the following: pine (*Pinus*) – alternating birch (*Betula*) – hasel (*Corylus*) – mixed woodland (QM) – spruce (*Picea*) – beech (*Fagus*) – fir (*Abies*).

The research stated in the submitted work are compared with results of many years study of the above mentioned paleobotanists (Rudolph, Firbas, Jankovská), whom I thank very much to for the written heritage and valuable remarks to the work on the territory of the Ore Mts. The author continued in dealing with this problems during the geological mapping on scale of 1 : 25 000 within the research aim of MZP 0002579801 and within the research aim of MZP Global climatic changes, in the internal project of CGS Prague (323000, 335600) and the international project ArchaeoMontan.

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THE AIZM FLOOD MODEL - ACCURACY AND PERSPECTIVE IN THE GEOMORPHOLOGICAL RESEARCH

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Keywords: *flood extend, GIS, hydrological modelling, Model Builder*

The AIZM flood model (originally in slovak 'Alternatívny Indikatívny Záplavový Model) works on the basis of chaining of several tools in the ArcGIS Model Builder. It represents an alternative to hydrodynamical models. Amongst the advantages, low amount of the input data should be emphasized (the relief data, the course of stream's axis and the height of water level above the river bed at a given point). Despite the fact that the modelled flood extends (from hydrodynamical models) are available for many sections of rivers in the Czech republic, in many other cases the modelled flood extends are absent.

In order to be able to compare the differences of flood extends computed by hydrodynamical models and the AIZM flood model, over 30 sections of czech rivers were chosen. Among them, 6 types of streams were sorted out (1. straight channels, 2. large meanders, 3. small meanders, 4. confluence of equal rivers, 5. confluence of unequal rivers, 6. bifurcation). All the sections have had the modelled flood extends available and the AIZM flood model was used to compute the inundation extend. Further, the differences between modeled extends of inundations were measured, also with regard to the input data for the digital terrain model (DMR 4G, DMR 5G by Czech Office of Surveying, Mapping and Cadastre).

It has been found out, that the accuracy of the AIZM flood model is related to the type of stream and to the parameters of the relief. The crucial moment is connected with the generation of the digital terrain model on the scale of a river bed. Regarding the obtained outputs, it was possible to choose types of rivers where the use of the AIZM flood model is relevant, as well as those where the model produces incorrect results.

The AIZM flood model is a relatively universal tool which may (and will be) be further modified. It can be used in all disciplines focused on the flood extend, including dendrogeomorphological research of flood events.

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DEBRIS FLOWS MODELLING IN THE KRKONOŠE MTS.

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Keywords: *Debris flows, Debris flows modelling, Flow models (SINMAP, FLO 2D and Flow R), Krkonoše*

This poster present general comparison of the three models for modelling of debris flows in selected areas of the Krkonoše Mts. The aim of this poster is to analyze suitability of models propose in the simulation of debris flows events. Debris flow is a form of rapid mass movement of rocks and soils in a body of granular solid, water, and air analogous to the movement of liquids. Debris flows are a common type of fast - moving landslides that tends to flow in channels. In poster are using following flow models: SINMAP, FLO 2D and model Flow R. Model SINMAP means Stability Index Mapping. FLO 2D model simulated the rainfall and the debris flows event. Model Flow R is a distributed empirical model for regional susceptibility assessments of debris flows. (Flow path assessment of gravitational hazards at a Regional scale). Precipitation are the main triggering factor of the debris flows. Important part is analysis of precipitation data (from Czech hydrometeorological Institution). The results obtained from analysis of precipitation are compared.

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PLEISTOCENE THERMOKARST PROCESSES AND LANDFORMS IN CZECHIA

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Keywords: Pleistocene, permafrost, thermokarst, Czech Republic

The term thermokarst describes the processes and landforms that involve collapse of the land surface as a result of the degradation of ground ice rich permafrost. Thermokarst is a major driver of landscape change in the periglacial environment, but has been mostly considered to be a minor process in Pleistocene landscapes of Czechia. Melting of segregation ice, ice-wedges and injection ice causes land surface settlement and origin of various thermokarst landforms. It results mainly from the fact that during thawing of ground ice, mineral material

collapse into the spaces formerly occupied by ground ice. Thermokarst features are developing in soft rocks, mostly in unconsolidated deposits. An increase of the depth of the active layer causes terrain subsidence and formation of thaw-depressions. Shallow pan-like hollows are called *dujoda* depressions and distinct thaw depressions with steep sides, flat bottom and thaw-in lakes than *alasses*. Depression after collapsed ice core of pingo is called post-pingo depression. V. Jankovská (1980) discovered in the Basin *Třeboňská pánev* oval closed depressions the can be classified as thermokarst depressions. Later were found several large closed depressions with ramparts with diameters of several hundred meters and some tens of smaller depression with diameters up to 20 m on the bottoms of fishponds *Tisý* and *Švarcenberk*. Some depressions contain peat and lake deposits. These fossil landforms are interpreted as post-pingo depressions (Šída, 2013, p. 159). The thermokarst processes are changing the properties of soft-sediments and thermokarst involutions are formed. Often are these thermokarst features mistaken for cryoturbation. Thermokarst involutions take form of load casts, pseudo-nodules, ball-and-pillow structures, and diapirs (French, 2007, p. 193). Frost pots (sediment-filled pots) common in the Czech Republic can be interpreted as thermokarst landforms (French, 1996, p. 323) connected with ice-rich permafrost degradation. Gravels and sand sunk into thawed material during permafrost degradation – mostly producing mud. Many slopes thus reflect, to varying degrees, the imprint of Pleistocene thermokarst activity. Typically, thermokarst sediment mantle slopes and infill depressions (e. g. *dells*). Settlement due to thawing of ice-wedges gives characteristic troughs – thermokarst gullies, dry valleys and *dells*. Troughs and gullies may become water courses. Dry valleys developed as the result of thermal melting and erosion operating preferentially along larger ice-edge systems in unconsolidated sediments. Dry valleys are much like regular river valleys save that they lack surface stream channels on their floors. Slope retreat of dry valleys occurs by slumping associated with melting ground ice.

Extensive dry valley and also dell networks occur in areas of unconsolidated rocks (e.g. in the Carpathians Foredeep or in Vienna Basin).

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POTENTIAL CHANGES IN THE LANDSCAPE DUE TO OX-BOW REVITALIZATION (CASE STUDY FROM DRAVA-BASIN, HUNGARY)

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Keywords: *aerial photogrammetry, landscape changes, Drava-basin, ox-bow*

The Hungarian section of the Drava River floodplain is equally affected by flood and drought hazards. Drought hazard shows an increasing trend as damming and regulation has changed the water regime and the river channel gradually incises. A large-scale rehabilitation project, the Ancient Drava Programme, is designed to solve problems of water governance, land management and employment. As part of this project, water replenishment of oxbows is planned indirectly from the main channel utilising old courses and tributaries of the river. The efficiency of the project basically depends on the success of this replenishment scheme. In order to assess the benefits of the Programme, we perform hydrological monitoring to establish the complete water budget of the Cún-Szaporca-oxbow, an important wetland within the Danube-Drava National Park, with a wide range of ecosystem functions. The monitoring covers virtually all the possible water inflows into and outflows out of the lake with recording of precipitation, infiltration, water retention potential, soil temperature, soil moisture content, groundwater level indicating water movement.

Floodplain landforms, such as oxbow lakes, play a particularly important part in satisfying ecological and agricultural water demand. For a more detailed examination the Drava oxbow of 257 ha area with a maximum water depth of 2,4m m and an average water depth of 1.12 m (DDKÖVIZIG 2012) was selected. The oxbow was partially cut off from the new Drava channel during the first stage of channelisation between 1842 and 1846. The water management plan (DDKÖVIZIG 2012) envisions "ecologically sustainable and cost-effective water supply", water retention, wetland habitat restoration and recreational development, first of all, through a rise in lake water level from the present 90.15 m above sea level to 91.25 m. Water recharge will be implemented from a reservoir on a minor tributary through a feeder canal of 1.25 km length and only 0.4 m³ s⁻¹ capacity.

Changes in groundwater level and some soil moisture parameters (indicating water movement) are also observed. The monitoring of groundwater conditions is supplemented with well testing to estimate subsurface communication between the oxbow and the groundwater of the surrounding areas, Alluvial sediment analyses are carried out to estimate the conductivity of the different horizons/beds and land use and vegetation dynamics are surveyed by remote sensing. The influence of local rainfall events on the groundwater table is evaluated in the light of precipitation amount and

intensity as well as soil temperature and saturation. Since seepage to groundwater is a major type of loss in the water budget of the oxbow, the monitoring of groundwater levels is central to our investigations.

The requirement of an ecologically optimal lake level, however, contradicts the need for floodwater retention in the oxbow – at least during the early summer flood period. Some natural groundwater replenishment seems possible from precipitation falling on the higher-lying terrain in the north. Although further investigations are needed, it is probable that the capacity of the feeder canal will prove barely adequate to maintain the desired water level in the lake. Water recharge would also involve land use conflicts, which will be difficult to resolve on a strictly scientific basis.

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GOOGLE-EARTH 3D AND CAVES – USEFUL TOOLS IN GLOBAL PLEISTOCENE LGM GLACIAL GEOMORPHOLOGY RECONSTRUCTIONS

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Keywords: Google Earth 3D, Pleistocene glaciomorphology, LGM glaciers, reconstruction tool, comparisons Modern Canada-Pleistocene in Europe, Germany/Czech Republic

Before or after field work – Google Earth 3D is a digital tool, that was demonstrated to be useful in the reconstructions of Pleistocene glaciers, especially LGM glaciers in Middle high elevated mountain regions of Europe (Diedrich, 2013), which were partly not expected to have been covered by ice caps or with valley glaciers. Such reconstructions include comparisons to modern glaciers, e.g. of the Canadian Columbian Ice field region of West-Canada (Baranowski et al, 1978).

Google Earth 3D can show details of different glaciomorphological features such as kars, side- end moraines, drumlins etc., but it has to be used carefully and not as a single tool, because the result depends much on the day-light and/or angle of photography (see <https://earth.google.com/>) . In some cases details of glaciomorphological structures can be seen, in others none. Important is the function of the rotation modus, which allows to “fly” within old glacial valleys, or to reconstruct moraines in birds-eyes views snap shots. Only in combination with field prospections and especially with cave research, LGM-glaciations models can be developed in Central Europe in middle high elevated and today under non-alpine conditions mountain regions.

The best example is the recently studied Harz Mountain Range in northern Germany (Diedrich, 2013), where Late Pleistocene LGM glaciation of the Brocken Peak was proven by the combination of: 1. Google Earth 3D (after field work), 2. Verifying of glacial structures (after using Google Earth 3D before field work) within the field, 3. Cave work (genesis history, sedimentology, and dating of the refilling by faunas, or human occupations). Especially caves within valley positions of limestone/dolomite karst areas are key sites to prove and reconstruct Pleistocene glaciers or their distal river terraces in general.

Herein, new presented are preliminary studies using Google Earth 3D for the northern Czech/German and Polish boundary mountain chains. After the knowledge of the presence and first reconstructions of the Krkonoše Mountain Chain (Czech Republic/Poland) LGM glaciers with three stages (Engel et al., 2010; Mentlik et al, 2010), those were tested with Google Earth 3D. In the southern slope areas Google Earth was not useful to improve the models. In the northern Slopes, especially the Snow Pot Hole area, this can be used as the recently best example for reconstructions of details of LGM glacier geomorphology and the reconstructions of glacial stages (using the terminal moraines, Fig. 1).

Google Earth 3D is also useful to reconstruct former glacial coastlines. This is

demonstrated herein with one archaeological example of the early Neolithic (Diedrich, in prep.), which settlements relate to Pleistocene beach sand deposits on the Island of Pag.

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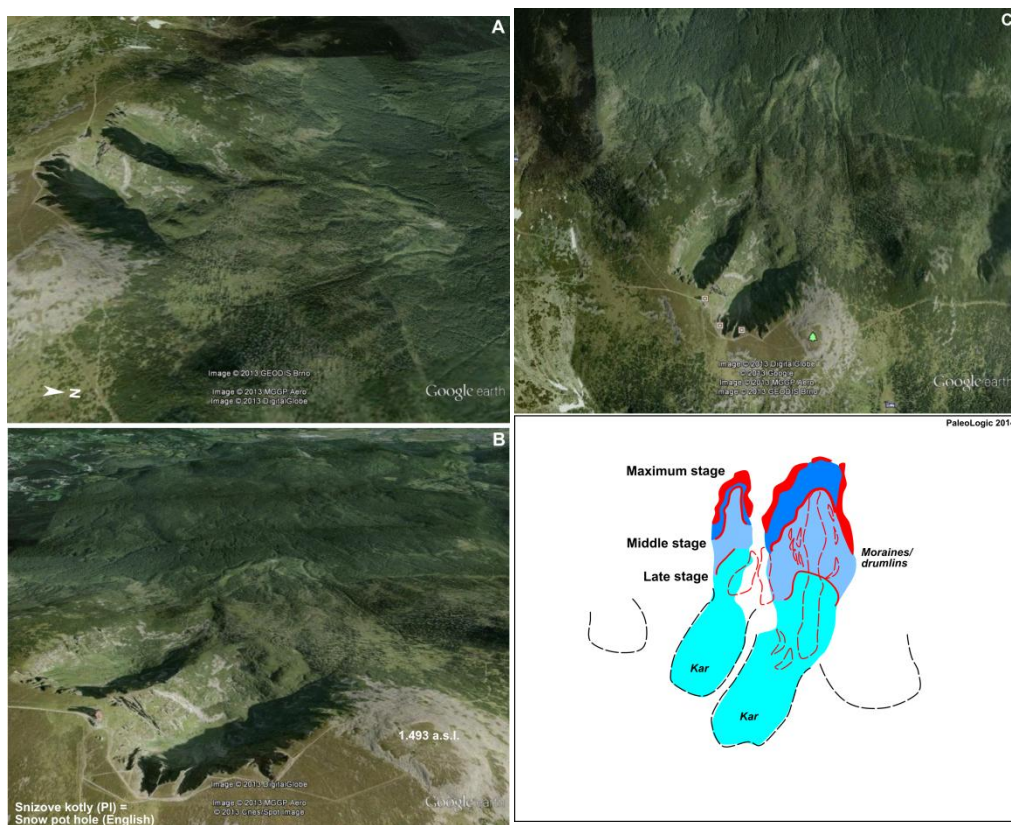
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Fig. 1. Krkonoše Mountains (Czech Republic/Poland boundary): A-B. Snizove kotly (Engl. = Sow Pot Hole, 1.493 a.s.l), two parallel kar and 1.0/1.5 km short glaciers with well visible maximum extension terminal moraines, such as side moraines and drumlin fields in angled, and in C. vertical Google Earth 3D view (with drawing interpretation of three Late Pleistocene glacial stages).



RECENT EVOLUTION OF (PRO)GLACIAL LAKES IN THE TYROL (AUSTRIA) AND LONG-TERM BEHAVIORAL PATTERNS

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Keywords: *glacial lakes; glacier retreat; GLOFs, geoenvironmental change; hazard assessment; Alps*

This article presents results of the investigation of recent evolution of nine selected young glacial lakes in Tyrol since 2000 and synthesis these findings into the general geoenvironmental long-term behavioral patterns. Areal change of all mother glaciers was negative, varying between -2.5 % in case of large glaciers to -29.2 % in case of small glaciers. Considerable glacier retreat led to the significant lake growth at four localities, two lakes experienced stagnant or slightly negative areal trend, one lake experienced more significant negative areal trend and two lakes drained completely during analysed period. It is shown, that currently forming lakes have some similar features (topographical, hydrological and glaciological), which could be used in detection of localities with potential for near-future lake formation. An important issue also represents the threat posed by studied lakes. Four of them were chosen for more detailed hazard investigation. Based on field survey and detailed geomorphological mapping, potential triggers and mechanisms of glacial lake outburst flood (GLOF) have been identified, and peak discharge at dam (Q_{max}) and overtopping duration (t_o) for three different flood scenarios (involved volumes) have been estimated. Three distinct phases of glacial lake evolution (behavioral patterns) in relation to the susceptibility to outburst flood and hazardousness in time have been defined. Finally, based on those patterns, future perspectives of studied lakes as well as long-term evolution trends of glacial lakes in broader context are discussed.

RECENT EVOLUTION AND DEGRADATION OF THE BENT JATUNRAJU GLACIER (CORDILLERA BLANCA, PERU)

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***Keywords: debris-covered glacier; rock glacier; surface movements; buried ice degradation;
supraglacial lakes; Cordillera Blanca***

Our investigation brings new insight into the recent evolution and degradation of the bent Jatunraju glacier in the northern part of the Cordillera Blanca, Peru. Analysis of topographical maps and historical aerial photos covering a period of 66 years and a field survey performed in June 2013 and May 2014 helped to describe the geomorphological setting and ongoing processes. Recent evolution and degradation processes are also deduced from surface movements. Historical geodetic measurements (1967-1968; 1977-1984) and current LANDSAT images (2001-2013) were used to estimate surface velocities and changes in surface velocities over time. Our investigation showed that the most significant changes happened at an altitude of between 4300 and 4450 m asl. A significant decrease in surface velocities and increase in debris thickness indicate that this part of Jatunraju turned from a debris-covered glacier into an ice-cored rock glacier during the analyzed period. Particular parts of the article describe the cycle of formation and extinction of supraglacial lakes and the melting of buried (debris-covered) ice. A scenario of future evolution is outlined and discussed as well. We assume that ice degradation within the debris-covered glacier will continue and that the altitude of its presence will increase hand-in-hand with the changing environment.

CIRQUES, ROCK AVALANCHES AND THE BUZZSAW HYPOTHESIS FOR MOUNTAIN GLACIATION.

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Keywords: *Glacial erosion, cirques, ELA, Glaciation Level, Rock Slope Failure, morphometry, earthquakes*

Rock avalanches are important in the development of cirques and troughs, but can they be the main factor in cirque initiation (Turnbull and Davies 2006)? The widely accepted glacial origin of mountain cirques has been both reinforced and assumed by recent work on the ‘buzzsaw hypothesis’ of mountain range truncation by efficient glacial erosion including cirque headwall retreat. A range of geographical evidence supports the traditional emphasis on glacial rather than mass movement origins:

1. Cirque distribution is closely correlated with the distribution of former glaciers (as based on evidence other than cirques: i.e. moraines, striations and roches moutonnées) (Mîndrescu et al., 2010). Unglaciated mountain ranges, whatever their relief, generally lack cirques;
2. The generalised altitude of cirque floors is closely related to the generalised ELA (Equilibrium Line Altitude) of former glaciers (Mitchell and Humphries, 2014);
3. Present-day ELA varies spatially in a similar way to former ELA as estimated from cirque floors or from reconstructions of former glaciers (based largely on moraines). Likewise present GL (Glaciation Level, altitudinal threshold of glacier generation) varies similarly to former GL estimated from cirques (Evans, 1990). Neither ELA nor GL follows an isotherm;
4. Cirque distribution favours poleward and leeward aspects, as does glacier distribution, because of differential solar radiation receipt and wind drifting of snow. The degree of this bias varies as predicted from climatic variations with latitude and between maritime and continental climates (Evans, 2006a);
5. Once a mountain range rises more than a few hundred metres above ELA, the distribution of cirques is continuous: cirques are contiguous to other cirques;
6. The distribution of RSF is more scattered, and is expected to relate to geological (especially active tectonic) structures. Distributions of deep-seated landslides mapped in the same regions as cirques show quite different distributions;
7. The distribution of cirques is not correlated with the intensity and frequency of earthquakes;
8. Cirques are found on all rock types: RSF are less frequent on massive granitic rocks (Jarman, 2006);
9. The morphometry of RSF source scars, while comparable to that of poor cirques, differs from that of classic and well-developed cirques (Evans, 2006b; Evans and Cox, 1995; Evans, 2010). In particular, the presence of overdeepened rock basins is rare in RSF source scars; those in cirques have thresholds that are not back-tilted rock masses;
10. Valley-head cirques are continued down-valley by glacial troughs, with or without an intervening threshold to separate them;
11. Degree of cirque development can be related to duration of exposure to glaciation. Rock slope failure can produce scars with similarities to medium-grade cirques, and

the two are occasionally difficult to discriminate (detailed fieldwork may be required). If scars are situated where glaciers can form, they are readily transformed to truly glacial cirques. However, when clusters and populations of cirques are considered, it is clear that glaciation provides a general explanation whereas rock slope failure alone cannot. In most cases rock slope failure is an ancillary process, of cirque extension or widening through collapse of glacially-oversteepened slopes. Given the duration of the Quaternary, currently observed rates of glacial erosion are sufficient to erode well-developed cirques.

The relation between summit altitudes and cirque floor altitudes is a general one, inbuilt by definition; it does not support the buzzsaw hypothesis as it is found in mountains with summit plateaux (Mîndrescu and Evans 2014). The buzzsaw hypothesis is applicable only where sharp ridges delimit contiguous, intersecting cirques. This does seem to be the case for example in the Washington Cascades and the Southern Alps of New Zealand. As abrasion is unlikely to be rapid beneath slow-flowing ice near glacier sources, such headward erosion requires glacial quarrying and/or headwall collapse by rock mass failure (Evans, 2013). Further work is needed on the balance between headward and downward glacial erosion, which seems to vary at different stages of Quaternary glacial history (Pedersen and Egholm, 2013).

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DESIGN CRITERIA FOR RESTORATIONS OF MOUNTAIN STREAMS - EXAMPLES FROM THE MORAVSKOSLEZSKÉ BESKYDY MTS

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Keywords: *mountain stream, restoration, gravel-bed stream, Kněhyně, Moravskoslezské Beskydy*

Occurrence of channel-reach morphologies with specific ratio of transport capacity to sediment supply (e.g., bedrock channels, cascades, step-pools, pool-riffles) in mountainous landscape is driven by several internal and external time-variable and space-variable factors. Especially, the identification of sediment supply potential is crucial for later stream management in mountains. The contribution deals with theoretical aspects of stream restorations of this part of stream net with emphasis on the flysch Western Carpathians.

At first step, the parameter of bankfull width was compared between headwater streams located on windward and backward side of the mountains, when also lithology was considered. In general, streams located on the windward side of ridges showed rapidly increase in channel width by increasing watershed area than other ones. It implies that a relatively high variety in bankfull width exists between individual headwater channels in the same region at equal upstream watershed areas. The second part discusses the restoration of anabranching reach of the Kněhyně torrent, which was partly renaturalized by the 100yo flood event in 1997. The single riprap-limited channel was transformed into anabranching channel pattern with relatively large gravel deposits during that event and later, restoration stabilization elements were added into the channel to preserve that morphology. The field geomorphological mapping shows, that longitudinal disconnectivity (check-dams) exists in the stream longitudinal profile and recent potential sediment sources are limited at the watershed scale. These facts make difficult the sustainable preservation of the transport-limited conditions in the Kněhyně. The anabranching channel pattern noticed by the 2nd Military survey (half of 19th century) could be result of higher sediment supply caused by Pastoral and Wallachian colonization and climatic conditions during the Little Ice Age. Moreover, the role of bedload transport modelling and dendrogeomorphological approach is discussed in order to better estimate relations between the sediment supply, transport capacity and resulted channel-reach morphology.

SEDIMENTATION IN THE CUTOFF CHANNELS, CASE STUDY IN THE STRÁŽNICKÝ MEANDER, RIVER MORAVA

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Keywords: Strážnický meander, cutoff, sedimentation, abandoned channels, groundwater, Morava river

We study the cutoff Strážnický meander on the river Morava. Research is mostly based on continual groundwater level measurement. We focus deeply on this part from the methodological point of view and specific algorithm is presented, that can be used as an example for similar research in other localities. We analyze, how often the cutoff meander is connected to the active river channel and for how long part of a year is the meander connected at both ends, allowing water to flow freely in the abandoned channel. Due to a relatively dry period, that was observed in the locality in the last year, this did not happen very often. Further research was focused on estimating the sedimentation rate by generating cross-sections from digital surface model in the interval of two years and also generating cross-sections with other geodetic measurements. The digital surface model was created by using the standard photogrammetric methods. The dominant process in the Strážnický meander is sedimentation, which however happens selectively, depending on the location in the meander. By analyzing sedimentary samples, the character of sedimentation was determined with regard on the specific location in the meander.

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GEOMORPHIC RESPONSE TO RIVER REGULATION OF THE VISTULA CHANNEL IN THE FORELAND OF THE CARPATHIAN MOUNTAINS IN THE LAST 200 YEARS

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Keywords: Vistula, channel regulation, anthropogenic influences, channel geometry

In many areas of the world, channels and bottoms of river valleys have been changed over the past hundreds or even thousands of years, what led to modifications in river flow regimes, and consequently result in constant changes in channel geometry of these rivers. The aim of this article is to identify changes in remodelling of the foreland Vistula course due to regulatory works conducted during the past two hundred years.

Regulation of the Vistula in the Carpathian Foreland involved cutting off meanders and even straightening the river course, strengthening the river banks, building flood embankments and rock groynes, as well as various types of hydro-technical facilities.

Shortening the Vistula course and narrowing its channel led to disturbance of natural conditions of balance for the river channel bottom. During the last 200 years, the Vistula channel in the Carpathian Foreland has been deepened by approx. 1.5 m - 2 m, and the bottom erosion rate was ranging from 0.1 cm/year to 3.0 cm/year in this period. The channel is still aggrading along the short sections in the Oświęcim Hollow, near Cracow and in the Małopolski Gorge of the Vistula. The process of sediment accumulation is slower than the process of erosion and amounts to approx. 0.1-1.0 cm/year; and only in short periods of time, it has a more dynamic character and reaches even 5.2 cm/year.

The current zone has been narrowed by building rock groynes, what led to reducing the average width of the channel. Since the beginning of regulation works, the Vistula channel has been narrowed twofold, and the most along the section with primarily meandering course. Between the mouths of the San and Wisłoka rivers, the Vistula channel has been narrowed even threefold, i.e. from 830 m to 280 m.

As a result of deepening and reducing the average width of the Vistula channel, the geometric parameter of the river channel, called width-to-depth ratio (W/D – a quotient of the channel width and average depth) which decides on the flow rate of channel waters, has undergone enormous changes. Before the beginning of regulatory works, this parameter was being increased alongside with the river course from approx. 100 along the river sections with meandering course to even 400 along the braided channel section. Nowadays, this parameter has been decreased on average fivefold.

The negative results of changes in the channel geometry of the Vistula in the Carpathian Foreland on a local scale are: elution of regulation constructions and bridge piers as well as emergence of intakes on river banks, excessive desiccation of lands in the valley bottom, and exposure of root zones of trees growing in the river banks, what lead to impoverishment of plant and animal communities. On the other hand, changes

in the channel geometry, which led to changes in the width-to-depth ratio, and consequently to acceleration of the flow rate of channel waters along the sections where the Vistula channel nowadays undergoes shallowing, may cause an increased flood risk.

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GEOPHYSICAL SURVEYING IN CONDITIONS OF HIGH ARCTIC: EXAMPLES FROM SVALBARD

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The research in extreme arctic condition has many specific facets, ranging from climatic conditions through difficult logistics to hostile nature. Our studies of tectonic and slope deformation phenomena on the Svalbard archipelago included significant amount of geophysical surveying, mostly using an ERT profiling. The three described case studies illustrate various difficulties of the ERT surveying in Hornsund bay, Svalbard archipelago.

First case was the study of rock block accumulations situated at the foot of Rotjesfjellet ridge on the northern side of the Hornsund fjord. The ERT revealed ice core in the accumulation and the Schmidt hammer we were able to establish younger age of the lobe-like left part of accumulation. The major problem was the grounding of the electrodes, as the rock glacier is formed by rock blocks with no soil or fine material. Next study aimed to create a 3D image of a sorted polygon, one of very well-developed landforms in a sorted polygon field. To create a 3D image, a star-like configuration of four profiles was measured. The difficulties here were also connected to grounding, as the polygon was formed by gravel-size stones whereas the inner part of polygon by very fine-grained clayey and silty material. Thus the difference in grounding had to be dealt with. Another problem was the short stepping (0,2 m), where every cm of inaccurate electrode placing can influence the quality of the results.

Finally, we studied a giant rockfall on southern coast of the Hornsund fjord on a site called "the Stonehenge". We used ERT to assess the thickness of the rockfall deposits on the top of a coastal plain. Altogether four profiles were measured across the accumulation. Main obstacle was the demand to lead the profiles along a straight line, as the huge blocks (up to 10x10 m) were scattered across whole site.

Overcoming the difficulties and problems in all three case studies lead to yielding of fine, usable and highly informative ERT cross-sections, and helped to understand the underground conditions and thus to answer the research questions.

LONG-TERM MONITORING OF A SLOW SLOPE DEFORMATION - CASE STUDY OF OBŘÍ HRAD

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In August 2003, a system of dilatometric monitoring was installed on an outcrop called "the Gate", attached to one end of the remnants of the walls of the Celtic fortifications. The network is using portable rod dilatometer of Hölle type, with a precision of the device approximately 0.05 mm. Also temperature is measured as it is a very important factor in monitoring, for a thermal extension of the rock mass strongly affects the dilatation of the fissures. The measurements were originally taken every month (2003 - 2010), currently (since 2011), the measurements are taken once every two months, which is sufficient in the slow-moving blocks. The number of readings has currently (as of January 2015) has exceeded 100 and the monitoring is running for over 10 years. While the yearly sinusoid curve was present at all the measurements, some showed surprising behaviour, including temporary periods of sudden acceleration and even long-term trend changes.

Second monitoring network was installed in September 2006 and consisted of two chain profiles along the dropline at two opposite-situated block fields, one under Obří Hrad site (facing NE), the other across the Losenice valley, (facing SW). This network uses different measuring device: a steel tape extensometer. The accuracy is lower (approximately 0.1 mm), but the device is more flexible as the span between the measured points can vary between 0.7 and 30 meters. As in the case of the dilatometer the measurements are taken once every two months, lest the highest winter when the blockfields are often covered with snow. The results are also surprising, as the general trend is shortening of most of the distances, which is unusual as the fixed point is on the top. The reason will be probably related to the settlement and consolidation.

For certain period (12/ 2005 - 04/2008) there was a third monitoring system installed in the Obří Hrad area: the automatic extensometric network. Working on the electroinduction principle, it is an expensive, but also a most useful and accurate technique, reaching a high precision of (<0.001 mm) and a has a high frequency of measuring (technically can be anything up from 1 s, here the measurement was taken every 3 hours). The device also includes a digital thermometer used for correction of thermal expansion.

LONGITUDINAL PROFILES OF THE TATRA VALLEYS AS A MIRROR OF MORPHOTECTONIC DEVELOPMENT

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Keywords: *The Tatra mountains, morphotectonics, empirical longitudinal profile, theoretical longitudinal profile*

The Tatras are asymmetric horst structure (Nemčok et al., 1993) mountains in the Western Carpathians. The High Tatras and the Belianske Tatras (Slovak part) are the main object of this contribution, which tried to prove the existence of an asymmetric tectonic uplift. As a principal tool 11 longitudinal river profiles (7 streams on southern hillsides, 2 streams on northern hillsides of High Tatras and 2 streams in the Belianske Tatras) were selected, including empirical and theoretical (power function) profiles. Courses of SL index, its peaks and points of field research are indicating on the profiles.

Field work was performed in all 11 valleys from piedmont to the water source area (cca 1 700 - 2 000 m a.s.l.). There are 30 points with measured characteristics of rock joints altogether, along with 30 points with grain-size measurements in channels. We also observed the segments of bedrock and alluvial channel.

The synthetic map of manifestation tectonics in longitudinal profiles, joint parameters, faults and morpholineaments was elaborated.

According to results of this paper, tectonics has the biggest impact on the areas of Mlynická valley, Velická valley and Studenovodské waterfalls.

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‘I AM BECOME DEATH, DESTROYER OF WORLDS’ – MAN AS A CREATOR AND VICTIM OF LANDSCAPE CHANGE: CAN WE IDENTIFY AND EXPLOIT ANTHROPOGENIC SIGNALS?

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Keywords: anthropocene, environmental management, fpXRF, geomorphic markers, legacy pollution, palaeoenvironment, Pb

Oppenheimer’s apocalyptic words were of the moment, but we are becoming increasingly aware of the likely impacts of people on the environment and both the direct and indirect consequences for humankind (IPCC 2013). Consequently, the accurate quantification of such impacts, informing effective environmental management, is paramount. Indeed in some contexts managing the legacy of our industrial past may be a key consideration even when our actions aim to enhance environmental conditions. Nevertheless, the traces of human activity, when carefully characterised, can also offer an opportunity as well a threat, allowing a longer term perspective on the operation of environmental processes.

The term Anthropocene now seems to be relatively commonplace and to have extended beyond the scientific literature. However, the definition of this so-called and newest geological time zone has been much debated (*e.g.*, Zalasiewicz *et al.* 2008). There are also important regional variations. In the Carpathian Basin the point at which human impacts became significant in the landscape is being redefined as palaeoecological research moves out of the forests in the mountains and in to lowlands *e.g.* Feurdean *et al.* (*in press*). This also applies to the geochemical record of human activity, not only since the Industrial Revolution, but also earlier and more subtle evidence of local signals, where important regional differences are becoming evident from a range of depositional environments (Geantă *et al.* 2014).

In a post industrial landscape, where contemporary pollution levels may have significantly abated, previous emissions may still require careful consideration. The remobilisation of legacy pollutants may lead to significant, unforeseen consequences as a result of climate change. This was exemplified by the Europe-wide millennium flooding described by Macklin *et al.* (2006) as an environmental ‘wake-up call’. In the Mersey Estuary (NW England) the fine sediments of saltmarsh deposits effectively record of the region’s extensive industrial history. Recent fieldwork suggests that although surface sediments are relatively uncontaminated, erosion of deeper (older) sediments as a consequence of climate change induced conditions could effectively re-contaminate this now recovering site. Furthermore, potential impacts of a major construction project creating a new river crossing (The Mersey Gateway) (and associated environmental enhancement activities) provide an example of the need to consider legacy pollutants, even when the motivation for the landscape change is considered ecologically beneficial.

Elsewhere we have successfully employed legacy pollution as a geomorphic marker. The uplands of central England hold extensive areas of blanket peat. These areas are important water gathering, recreational and amenity areas and also store a significant quantity of carbon. However, many have become significantly degraded and surface erosion can be marked and commonplace. As part of research in the Peak District National Park to assist in their regeneration and sustainable environmental management for the future, the legacy fallout from the Industrial Revolution of Pb has been employed to trace, map and model peatland erosion (Shuttleworth *et al.* 2014a). Indeed, alongside the use of mineral magnetic measurement we have pioneered the use of handheld fpXRF as the next ‘simple, rapid and non destructive’ research tool (Shuttleworth *et al.* 2014b). This is a technique which is also particularly pertinent to the role of fieldwork in geomorphology allowing rapid analysis and thereby prompt decision making.

The environmental impact of people is ubiquitous and, while the future scenarios are debated by many, its consequences are already with us. However, anthropogenic signals may also assist us in our endeavours to understand and plan for a changing environment and, in the context of legacy pollutants, must not be ignored: to offer another quote from William Falkner’s writing “The past is never dead. It’s not even past”. A palaeoenvironmental perspective can provide a valuable approach to environmental research. While not new, the application of high resolution, multi-proxy studies, linked to modelling can offer important insights into the role of man as a creator and victim of landscape change. One last quote from the 18th century Irish statesman Edmund Burke “Those who don’t know history are destined to repeat it”.

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THE PLEISTOCENE LOAMY DEPOSITS IN THE ORAVA BASIN (WESTERN CARPATHIANS) BASED ON GRAIN-SIZE ANALYSIS

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Keywords: *loamy deposits, glacifluvial fans, grain-size analysis, Orava Basin*

Intra-mountain depressions are natural sites allochthonic material deposition. These materials are typically glacial, aeolian and fluvial or deluvial deposits and occur in most basins in the Western Carpathians (i.e. Cegła 1963, Gerlach, Koszarski 1968, Zuchiewicz 1990, Butrym 1991, Gerlach et.al. 1993) and the Sudetes (Jahn 1968, 1972,). Loamy deposits from the Orava Basin are difficult to classify and their origin is unclear: they are not typical aeolian, fluvial or glacial deposits. The studied loamy deposits occur within the Orava Basin on the terraces and glacifluvial fans of the Czarny Dunajec River. To date, most works on these deposits were limited to the description of their macroscopic characteristics and point measurements of the thickness of the loams (Watycha 1976, 1977a, 1977b; Baumgart – Kotarba 1991-1992). Their origin and structural and textural characteristics have not been well-recognized. This paper focuses on the characteristics of grain-size composition of the loams with and is a part of a larger project aiming at the complex analysis of the loams on the Pleistocene fan of the Czarny Dunajec in the Orava Basin to determine their origin.

The loams were sampled at several locations on the glacifluvial fans of the Czarny Dunajec River (Mindel, Riss and Würm terraces) and studied using graphic measures (mean grain size, skewness, kurtosis and standard deviation) by R. L. Folk and W.C. Ward (1957).

The results of the grain- – size analysis indicate that the study deposits are composed mainly of fine silty material and grain-size of the sampled material is very similar. The proportion of clay in the loams is relatively small. Loamy deposit is polymodal and poorly sorted. The content of the silt fraction increases from the pavement to the ceiling in analyzed profiles. On the hilltops of the Pleistocene fan, the loams are massive, whereas on the Czarny Dunajec terraces they present some stratification.

At present, the results of the analysis indicate that the origin of these loams is likely complex. The high proportion of silt fraction may be associated with aeolian origin as it is generally assumed in the case of the silty covers in the Sądecka Basin (Butrym, Zuchiewicz 1985, Alexandrowicz et.al. 1990) and Doły Jasielsko-Sanockie (Krysowska – Iwaszkiewicz, Wójcik 1990). However, similarity to loess may be a secondary feature. The study deposits could have been formed due to long-term weathering of the deposits of a glacifluvial-alluvial fan (terraces) of the Czarny Dunajec under cold climate and limited vegetation cover (Dylik 1952, Kukulak 2001, Smith, Wright, Whalley 2002, Wright 2007). However, grain-size analysis also suggests fluvial origin of the loamy deposits. Grain-size composition of the study deposits is similar to the one typical of braided rivers and even over bank deposits where percentage of the finest fraction of sediment can achieve a similar size (Gębica 2004, Kalicki, Szmańda 2009).

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WEATHERING ORIGIN OF THE LOAMY DEPOSITS IN THE ORAVA BASIN (WESTERN CARPATHIANS)

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Keywords: *weathering, loamy deposits, glacifluvial fans, Orava - Nowy Targ Basin*

Floors of the intra-mountain depressions in the Western Carpathians are commonly filled with alluvium. This sediment is locally covered with loamy deposits. In Sącz Basin and Doły Jasielsko- Sanockie a large part of loamy deposits is of aeolian origin (loess and loess-like loams) (Cegła 1963, Janiga 1971, Alexandrowicz, et al. 1990, Kryszowska – Iwaszkiewicz, Wójcik 1990, Gerlach, et al. 1993). In the Zywiec Basin thin deluvium covers occur over extensive alluvial fans (Ziętara 1964). The deposits occurring in the Orava - Nowy Targ Basin they are loams with a more complex origin (Watycha 1977a; Baumgart-Kotarba 1991-1992; Birkenmajer, et al. 2008). These loams form a cover on glaciofluvial fans and terraces of the Czarny Dunajec River.

To date, the results of studies indicate that the loamy deposits are polygenetic in origin (Chmielowska 2013). The loams could have been formed during long-term weathering of the gravelly material, of Tatra provenance, which built glaciofluvial-alluvial fan (terraces) of the Czarny Dunajec.

During the Pleistocene, the Tatra Mountains were frequently glaciated and the Czarny Dunajec River supplied large amounts of gravelly material (quartzite, granitic, granite-gneiss and schist gravels) from the Western Tatra Mts. These material filled the basin forming extensive glaciofluvial and alluvial fans. The petrographic composition of gravelly material in each level of the fans is probably similar. The thickness of gravels in glaciofluvial and alluvial fans ranges from a few to tens of meters.

The weathering of gravels has proceeded since their deposition. The activity of weathering processes depended on changing environmental conditions during deposition (temperature and precipitation fluctuations, depth and circulation of infiltration and their direction in gravels, limited vegetation cover, wind velocity). Mechanical processes of disintegration of gravelly materials occurred under colder periods of Neopleistocene and Holocene whereas chemical decomposition of crystalline rocks proceeded during the warmer periods. Glaciofluvial and alluvial fans are covered by thick and impermeable loams which may have resulted from post-depositional processes or they could also be a record of the final stage of accumulation glaciofluvial and alluvial fans within the basin. The loamy covers are massive, but locally they exhibit some stratification and layers of material differing in grain-size can be distinguished. These structural features of the loams may be associated with fluvial environment. However, in many outcrops features of the loams point to their weathering origin. In ditches within the peat bog of Bory Orawskie, bright, oily loams with an admixture of granitic debris and quartzite pebbles are exposed. Granitic pebbles weather easier and faster than quartzite because their mineral composition is

more susceptible to hydrolysis and kaolinization. The abundance of water in the soil and acidic environment are aggressive factors of the weathering process. During hydrolysis of Si-O-Al crystal surface structure is damaged. Also biotite is subject to degradation under this conditions. Only quartz crystals remain unchanged after weathering of granitic pebbles. The final product of weathering of granites is coarsely grained loams (grus saprolites). The thickness of this loamy cover is 1-1.5 m under peat bog of Bory Orawskie. On Domanski Wierch, where groundwater is deeper, oxidation was decisive in the weathering of granites (Kukulak 1998, 2001). As a result of oxidation weathering crusts formed on surface of pebbles, the colour and hardness of rocks were also changed.

Limestone pebbles are no longer present in the Pleistocene gravels as they had been first eliminated as a result of carbonatization; the presence of nearly non-weathered quartzite pebbles is the consequence of their general resistance. In the case of gneiss and schist pebbles their susceptibility to weathering is related to preferred mineral orientation.

The presence of debris and sands in the non-structural loamy deposits and also the transitional boundary between underlying gravels and loams suggest their weathering origin and in situ formation of the loams.

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GEOTOURISM ON LANDSLIDES AS A NEW WAY OF EDUCATION ABOUT MASS PROCESSES

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Key words: geotourism, landslides, educational geosites, mass processes, flysch, Podhale Region

Geotourism is a new trend in qualified tourism, promotes geology, geomorphology and landscape (Dowling, Newsome, 2010). Significantly over the last decade, the role of qualified tourism grows, tourists are looking for a new, sometimes challenging experience during the trips. Geotourism is a kind of novelty which can fill the missing gap. It is a combination of leisure with education. Landslides as a potential geosites is a quite new, unique idea. However from the esthetical point of view, they are typical in the landscape, where we are dealing with flysch (Alexandrowicz et al., 2003).

For the purpose of this contribution, author chose 3 landslides (Usypy, Nad Kościołem, Witów-ski) located in Witów village (west Podhale region, southern Poland). They were formed on the western slope of Magura Witowska Mountain (Spisko-Gubałowskie Foothills) in sandstones and shales of Podhale Flysch (Chocholowskie Units) (Gołąb, 1959). Landslides were formed in the Early Holocene, but nowadays they are refreshed from time to time. Main reason of the landslide process is violent rainfall (Długosz, 2011).

Selected landslides have been described and valorized of Reynard valorization method (Reynard et al., 2007). The valorization revealed a considerable variation within the selected landslides from the viewpoint of their scientific, educational and additional value. The attractiveness of selected landslides is rated 7,75 for Nad Kościołem and Usypy and 7 for Witów – ski, what is a good rate. Maximum points in this method is 18. On the above assessment was mainly due to: the clarity of forms, accessibility, rarity of the country, sensitivity to anthropogenic pressure, Possibility of visual observation and the representativeness of the geomorphological process and educational value (Chrobak, Cebulski, 2014).

Nowadays there is a need for a better marketing to present complicated geomorphological processes in an easy way in geotourism. Moreover geosites on landslides can be used as educational points to promote knowledge about slope mass movements among the local population and tourists.

Geotourism on landslides has also some disadvantages, like property of the landslide and overgrowing the landslide, that's way this type of geosites should be promoted especially in landsliding areas where there is a plenty of different landslides to describe and valorize.

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FLOODPLAIN DELINEATION ON SMALL STREAMS ACCORDING TO TRADITIONAL APPROACHES AND THEIR APPLICATION IN PRACTICAL TASKS

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Keywords: floodplain, small watercourse, fluvial ecosystem, floodplain delineation, anthropogenic influence

This contribution presents partial results of the study focused on analysis of quantitative parameters of floodplain on several small watercourses in the Czech Republic, located in mutually different natural conditions. The floodplain is understood here as a flat and fertile area lining the hydrographic network, traditionally studied by numerous domestic and foreign authors (i. e. Hynes 1975, Demek 1988, Hugett 2003, Křížek et al. 2006 or Ložek 2003 and many others). Selection of individual study areas was made based on efforts to capture the widest possible range of natural conditions which influence formation of the landscape runoff processes, dynamics of river systems and thus the extent of the territory which is directly influenced by the presence of watercourse. The second, equally important parameter taken into account when selecting the territory, constituted the degree and character of anthropogenic pressure to which the landscape structure is currently subjected. While the former natural conditions are an essential prerequisite for floodplain formation and thus affect a spatial pattern of the river and alluvial floodplains at larger landscapes level (river catchment or its part), the influence of human society can be considered as a factor which may significantly affect the extent of floodplain at the local level primarily (a reach of watercourse or selected part of a floodplain ecosystem only). Anthropogenic activities are most often associated with reducing the extent of alluvial landscape, usually caused by a significant intervention into the stream or the riparian zone and long-term interruption of contact with the surrounding landscape. Contemporary floodplain and its extent (as well as the character of the whole landscape sphere) can be considered as the result of interaction between human activities and natural conditions, specific to the time and place.

Based on the assumptions discussed above a total of 4 small watercourses has been selected – namely the Borovský stream (right-side tributary of the Sázava river near Přebyslav), the Kochavecký stream (tributary of the Zelenský stream flowing into the Vlára river in Štítná n. Vláří), the Košátecký stream (right-side tributary of the Elbe river near Neratovice) and the Ryzí stream (left-side tributary of the Mumlava river in Harrachov). There were applied the most frequently used methodologies to define the extent of fluvial ecosystems, whose nature (in terms of accuracy and availability of primary data) allow at least an approximate delineation even in the small stream environment. It was the geomorphological, geological, pedological, topographical, hydrological and geobotanical concept of floodplain delineation.

The main aim of this study was to analyse the basic variables affecting the floodplain in the given conditions, compare the results and evaluate the potential of different approaches and possibilities of their application. An important component of the analysis was also to identify the main problematic properties of the approaches that may negatively affect the quality of the resulting data (especially the positional accuracy of the floodplain boundaries). The results show that the various floodplain delineation concepts in terms of the surface area, as well as its spatial distribution within the basin can be significantly different, and the similar results could be expected in case of the major watercourses because of the nature of the studied phenomenon. Differences among the approaches surveyed are evident both in the case of relatively natural (“near natural”) state of the river network and environmental values of surrounding landscape, as well as in watersheds affected by human activity more widely. Relationship between the extent of the area defined by different concepts and specific location of the area within the watershed was identified using the approaches to defining the floodplain in the study areas. The variance of values increases in the direction from headwater areas (resp. upper limit of the floodplain) to the lower part of streams, while the significantly greater differences between the floodplain concepts have been identified in the case of lowland streams and rivers flowing through the large flat depressions with thick sedimentary layers. We can observe the important differences between approaches which take account of the relief genesis (i.e. pedological, geological and geomorphological concept) and approaches based only on morphometric parameters of the terrain and its relative elevation above the bankfull discharge line (i.e. hydrological and topographical concept).

The issue of methodological framework for defining the fluvial ecosystem and its practical field delineation is the traditional subject of geomorphological research in which the flat area along the hydrographic network seen just as a place of fluvial sediment deposition, characterized by direct, at least periodic contact with the water. For the purposes of sufficiently sophisticated, geomorphologically conceived definition of floodplain, in addition to own geomorphological research (i.e. morphological mapping of landforms) application of other approaches from related scientific disciplines is necessary. In particular, it is a survey of the soil properties, its potential in terms of possible channel overflow and consequent spatial extent of floodplain, marginally its geological structure. In general, we can say that the floodplain or the river landscape is, resp. should be, the result of expert interdisciplinary discourse, conceived in such a sense that the extent of the fluvial area in itself include knowledge on at least most of the factors involved in the formation of recent alluvium.

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VECTOR ANALYSIS OF VALLEY AXES IN A RELATION TO GEOLOGICAL STRUCTURES ON THE KUNĚTICKÁ HORA HILL NEAR PARDUBICE

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Keywords: *valley axes, vector, geological structures, Kunětická hora, Bohemian Plateau*

The aim of this paper is to analyse a relationship between geological structures and valley net on the Kunětická hora Hill (306.8 m) near Pardubice in E of Bohemia. The Kunětická hora Hill represents neovolcanic monadnock. It is build especially by the Tertiary magmatic rocks (phonolites, basalts) and by the sediments (calciferous claystones) of the Bohemian Cretaceous Basin.

Valley axes were analysed by a method of vector analysis (Juráček 2014). They were also evaluated by a construction of contour diagram. They were measured the data of the orientations of bedding planes and foliations by author's field work. The data of joints were obtained by Ferbar (2002). All these data were statistically analysed by a creation of tectonograms. Geological structures were compared to valley axes by an usage of the χ^2 -test. The results of main directions of the data were done:

bedding planes (group A): strike NNE–SSW to NE–SW, dip 30–40° to WNW–NW

bedding planes (group B): strike WNW–ESE, dip 50–60° to NNE

foliations (group A): strike WNW–ESE to WSW–ENE, dip 30–40° to SSW–SSE

foliations (group B): strike N–S to NNW–SSE, dip 50–60° to W–WSW

joints (group A): strike N–S to NNE–SSW, dip 80–90° to W–WNW / E–ESE

joints (group B): strike E–W, dip 70–80° to N / S

fault plane No. 1, No. 3: strike W–E, dip 70–85° to S

fault plane No. 2: strike NE–SW, dip 80–90° to NW

fault plane No. 4: strike NNW–SSE to NNE–SSW, dip 40–65° to ENE–ESE

striation No. 1: trend N–S, dip 15–30° to E

striation No. 2: trend NW–SE, dip 10–25° to NE

striation No. 3: trend N–S to NNE–SSW, dip 10–20° to W–WNW

striation No. 4: trend WNW–ESE, dip 5–10° to NNE

carbonate veins: trend NNE–SSW to NE–SW, dip 30–45° to WNW–NW

valley axes: trend WSW–SSW and NNE–E, slope <10°

The slopes of valley axes were statistically compared with the strikes (trends) and dip azimuthes of bedding planes, foliations, joints, fault planes and its striations. They could not be contrast to carbonate veins according to too little quantity of their relevant data. It was found out statistical relationship between valley axes and the strikes of

magmatic foliations primarily. Valley net was influenced by planar structures.

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SOURCES OF ALLUVIA DELIVERY TO A FORE-MOUNTAIN RIVER IN THE TEMPERATE CLIMATIC ZONE. ZLATY POTOK/CREAK, NORTHERN SUDETES FORELAND, SOUTHERN POLAND.

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Keywords: Zlatohorska vrchovina, gold ore and metal exploitation, alluvia pollution.

The north-eastern part of the Sudetes Mts.– the Zlatohorska vrchovina – is the mid-mountain ridge following the border between Czech and Polish territory (Fig. 1). The eastern part of this ridge between Olešnice creek in the west and Sadecky creek in the east, about 21km apart, dipping from 975m a.s.l (Příčný vrch) to 362m a.s.l.(Wężowa góra). Its western part is build up of Devonian metamorphic tuffs and quartzites, penetrating eastward under Devonian and Carboniferous phyllites, sandstones or greywackes. The first order fault cuts the northern margin of this structure. A few local transversal faults create the undulated relief of its northern slope. During cool periods of the Pleistocene the Scandinavian Ice Sheet reached mountain foothill (Anders 1939). As a result the glacial deposits covered the older bedrock and filled the depressions. During the last Pleistocene cool period the Scandinavian Ice Sheet reached a place 150-180km northward of this ridge. In the severe climatic conditions the bedrock weathering processes produced the regolith slope covers and loess mantle, which smoothed the former relief.

The northern margin of the Sudetes Mts. is situated within the temperate climatic zone of Central Europe. Here, in an interval of one or few years, there occur very different weather conditions, reflected sometimes in sharp temperature differentiations, as well as rains or seasonal snowfalls. Between 5-9 July 1997 the Zlate Hory gauge station (400m a.s.l.) located at the northern foothill of Zlatohorska vrchovina ridge recorded 513 mm of precipitation. The gauge station Jarnołówka, closing the mid-mountain forested catchment of 36 km², recorded a specific runoff of 1226 l/sec/km², while the Prudnik gauge station in the northern ridge foreland, closing a larger area with farming lands recorded a specific runoff of 1455 l/sec/km².

The Příčný Vrch massif (975m a.s.l.) is around 6km long and 4km wide. The weathering of rock outcrops in various climatic conditions caused the inclusion of mineralization zones (related to gold and other metals) within the regolith mantles of the outcrops. It is presumed that gold extraction was probably started by the Celts, and specific techniques were refined by the Slav, during the expansion of Great Moravia (Večeřova & Večeřa 2002). Gold was extracted in so-called soft-pits, i.e. holes dug in loose regolith mantles of alluvia, initially from the alluvia in the streams. After rain storms local streams, dissecting this massif slopes, eroded the metal-rich fine particles and deposited them few dozen kilometres downstream, on the flood plains.

Just a few km downstream of gold ore and metals exploitation prevailed overbank deposits with heavy content of Cd, Cu, Pb, Zn (Ciszewski et al.2014). In the upper course of the Zlaty potok the content of these metals is more than one or two orders of magnitude higher than in the overbank deposits filling other valleys in this region.

Since the Early Middle Ages, Zlatohorská Vrchovina belonged to the Kingdom of Bohemia, incorporated to the Holy Roman Empire in 1085. The region was intensively colonized, particularly during the reign of King Ottokar II of Bohemia, and later Charles IV (1346-1378)-king of Bohemia from 1346 and Holy Roman emperor from 1335. During this period numerous new villages were founded. A growing number of miners and farmers required increased food production, therefore the new villages began to expand cultivation areas. As a result forests clearance ensued, especially on fertile loess soils and on gentle slopes, including the main watershed areas. This was a second impulse to soil erosion and its redeposition on floodplains of the Zlaty Potok and its tributaries.

Glacigenic deposits, in particular loess patches, started to be eroded from the soils previously protected against erosion by forest communities. In contrast, the soils about 8 km eastward from the Zloty potok creek, developed on the regoliths of Devonian or Carboniferous phyllites or graywackes in the main ridge of Zlatohorská vrchovina, contain more than one order of magnitude lower trace elements than the alluvia of Zlaty potok creek. During snow melting periods, in the condition of freezing the soils, melting water not penetrating into the soils, result in large amounts of fine suspended sediments, bring delivered to the Zlaty potok creek, which is then transported downstream to river and finally deposited as overbank alluvia. The vertical sequences of these alluvia have highly variable content of metal pollution.

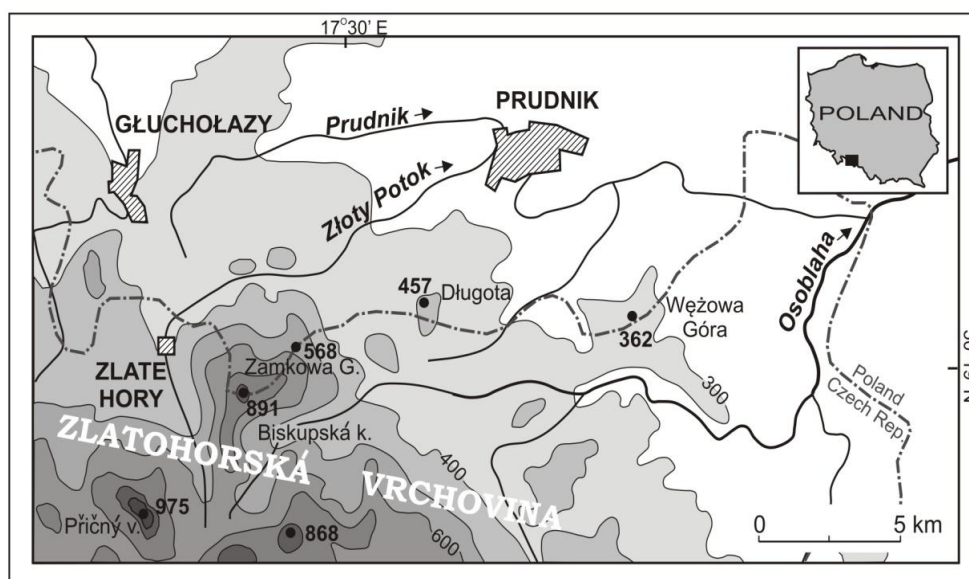
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GEOMORPHOLOGICAL CONDITIONS OF ROHAČKA KARST AREA

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Key words : *Geomorphological mapping, morphometric analyses, geomorphological forms, Rohačka*

The aim of this work is to characterize the geomorphological conditions of Roháčka karst area, which is located in the geomorphological unit Čierna Hora based on our own research and morphometric analysis area. The area is located in the cadastral territory of Hrabkov and Klenov. Study area is located on the Inner-contact (central – carpathian) Paleogene (Šarišská vrchovina) and the Slovenské Rudohorie – Čierna Hora. In this thesis, we evaluate different forms of geomorphological and morphometric analysis of the area such as slope, orientation, curvature topography, drainage water and the like. Individual analyzes are processed in the environment program Arcmap. The outcome of this work is geomorphological map capturing the current geomorphological conditions in the area. The aim is to bring a complete picture of the actual morphometric ratios relief area and highlight the importance of cooperation of the field geomorphological mapping with modern GIS methods.

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MICROMORPHOLOGY OF SAND GRAINS OF GLOF'S SEDIMENTS FROM PERU

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Keywords: *GLOF, exoscopy, quartz grain micromorphology*

The term glacial lake outburst floods (GLOFs) refer the sudden and in some cases cyclic release of meltwater from glacier-dammed or moraine-dammed lake (Iturrizaga, 2011). Glacial lake outburst floods can transport enormous masses, so it is assumed, that this transport will also affect the surface of drifted quartz grains. Past research (Krbcová et al. 2013, Krbcová, Křížek, 2013) has shown that fluvial transport on quartz grains appear within the first kilometer. This paper deals with the main microtextures of GLOF's sediments from Peru.

Samples were collected in June 2013 from Cojup valley in Peru. There were collected the samples from moraines, which were compared with samples from GLOF, which became in 1941. The grains from moraines have typical glacial microtextures, glacial microtextures as conchoidal fractures, straight steps, parallel striations, edge abrasion, meandering ridges and adhering particles were abundant. The grains from GLOF's sediments were very similar to grains from moraines, except roundness, straight grooves, irregular relief and rubbing traces. The effect of fluvial transport did not appeared on these grains. Using the one way ANOVA, there had been the differences only in occurrence of parallel ridges and rubbing trace. It is possible, that fluvial impact microtextures were not too developed because of the short fluvial transport and were covered by irregular relief caused by weathering or filled with silica globules, which were more abundant on GLOF's quartz grains.

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PATTERN OF STREAM CHANNEL MORPHOLOGY ONE THE NORTHERN SLOPE OF BABIA GÓRA MASSIF, WESTERN CARPATHIAN MOUNTAINS

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Keywords: Babia Góra massif, stream channel morphology, mountainous streams

Stream channels, especially their initial sections occurring in the headwater areas, are the most common landforms in the mountains. They are poorly studied due to their hardly accessible location areas with huge falls. Only recently, much more attention is drawn to the source sections of mountain streams, even in areas at high altitude. The aim of the author's study is quantitative geomorphological characteristics of the selected stream channels on the north slope of the Babia Góra Massif (the Beskid Żywiecki) with the attention to identifying processes that shape these landforms. Much attention was also paid to the effects of the past and present human activity, which have been registered in the morphology of these stream channels. Although the formation of particular stream channels in the mountains indicates in their longitudinal profiles fairly similar characteristics, there are some visible individual characteristics reflecting local conditions of their development. Each stream channel in the longitudinal profile may even vary considerably from one another. These changes can occur quickly, what may result from the whole complex of inanimate nature, i.e. geological structure, land relief, climate, soils, underground and ground waters, as well as human activity. Generally, the anthropogenic factor significantly changes the morphology of stream channels in the mountains. As an example of such human activity may be a destruction of knickpoints with dynamite in the channels of selected streams in the Bieszczady Mountains, which was to improve waterway transportation of timber logs to the lower parts of the mountains. Even greater changes in the morphology of mountain stream channels were caused by changing species composition of forests in the lower montane belt and establishing a dense network of forest roads which contribute to the rapid supply of water and suspended load from the slopes of watercourses (Łajczak, 1998). This results in a significant acceleration of the formation of flood waves which transport greater amounts of rock material, including more coarse silt and clay material. In the stream channels, especially in their lower parts, there are large amounts of forest rubble, i.e. fallen tree trunks. These fallen tree trunks, depending on their arrangement (diagonal, perpendicular or parallel to the channel direction), retain rock material and discharge water movement with varying degrees. Currently, the morphology of mountain stream channels is largely shaped by human activity and reflects its results, such as regulation works (river bars restraining coarse debris movement or bank revetment). Mountain stream channels, like river channels in the mountains, undergo constant changes under the influence of subsequent floods. The scale of these changes depends on a number of environmental factors, e.g. watercourse flow dynamics (Krzemień, 2012). Despite the fact that human

activity was completely ceased in the headwater catchment areas of the upper stream sections and that there is a significant reduction of such activity in the lower-lying slopes of the Babiogórski National Park, the results of anthropopression in the morphology of mountain stream channels will be visible in these areas for many years.

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DATED DEPOSITS ON THE TERRACES OF THE WIELKI ROGOZNIK STREAM (PODHALE REGION) IN THE ORAVA FAULT ZONE

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Keywords: *dated deposits, radiocarbon dating C14, Wielki Rogoźnik Stream*

Geomorphological and radiometric studies were carried out in the Northern part of the Podhale Region (Poland) along Wielki Rogoźnik Stream. Wielki Rogoźnik Stream is an 18 km-long tributary of the Dunajec River and drains the regions of Gubałówka Hills and the Pieniny Klippen Belt. The channel is sinuous with an average slope of 2.5‰. The valley of Wielki Rogoźnik Stream is typified by a series of terraces spatially varying in age, lithology and grain-size composition. Bedrock outcrops in the terraces occur only locally.

The valley of Wielki Rogoźnik is cut in the right flank of the Günz/Mindel glacial fluvial fan of the Czarny Dunajec River. Remains of the Tatra-derived deposits from that period have persisted on the valley sides as patches of loose quartzite pebbles (Domański Wierch, northern slopes of the Pieniny Klippen Belt). The highest terrace in the valley (5-6 m) with a fully preserved alluvium cover has been dated to the period of the last glaciation of the Tatra Mountains (Würm) (Watycha, 1977). The cover mostly consists of flysch gravels from the catchment of Wielki Rogoźnik Stream, with an addition of Tatra or Pieniny material and a thick, topmost layer of loams. The proportions in petrographic composition of gravels within the terrace vary with location. Flysch gravels are dominant in the Holocene terraces.

Height of particular Holocene terraces is are in the range of 0.5 – 2.5 m. For terraces with layered structure, the radiocarbon dating of charcoal from terrace alluvium was performed. We have obtained different dates for individual layers. This is typical for the 2.5 m terrace at the Stare Bystre site. The upper part (1.3 m) of the terrace consists of sandy-loamy alluvium covering a layer of gravels with clay intercalations. The lower part (1.2m) consists of a thin layer of peat and silt overlaying another gravel later. The gravels from the lower part of the terrace are less weathered, more cemented and have carbonate crusts (tufa) than these from the upper part. This layer of gravels is more resistant to fluvial erosion and forms a distinctly convex part of the terrace profile.

The alluvium rests on Neogene claystones are outcropping in the channel bed. Dating of the boundary peat indicates Pleistocene age (Alleröd) of the lower part of the terrace while the lack of cementation of the upper gravels suggests they are significantly younger. Thus, the structure of the 2.5 m terrace alluvium can be

considered two-phased and its lower part fossil. It suggests that the burial of Pleistocene deposits might be controlled by tectonics. This suggestion is supported by location the studied area. The dated peat is situated within the area of the Orava Basin fault system (Bac-Moszaszwili 1993; Baumgart-Kotarba 1991-92).

The height of the terrace with Pleistocene deposits increases from 1.2 m at Stare Bystre site to 3.5-5.5 m in the downstream part of the valley. Even the terraces with alluvium dated to Late Holocene are higher. Similar, two-part structure is typical of a 2.5m terrace at Ludźmierz site located at the foothill of the Beskidy Mts. The age of the lower part terrace composed of gravels, sands with charcoal is the Early Holocene while the upper one (sands, silt with charcoal, loams) formed during the Late Holocene. Similar to the Stare Bystre site, the contact of both parts is not erosional and marked with the presence of organic material; alluvium in both parts differs mostly in cohesiveness.

Apart from terraces, layers of different age occur also in cut-and-fill structures within older alluvium. Palaeochannels within the 3.0-3.5 m terrace in Stare Bystre and Ludźmierz sites are filled with laminated sands, silt and organic material.

It seems that (1) the overlaying of younger series over older ones, (2) the presence of cut-and-fill structures, (3) the spatial variation of terrace height as well as (4) the presence or lack of bedrock outcrops in the terraces suggest a tectonic control on the formation of these terraces, both upward (right-side terraces in the vicinity of the Pieniny Klippen Belt) and downward (Miętustwo Basin, vicinity of Rogoźnik).

Summing up, the impact of active young tectonic movements (both downward movement in Mietusia Basin and Rogoznik region and upward movement in right site terraces in vicinity of the Pieniny Kippen Belt) on formation of terraces is marked by: (1) the overlapping the younger series of sediments to older, (2) the presence of filled channels, spatial differences in height of terraces and (3) the presence or absence rocks underlying gravel materials.

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BEAVER (*CASTOR FIBER*) ACTIVITY AND ITS EFFECT ON THE STREAM CONNECTIVITY IN THE CHANGING WATERSHED OF THE KATEŘINSKÝ BROOK

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Keywords: beaver dam; beaver pond; sediment transport; stream connectivity; landscape changes; Sudetenland; didactic transformation

We studied the distribution of beaver dams and other beaver structures in order to describe stream connectivity in the beaver-affected watershed of the Kateřinský brook. The studied watershed is located in the vicinity of so-called iron curtain (border between democratic and communist Europe) and was largely affected by the land-use and land-cover changes in the second half of the 20th century. Whole region was closed to the public, nearly abandoned and major areas were reforested after the Expulsion of German population and establishment of border zone in late 1940s. The European beaver (*Castor fiber*) re-colonized this changing and semi-natural environment in the early 1980s. To date, we mapped the location and measured length, height and other attributes of over 200 beaver dams in the upper part of the watershed (area of ~20 km²). We created the longitudinal profiles of the most dammed stretches of the streams using the automatic level. We also measured the flooded area of beaver ponds. The grain size analysis was performed on two cores extracted from the beaver pond infill. The land-use changes were described from comparison of various historical maps and aerial photos. We also performed the didactic transformation of this topic and prepared the worksheet for high school geography fieldtrip.

THE CYRILKA CAVE: LONGEST CREVICE-TYPE CAVE IN CZECH REPUBLIC

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Keywords: crevice-type cave, pseudokarst, slope movements, flysch, Outer Western Carpathians

The Cyrilka cave (the Moravskoslezské Beskydy Mts., Outer Western Carpathians) with the length of 535 m is the longest crevice-type cave in Czechia. The cave has typically developed passages within the sedimentary flysch rocks – sandstones, conglomerates and claystones, siltstones. The whole cave complex is formed in the upper part of vast landslide and it is predisposed by three types of discontinuities: bedding planes, faults and joints. The cave complex represents an exceptional example of well-developed underground spaces within progressively evolving headscarp area of deep-seated landslide in sedimentary flysch rocks. The cave passages have specific morphology.

Currently, the geomorphological and also the biological research have been performed within the cave system in order to prepare the groundwork for natural monument declaration.

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METHODS OF FRACTAL GEOMETRY USED IN THE MORPHOMETRIC ANALYSIS OF ETHIOPIAN HIGHLANDS

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Key words: fractal – drainage pattern – valley network – fractal dimension - multifractal

The idea of describing natural phenomena by studying statistical scaling laws is not recent. Indeed, many studies were carried out on this topic (Bachelier, 1900; Mandelbrot, 1967). However, there has been a recent resurgence of interest in this approach. A great number of physical systems tend to present similar behaviors on different scales of observation. The fractal geometry methods allow to quantitatively describe the self-similar or self-affined landscape shapes, allow the complex/holistic study of natural objects in various scales and to compare the values of analyses from different scales (Mandelbrot 1967; Burrough 1981; Křížek&Kusák 2014; Kusák 2014). With respect to the hierarchical scale (Bendix 1994) and fractal self-similarity (Mandelbrot 1982; Stuwe 2007) of the fractal landscape shapes forms complex network, i. e. the drainage patterns and the valley networks, suitable morphometric characteristics have to be used and a suitable scale has to be selected in order to evaluate them in a representative and objective manner.

This paper deals and compares: 1) the basic terms in fractal geometry, i.e. the fractal dimension, self-similar, self-affined and random fractals, hierarchical scale, fractal self-similarity and the physical limits of a system; 2) selected methods of estimating the fractal dimension of drainage pattern and valley network, applied on the schematic valley networks by Haward (1967) and on selected networks on Ethiopian highlands.

If the drainage pattern or valley networks are self-similar fractals in various scales, it is appropriate to estimate the fractal dimension by „fractal dimension of drainage patterns and valley networks by Turcotte (1997)“. Conversely, if the river and valley networks are self-affined fractals, it is appropriate to estimate fractal dimension by methods, which use regular grids, i. e. the "fractal dimension of drainage patterns and valley networks by Mandelbrot (1982)", "box-counting dimension by Turcotte (2007a)", "box-counting dimensions by Rodríguez - Iturbe & Rinaldo (2001) / Kolmogorov dimensions by Zelinka & Včelař & Čandík (2006)" and "capacity dimension by Tichy (2012)".

In order to most accurate estimation of fractal dimension were on the valley networks applied mathematical methods of studying complex systems (Hajian, Movahed, 2010; Ariza-Villaverde et al. 2013) and application of Renyi dimensions shown that river and valley networks are multifractal shapes of landscape (Kusák 2014).

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THE NEW FEATURES OF LANDSLIDE RELIEF DISCOVERED USING LIDAR. CASE STUDY FROM THE BABIA GÓRA RIDGE, WESTERN CARPATHIAN MOUNTAINS

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Keywords: *Babia Góra ridge, Western Carpathian Mountains, landslides, geomorphological mapping, LiDAR data*

Basing on LiDAR data, the reinterpretation of the limit and distribution of the selected landslide forms in 9 test areas were carried out (Łajczak et al. 2014). The forms are located at the slopes of the monoclinical ridge of Babia Góra Mt. (1725 m a.s.l.) in the flysch Western Carpathians. The monoclinical ridge of Babia Góra Mt. is the highly located ridge in the flysch Western Carpathians reaching the height of 1100 m above the surrounding valleys. The ridge located along the W-E direction is 10 km long. The upper part of the ridge (above 1000 m a.s.l.) is built of Magura sandstone layers dipping to the south, and the lower part consists of less resistant sub-Magura layers. All elements of landslide relief occurring in the flysch Carpathians area are visible in the Babia Góra ridge and they are located on slopes from the ridge plateau to the valley bottoms.

The earlier knowledge on the landslide forms is shown in the unpublished map at the scale of 1:5000 which was prepared by A. Łajczak in 1997-2007 basing on geomorphological mapping. Basing on the newest information source, subtle geomorphic signatures of landslides were found, the dynamics of these forms and directions of their further development were determined. Local differentiation of deep-seated landslides was indicated according to the relation between the sandstone layer dip and slope inclination, slope length, and altitude of the location of headwaters. An attention was paid to polycyclic relief of the highest located landslide forms, which contain the elements of glacial and nival morphology, and some are modelled by debris flows.

The commonly occurring landslide forms present in the whole area of the massif include: ridge and slope trenches with dilatation caves, escarpments, headwalls, rocky walls; and in the places covered by debris or block colluvia: hummocks and isolated hills, ramparts distributed similarly to contour-lines, tongues and wide lobes going down to headwater areas. Landslide headwalls in the cuesta, as opposed to the slope convergent with the dip of Magura sandstone, are deeper but their limit is smaller. They are accompanied by thicker covers of colluvia which build accumulation forms up to several tens of meters high.

The distribution and the range of landslide forms on the slopes of Babia Góra ridge were determined basing on the contour-line map at the scale of 1:10000 and on the orthophotomap of the pixel size of 0.25m. Also the geomorphological map of the massif at the scale of 1:5000 was taken into account. This map was transformed with 1st affine type and with mean RMS 2.1 m. Basic information for reinterpretation of

landslide relief of Babia Góra ridge were obtained from the LiDAR data (2012). The scanning was carried out with accuracy of 6 points at 1 m² to the border of the Board of Babiogórski National Park and facilitated for the needs of the research project. Digital Terrain Model were computed using “bare Earth” data types from cloud points (*.las) of original resolution 0.5 x 0.5m. Using ArcGIS 9.3 – ESRI software it was filtered to eliminate information noise and reinterpolated to 1x1 m model. For Babia Góra ridge, which is relatively small area (30 km²) that was optimal resolution to detect most of the landslide forms. A slope reduction map and a hillshade model was prepared as a basic tool of relief analysis. Additionally the analysis of the curvature of a raster surface to detect convex and concave forms of the relief were performed. This was the base to determine the limits and configuration of the selected landslide forms which are the subject of this work. Investigated landslide forms were identified and mapped employing on-screen mapping aided by elevation profiles. These analysis were supported by field observations.

The mechanism of landslide development reflected in their morphology, which detailed analysis was possible with the use of LiDAR data, is typical for landslides from other areas. Development of landslides in the Babia Góra ridge is initiated in the low located or the highest located slope fragments. Despite the fact that landslide relief of Babia Góra Mt. has been investigated for over 100 years (Rehman 1895, Ziętara and Ziętara 1958, Alexandrowicz 1978, Łajczak 1998, 2012, 2014, Ziętara 2004), a geomorphological map of this massif has not been published. It is necessary to reinterpret the relief of the whole massif basing on LiDAR data including all the landslide forms. Other information sources considered in the work will have only secondary importance.

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ROLE OF LAND RELIEF AND STRUCTURE IN THE FORMATION OF PEAT BOGS IN MOUNTAIN AREAS, AS EXEMPLIFIED BY THE POLISH CARPATHIANS

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Keywords: peat bog, raised bog, Orawsko-Nowotarska Basin, Bieszczady Mountains, Western Carpathian Mountains

It has been often argued that the formation of peat bogs in the mountains is predominantly influenced by a humid climate. Although in many mountains precipitation during the vegetation growth season is greater than evaporation, bogs, especially of the raised type, do not cover all gently sloping areas and often develop only within certain landforms. Local hydrological conditions determined by land relief and structure are the most crucial factor in the development of bogs in such areas. Peat bogs of the Polish Carpathian Mountains demonstrate that bogs, irrespective of altitude, develop mainly in concave landforms or below convex morphological recesses, where outcrops of poorly permeable rocks offer numerous low-capacity but stable outflows of groundwater that continuously humidifies the slopes lying below thus supporting the formation of habitats for hydrophilic plants. This research project covered the parts of the Polish Carpathians having the largest number of bogs, thus allowing local-scale analysis of their location in relation to the lithological, geomorphological and hydrogeological properties of the substratum (Łajczak 2006, 2009, 2013, 2014). It is assumed that an assessment of the influence of substratum on the location and formation of peat bogs is only correct when the coverage of the individual mires in the period preceding their anthropogenic degradation is known. Only then is it possible to establish what types of bedrock and which landforms are most favourable for bog formation.

The problems outlined in this work are discussed on the basis of the example of raised bogs in the Polish part of the Carpathian Mountains. The number of raised bogs in these mountains is low compared to the northern, lowland part of Poland which has a young-glacial land relief. Locally, the number of bogs is large enough for their location to be analysed on the basis of the lithological, geomorphologic and hydrogeological properties of the substratum. Most bogs in these areas of the Polish Carpathians have an area of less than 1 ha, with only a few being larger than 100 ha. They occur on hilltops, slopes and in some mountain valleys and basins. Bogs located on ridges are for the most part ombrogenous in nature, while the more numerous slope bogs are soligenous. The lowest located bogs are fluviogenous and topogenous, and locally there are also ombrogenous ones. This work covers bogs in the Orawsko-Nowotarska Basin, on the floors of the upper San River and the Wołosaty River valleys in the Bieszczady Mts, on the mountain ridges of the Beskid Śląski, the Beskid Żywiecki and the Bieszczady Mountains, and in the Tatra Mts.

The aim of this work is to explain the role of land relief and structure, as well as the

hydrogeological conditions of the development and location of peat bogs, especially raised bogs, located on ridge tops, slopes, the floors of mountain valleys and basins in the Polish Carpathians, i.e. places with a variable excess of precipitation over evaporation in the vegetation growth season across the elevation profile. Thus, this study addresses the role of land hydration in peat bog expansion and explains how expanding raised bogs have changed the land relief and location of watercourses on a local scale.

This study is based on the results of the author's own geomorphological and hydrographical mapping of peat domes, post-peat areas, low bogs and their surroundings, along with the areas adjacent to the neighbouring watercourses in the Carpathian areas under study. Use was also made of studies on the location of peat bogs in the Tatra Mountains and within selected landslides in the Beskidy Mountains by other authors. Changes in the coverage of peat bogs in the last 230 years were assessed based on maps from 1779-82, 1855, 1894, 1937, 1965 and 1997, and for the last 50 years, also on the basis of aerial photographs. The use of GPS technologies allowed the current extent of individual peat bogs and their location relative to landforms and groundwater outflows and watercourses to be established. The permeability of the mineral substratum of peat bogs was established by means of the Burger cylinder method. Peat thickness was investigated by drilling, while information on the greatest thickness was taken from literature. During field studies attention was paid to the location of remnant peat deposits outside the locations where peat is present in a compact form, especially in areas where peat mining was discontinued before ca. 1850. The information allowed the previous coverage of peat domes to be established, which was often greater than that shown by the earliest maps.

Peat bog development was analysed in eight geomorphological situations. By analysing the relief of raised bogs in the Polish Carpathians some of the characteristics of bogs were examined which had not been previously addressed. The following groups of peat bogs were analysed: soligenous, topogenous, fluvioigenous and ombrogenous.

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TRANSPORT OF SUSPENDED SEDIMENT BY THE VISTULA RIVER BASIN UPSTREAM OF KRAKÓW, SOUTHERN POLAND, AND THE HUMAN IMPACT DURING THE SECOND HALF OF THE 20TH CENTURY

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Keywords: suspended sediment, sediment loads, human impact, Upper Vistula River basin, southern Poland

The upper part of the Vistula River basin, upstream of the city of Kraków (7524 km²), southern Poland, represents an area where human activity has had a major impact on the rate and long-term trend of suspended sediment transport by rivers. During the 1950s and 1960s, the studied stretch of the Vistula River received increasing volumes of wastewater from industrialised and urbanised areas, primarily via its tributary the River Przemsza, which runs through the Upper Silesian Industrial Basin. These inputs subsequently reduced. At the same time, the transport of suspended sediment by other tributaries was declining due to reforestation and construction of new dams. Below the confluence of its three largest tributaries, the main river becomes overloaded with suspended sediment, largely of anthropogenic origin, and this rapidly accumulates within the embanked zone, especially along the two reaches where the river level is raised by several metres, due to impoundment.

In Poland, the largest changes in suspended sediment transport due to human impact took place during the 20th century in the catchment of the Vistula River, upstream of the city of Kraków. This region of Poland is largely urban and industrial. However, the intensity of human impact varies significantly across the area and has changed substantially over the years. This has affected the suspended sediment transport regime of the rivers of this region. This conclusion is based on analysis of data on suspended solids concentrations provided by Poland's State Hydrological Survey. The data cover the second half of the 20th century.

The purpose of this work is to investigate suspended sediment transport in the Vistula upstream of Kraków. The paper looks at changes in the suspended sediment loads, both along the course of the river, as well as over time. The background for this paper is the transport of suspended sediment in tributaries flowing across the main morphological units of a study area with diverse land use. The studied part of the catchment of the Vistula River includes the Western Flysch Carpathians (Beskid Mountains), the eastern part of the Silesian Upland, the Oświęcim Basin as well as some parts of the Carpathian Foreland and the Kraków Upland. The elevation of the catchment ranges from 201 m to 1725 m a.s.l. The Vistula River between its source and Kraków is 167 km long. The river is joined by two large mountain tributaries (the Soła and Skawa rivers) and by one large upland tributary (the Przemsza River).

Measurements of suspended sediment concentration in the Vistula River within the study area were made by the Polish State Hydrological Survey between 1946 and the 1990s. Similar measurements were initiated in the tributaries of interest during the 1950s and 1960s. Measurements upstream of Kraków were made at five gauging stations. Measurements on the four largest tributaries were made at eight gauging stations. In 1995 most of the gauging stations ceased to collect data on suspended

sediment concentrations. The various sub-catchments where suspended sediment transport has been gauged, represent all of the geomorphological regions of the portion of the Vistula's catchment under investigation. Each sub-catchment also varies in terms of the degree of human impact. The work is based on annual values of suspended sediment load R ($t \text{ year}^{-1}$), estimated by the author on the basis of data obtained from the State Hydrological Survey.

In the period after the start of the Vistula River channelization, two phases, characterised by rapid changes in the suspended sediment load of the river, can be distinguished (Łajczak 1995, 2003). An increase in the transport of suspended sediment in the Vistula River during the four decades after the initiation of the river regulation (1890s–1930s) was followed by a rapid decrease in suspended sediment loads, due primarily to the construction of dams and changes in land-use in the river basin. The decline subsequently continued, but at a slower pace and with fewer fluctuations (Łajczak 1999). If this trend continues, the rate of sedimentation in reservoirs will decrease and the ecological state of the Vistula valley will improve. The sequence of changes shown by this study is similar to those reported by other studies of long-term changes in fluvial sediment transport and shown by the contemporary modelling of floodplains and river channels in other areas, particularly in response to the urbanization of catchments (e.g. Wolman 1967, Walling 1974). Similar causes for recent decreases in the suspended sediment loads of other rivers have been indicated by Winkley (1982), Keown et al. (1986), Kesel (1988), and Weiss (1996).

The short period with increased suspended sediment load in rivers as a result of construction work in the catchment area, identified by Wolman (1967), and the subsequent decrease in sediment load as a result of impoundments in the river basin, may be considered an analogue for the documented changes in sediment load in the study reach of the Vistula River, caused by human impact.

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THE IMPACT OF EARTHQUAKES ON LANDSLIDE ACTIVITY IN THE WESTERN CARPATHIANS DETERMINED BY THE MEANS OF DENDROCHRONOLOGY

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Keywords: *seismic activity, earthquake, landslide, dendrochronology, tree-ring eccentricity*

With the use of dendrochronological methods we have analysed the activity of selected landslide slopes in the Polish and Czech Western Carpathians. We have used a method of per cent eccentricity index of tree rings. We have selected 5 landslides for the analysis: (a) in the Grapa massif (Spisko-Gubałowskie Foothills), (b) in the Hołowiec massif (Magura Spiska Mts), (c) in the Kamień massif (Beskid Niski Mts), (d) in the Prusów massif (Beskid Żywiecki Mts) and (e) in the Lysa hora massif (Moravskoslezské beskydy Mts). Landslides in Grapa, Hołowiec and Kamień massifs are located closely to epicentres of earthquakes in Podhale region and in the Beskid Sądecki Mts.

We have sample 20-47 trees on each of the analysed landslide slopes. We have sampled Norway spruce trees (*Picea abies*) and European silver firs (*Abies alba*). Through the analysis of tree-ring chronologies with the use of eccentricity index we have determined the temporal pattern and variability of the activity of five landslides studied during the last decades. Results (per cent of trees showing reaction to landsliding in the sampled population in each calendar year) were compared with the occurrence of earthquakes recorded by seismographs in Poland and data available in the literature. We have found out that often in years of earthquakes (e.g. 1956, 1992-1995, 2004-2005) increased landsliding occurred on studied landslide slopes. Landslides responded not only to earthquakes with epicentres located in the Polish Carpathians and Carpathians in general, but also in remote areas like the Balkan Peninsula. It seems that the impact of seismic activity on the Carpathian landslides is significant. We have found that earthquakes were probably able to trigger landsliding even in years with particularly low precipitation rates (e.g. in 1992).

The comparison made for all five studied landslides show large differences between their reaction to earthquakes. Seismic shaking had the strongest influence on landslides located close to epicentres (Grapa and Hołowiec study sites). Strong impact of earthquakes on landsliding was also observed in case of the and Kamień study site. The weakest reaction to earthquakes was recorded on the Lysa hora study site in the Czech Carpathians, with the longest distance to earthquake epicentres.

THE INFLUENCE OF MINING ACTIVITY ON LANDFORM FEATURES

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Keywords: *hypsographic curve, subsidence, a topographic map, Ruda Slaska, the Upper Silesian Coal Basin*

Mining and heavy industry affect many parts of the geographical environment, including modifying the natural lie of the land. Such interference results in both the emergence of new forms of land, as well as a general decrease in the altitude above sea level.

Will be presented geomorphological results of intensive exploitation of hard coal and urbanization on the area of Kochłownicze Hills (Ruda Slaska, Poland). The analysis covered the second half of the twentieth century and focused on artificially delimited area of research (5,9 sq km). The basic source materials were the archival and current topographical maps at a scale of 1 : 10 000 and 1 : 5 000. Hypsographic curves and hypsometric profiles were used to appropriately depict achieved results.

The study attempted to determine the average amount by which the height of the study area has changed, and the average annual rate of land subsidence. The transformation scale reached a very high level. Based on the analysis it can be concluded that the main features of research areas have been preserved. These type of surface transformation are characteristic of mining areas.

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NEW, BEAUTIFUL BYTOM

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Keywords: post-mining reclamation, relief, hard bituminous coal, Bytom, the Upper Silesian Coal Basin

Landscape can be understood as a heterogenous fragment of land with a specific physiognomy constituting a dynamic system which comes under the evolution. Moreover, landscape is ceaselessly modified as a result of intensifying human activity. Bytom is a city localized in the Upper Silesian Coal Basin, on Bytom and Katowice Plateau where the exploitation of hard bituminous coal is led. A result of this kind of human activity is, among others, transformation of the lie of the land. Different types of forms of anthropogenic origin come into existence, which add variety to or completely change the primeval topography. In the landscape there are, among other things: closed excavations, post-mining and post-smelting landfills, mineral ponds, disordered dumps, excavations operated within the secondary piles, leveled areas, anthropogenic embankments and banks and subsidence basins. Upon completion of mining in the mining area problems occur in the form of highly transformed, unused site, which is waiting for its "second life". Finding a new function for this area is important because of the increasing significance of reclamation and remediation of post-mining areas. An example of an area that was once again put to good use is a fragment of Bytom Szombierki district, located in the Bytomka Upper Valley, where, in the twentieth century, there has functioned a deep coal mine, and since 2013 has been serving a recreational function. The discussed site has been transformed into a high-class golf courses.

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ON THE GENESIS AND AGE OF LOESS IN SOUTH-EAST PART OF THE DANUBE BASIN. THE PRESENT STATE OF RESEARCH.

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Keywords: *loess, Danube Basin, Hron River, sedimentology, research methods, Malá nad Hronom, brick-yard*

Loess and loess loams are characteristic Quaternary sediments of lowlands forming more or less continuous covers in Slovakia. In spite of this there are only a few localities at which a wider complex of new methods were applied (Vlačíky et al. 2013). A paper gives the review of the knowledge of loesses and fluvial sediments in the South-east part of the Danube Basin. A new detailed research was conducted in 2014. Focusing on abandoned brickyard near Malá nad Hronom village and its vicinity it had included detailed sedimentological analyses and field observations. Main goal of new research is to complete the malacological and sedimentological results of former research realized by Schmidt (1982) at this locality and to acquire new results obtained with modern methods (sedimentological: lithostratigraphical logging, magnetic susceptibility, spectral reflectance, carbonate content, pH, TOC, grain size analysis; complex analysis of the paleosol horizons: Hardentest, semiquantitative analysis of layers, age estimation; mathematical analysis: Cluster analysis; chronometric age determination: 14 C analyse, OSL dating). Next goal of research in the future will be the comparison of loess at south-east part of the Danube Basin to those at Danube river left banks in Hungary.

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MORPHOTECTONIC HISTORY OF THE WESTERN CARPATHIANS (STORY OF RECOGNITION).

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Keywords: *morphotectonics, planation surfaces, river terraces, OSL, cosmogenic nuclides, thermochronology, Western Carpathians*

Plenty of studies deals with geomorphic history of the Western Carpathians parts but synthetic views of the whole mountain are rare. Mazúr (1965, 1979) defined active morphostructure of the Western Carpathians as the first, considering already a basic principles of plate tectonics. Some year ago we realized a first step of latter synthesis including current geological, geomorphological and geophysical knowledge (Minár et al., 2011), the picture is complemented and verified by targeted fieldwork and modelling on the present (Fig. 1).

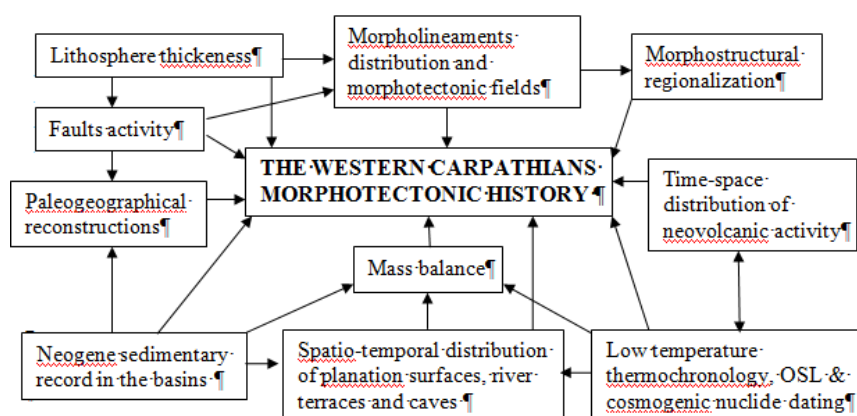


Fig. 1 Interaction of fundamental information for revelation of the Western Carpathians morphotectonic history.

Following main stages of modern Western Carpathians land surface formation we can recognise today:

1) Prologue (till ~20 Ma): Despite of complex morphotectonic development only remnants of exhumed and descendant paleosurfaces and some rejuvenated morpholineaments are preserved in the Western Carpathians land surface. Confirmation of impression of older stages of planation on the recent land surface is the main actual result.

2) Initial stage (~ 20 - 5 Ma): Formation of microplate ALCAPA and subsequent start of the Outer Western Carpathians rise gave a basic limitation of the Western Carpathians morphostructure. Middle Miocene extension and elongation of the ALCAPA started build up the recent mosaic of marginal and intramountain basins. From the contemporary volcanic activity only denudation remnants of central volcanic

zones are preserved in the recent land surface. Collected indicia suggest that in this stage - culminating by tectonic inversion in the basins - was created initial planation surface of modern land surface as a tectoplain (Minár, 2003). Areas with largest extent of this surface are connected with exhumation and cut-down of older paleosurfaces and periphery of Neogene volcanoes - nearly exclusively in the Inner Western Carpathians. External Western Carpathians raised from the W to E by nappe stacking during forepart of the stage and gradually formed closed mountain belt. Simultaneous intensive denudation could integrate a part of inner side of the belt into initial planation surface in fine and individual bevels could have been shaped at different altitudes, with respect to local base levels and bedrock resistance also at the outer side (Zuchiewicz, 2011).

3) First neotectonic stage (~ 5 - 3 Ma): Rise of the recent dome-like morphostructure started after full devolution of continental collision impulse into the Inner Western Carpathians. Crushed thin lithosphere has been probably responsible for different uplift that emphasized mountain - basin mosaic in the relief. However a denudation of the soft basin infill (reflected in significant stratigraphic hiatus) could contribute too. Tectonic impulse appears from the frontal collision zone - the northernmost part of Klippen belt. Mountains with the best preserved remnants of initial planation surface at the present time were uplifted at least.

4) Pediment relaxation (~ 3 - 1 Ma): Intensive neotectonic uplift has been interrupted by relatively calm period that could be a consequence of temporary modulation or finishing of the continental collision. Resulting stabilisation of the erosion base led to the creation of at least two levels of pediments increasing to pediplain on the periphery. Our recent investigations confirm this stage in the sedimentary infill of the basins as well as highest cave filling. Morpholineaments as well as another tectonic markers support an idea of postorogenic stage of development characterized by gravitational collapse of the orogene.

5) Second neotectonic stage (~ 1 - 0 Ma): Mostly 100 - 150 m incision of main rivers into the youngest pediments and creation of river terraces system characterize the last tectonic activity. Distinct faceted fault slopes up to 500 m high (1000 m in the Tatras) as well as "delayed elevations" (Minár et al, 2011) are a consequence too. Because big spatio-temporal differentiation we suppose more reasons. Along with a new compressional phase a glacio-isostatic adjustment involved in the convergent gravitational collapse could be fundamental.

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ADVANCING PLEISTOCENE AND HOLOCENE CLIMATE CHANGE RESEARCH IN THE ROMANIAN CARPATHIANS USING GLACIAL DEPOSITS AND LAKE SEDIMENTS CHRONOLOGY

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Keywords: *glaciation history, glacial deposits, paraglacial processes, lake sediments, Romanian Carpathians*

The Carpathian Mountains is one of the main transitional climatic zones in Europe, and one that seems to be greatly affected by current climatic modifications. The region lies at the very contact between oceanic, continental, Mediterranean and Black Sea air masses (Fig. 1), and the dynamic interplay and variations in the strength of these influences determine major changes in climatic regimes (temperature/precipitation) over very short distances and time intervals, the key factors in the distribution of biogeographical zones in the region (Gâștescu et al., 1975). Studies of vegetation dynamics and palaeoclimate highlighted the importance of this region as glacial refugia (Willis, K.J., & van Andel, T.H., 2004; Bertalan et al., 2014) but also pointed out significant regional differences compared with Central and Western Europe (Farcas, S., et al., 1999; Wohlfarth, B., et al., 2001; Tantau, I., et al., 2005; Feurdean, et al., 2007). However, as these studies were addressing only the Late Glacial and Holocene environmental development, palaeoclimate data are still scarce for this part of Europe for most of the last glacial cycle Marine Isotope Stages [MIS] 6-2), and earlier.

The last glacial cycle (LGC) was characterized by abrupt and high-amplitude climate fluctuations on millennial to centennial time-scales, the Dansgaard-Oeschger (DO) interstadials and stadials, and Heinrich events (Bond, G., et al., 1993; Dansgaard, W., et al., 1993). These events have been extensively documented for North Atlantic and Western Europe, yet such evidence is scarce for central Europe and Eastern Europe.

Crucial information for answering some of these questions can be obtained by studying palaeoclimatic evidence in the Carpathian Mountains (Fig. 1). This mountain chain is circa 1600 km long (800 km in Romania) and rich in primary climatic archives such as glacial landforms, lakes and peat-bogs. It represents the last orographic barrier for oceanic air masses in front of the vast steppe regions (and continental climates) of Eurasia. Precipitation in the Carpathian region is strongly controlled by the short and long-term variations of oceanic influences, and clearly distributed as a function of altitude. It is expected therefore that the small mountain glaciers (5-30 km in length) which formed in these mountains during LGC were very sensitive to the probably large variations in temperature and precipitation at a millennial-time scale. A record of these variations seems to be preserved not only in the widespread glacial landforms (moraines, glacial sediments, erratics), but also in the sedimentary records of lakes and peat-bogs closely associated, genetically and spatially, with the glacial landforms (Șîrcu, I., 1978; Niculescu, G., et al., 1983; Urdea, P. et al., 2011) such as glacial cirques (Mindrescu & Evans, 2014; Mindrescu et al., 2010; Mindrescu, 2006) and geomorphic patterns following glacial climates (Mindrescu & Gheorghiu, 2014; Gheorghiu & Mindrescu, 2013)

Here the investigation of three key regions for understanding the pattern of

glaciation/deglaciation in the Romanian Carpathians in the context of rapid climate variability is proposed. This approach is one of the first to address these questions in the region using evidence from a network of records and focusing on multi-proxy investigations, chronological considerations as well as interpreting the data in the context of rapid climate variability. A model will be developed linking chronology of the glacial sequence and lake sediments in three sites of the Romanian Carpathians during the transition between the Lateglacial and the Holocene in order to (1) better constrain the timing and sequence of deglaciation, (2) relate its history to millennial-scale climate change, (3) assess the sensitivity of the Carpathian glaciers to temperature changes during the early Holocene, and (4) outline the changes of landforms after deglaciation (periglacial and paraglacial processes and environments).

Application of cosmogenic nuclides in the study of Quaternary glaciations has increased rapidly during the last decade, remedying the previous absence of direct dating methods for glacial landforms and sediments. Although several hundred publications have already been released on exposure age dating of glacial landforms worldwide, very few studies targeted the Carpathians so far (Kuhlemann et al, 2013a; Makos et al., 2014, 2013; Mentlík et al., 2013, Reuther et al, 2004, 2007; Rinterknecht et al. 2012; Gheorghiu, 2012).

There are many unresolved or contradictory issues regarding the glacial chronology of the Romanian Carpathians (Ruszkiczay-Rüdiger et al., 2014). Albeit several datasets derived from cosmogenic ^{10}Be dating have been employed in recent years for building an improved temporal framework for glaciations in this region (Reuther et al. 2004, 2007, Kuhlemann et al. 2013a), in some instances these studies generated more confusion; i.e., the local last glacial maximum, for instance, apparently occurred asynchronously compared to each other, as well as to other dated glacial events in Europe (Hughes et al, 2013). Furthermore, the local Last Glacial Maximum (LGM) appears to coincide with the global LGM derived from the Eastern Balkans (Kuhlemann et al. 2013b), whereas the penultimate glaciation seems to significantly overtake the LGM advance over the Western Balkans (Hughes et al. 2011).

Recent studies have shown that the Holocene climate has fluctuated significantly and abruptly, with less intensity than during the previous climatic stages, but with considerable regional variations (Bond et al., 1997; Mayewski et al., 2004). Next to the ample climate shifts of the Late Glacial, such short term Holocene abrupt events have been shown to impact on CE Europe and were also tracked on the Romanian territory (Magyari et al., 2013; Buczkó et al., 2012; Tanțău et al., 2009; Feurdean et al., 2008; etc). Identification of such past climatic events in Romania became possible due to enhanced methodology and high quality available records for comparison, which impelled a development of palaeoclimatic and palaeoenvironmental studies during the past decade.

Due to their location, the Carpathians are ideally positioned to capture the dynamics of changes in atmospheric circulation, temperature and precipitation regimes during Late Pleistocene and Holocene in the mid latitudes of Eastern Europe. From a palaeoclimatological point of view, the Carpathians (and to a large extent also the lowlands around) are poorly explored, with an urgent need for studies filling the gaps through linking detailed geomorphological mapping with chronologically-well constrained investigations. Only through efforts to integrate this region into a European context will it be possible to obtain a reliable picture of palaeoenvironmental development at a continental scale.

DISTRIBUTION AND MORPHOLOGY OF ROCK GLACIERS IN THE TATRA MOUNTAINS

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Keywords: *rock glacier, morphometry, Tatra Mountains.*

Rock glacier (RG) is lobate or tongue-shaped landform consisting of mixture of debris and ice, which moves down-slope by deformation of containing ice (French, 2007). Active RGs are considered as indicator of lower limit of high-mountain permafrost (e.g. Barsch, 1996). Change of climatic conditions can result in melt-out of ice from body of a RG (i.e. degradation of permafrost) and termination of creep movement. In such case, morphological remnants of active RGs are known as relict or fossil RGs.

In Slovak Tatras, Nemčok & Mahr (1974) identified 49 sites with RG occurrence and it is believed (Kotarba, 1991-1992, 2007) that last phase of RGs activity took place during the Younger Dryas. According to relative dating by Schmidhammer, three groups of relict RGs can be distinguished in Bystrá and Žiarska valleys, Western Tatras (Klapyta 2011, 2013).

Here, we provide the most comprehensive RG inventory for the Tatra Mountains and we analyze their spatial distribution and morphology. RGs were manually mapped and digitized based on aerial photographs with 0.1, 0.25 and 1 m resolution, supported by field validation. Morphometric characteristics were derived from DEM with 10 m resolution.

RGs are located in upper parts of glacial valleys at the foot of talus deposits beneath the main ridges. Fronts of most of the nearly 400 mapped RGs are located within an altitudinal range of 1400 to 2200 m asl.

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IS SACKUNG DIAGNOSTIC FEATURE FOR (DE)GLACIATED MOUNTAINS?

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Keywords: *sackung, mountain glaciation, paraglacial processes, ¹⁰Be dating, ¹⁴C dating, OSL dating, trenching, Western Carpathians*

Deep-seated gravitational slope deformations (DSGSDs) with characteristic sackung landforms (e.g. double crests, trenches, uphill-facing scarps, toe bulging etc.) are considered by some authors as diagnostic features indicating past mountain glaciations. However, recently growing database of sackung features throughout the world reveals that in some regions, paraglacial processes are not causes for such phenomenon. Sackung occurs across diverse spectrum of mountain types, with different morphoclimatic histories and some of these regions have never experienced glaciation. Based on the two case studies from the Western Carpathians (Czech Republic/Slovakia) supported by detailed geomorphic mapping, trenching and numerical dating (¹⁰Be, ¹⁴C and OSL), this paper demonstrates that sackung might originate independently on glaciation. As for the Ondřejník ridge (Outer Western Carpathians; Czech Republic), the sackung occur in mid-mountain area where glaciation at least since LGM was excluded, its genesis was dated to ~6 ka BP. Concerning the Salatín Mt. (Tatra Mts.; Slovakia) the sackung affected formerly glaciated terrain and its activity was stated between ~7.5 and 4.2 ka BP, i.e. with > 4 ka time lag after the disappearance of glaciers. This case suggests that the direct link between the ice retreat and onset of sackung is not obvious even in the case of the once glaciated mountain range. Although paraglacial stress release is without any doubt one of the crucial agents for the genesis of sackung in many mountain regions, it is by far not only possible driven mechanism. Therefore, despite occurring in numerous (de)glaciated mountains, sackung features cannot be considered as proofs of the past mountain glaciations, matter recently applied e.g. for some extra-terrestrial settings.

FLUVIAL GEOMORPHOLOGICAL MAPPING AND CLASSIFICATION OF THE ČERNÁ OPAVA RIVER

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Keywords: the Černá Opava River, fluvial forms, channel sediments, geomorphological mapping, stream channel classification, human impact

Upper reaches of rivers are very important in a context of the whole river basin, because this parts represents zones of erosion. Eroded material is transported downstream the river basin. This high-gradient streams are mostly situated in the mounstains or in the forested uplands, as is the case Černá Opava. Studied area (the Černá Opava River Basin) in section from Rejvíz to Vrbno pod Pradědem in Hrubý Jeseník Mts. Was surveyed during summers 2012 and 2014. Černá Opava is the longest source of the river Opava and is characteristic by the black color due to the presence of organic substances coming from peat bogs. In the river basin I studied influence of topography, lithology and hydrologic regime to the fluvial forms. The most important part of this work is a field work including geomorphic mapping. I presented map of the geomorphic classification of the Černá Opava channel, which is one of the outputs. The most common type of channel is plane-bed, but there are also other interesting types (step-pool, colluvial, cascades,...). In this work I used classification of Montgomery, Buffington (1997, 1998) modified for local conditions. Next goal was mapping of direct anthropogenic influences in the channel. There are two main types - historical remains (flumes to the sawmills or iron mills) in the upper reaches. Recent channel regulations in the intravilan of Vrbno pod Pradědem (flood control measures after flood in 1997, straightening the river, concentering the channel,...). Second output is the map of human impact to the channel of the Černá Opava river. In present time is the research extended about sediment flux conditions and mapping of natural and anthropogenic barriers to the movement of sediments. In this part I was inspired by the Fryirs et al. (2007), who studied (dis)continuity in sediment flux. Last map represent these specific forms affecting sediment flux.

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MORPHOSTRUCTURES OF THE WESTERN CARPATHIANS

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Keywords: mountain uplift, Western Carpathians, plastic flow models, morphostructural fields, topology of lithospheric deformations

Mountain uplift in the intracontinental space is still not fully understood. Morphostructural fields of mountains must have been produced by discrete lithospheric deformations, giving areas their typical shape, form and pattern. Studying topologies of these elevation-defined structures, it could be possible to distinguish specific common features and elementary similarities. The aim then, is to match real orogenic fields with the physical models of compressional deformations. The most extensive studies of this subject has been given in the plasticity theory. This investigates the properties of visco-plastic materials under the various kinds of applied stresses. When sufficiently compressed, crossing the yielding point, majority of apparently brittle media start to behave plastically. Plastic flow does not affect the whole volume, only specific narrow zones. These are simplified to slip-planes, or slip-lines in the plain mathematical approximation. Combination of slip-lines, originated during compression, forms the slip-line field. Its specific pattern is unique for every particular kind of compressive deformation and can be used to identify acting forces. Though very useful, these models are two-dimensional only, so analogue modelling can be performed to support the investigations. Principally many materials can be used, the most common are sand, wax, plasticine or silicone. Knowing the overall topology of these fields, methods of physical geography can be applied to identify specific structural patterns on elevation models. It is possible to visualise their resemblance to plasticity examples by tectonic markers, morpholineaments, morphoareas, river net or others. Deformation fields are often complicated and interconnected as they interact, but in careful study, they could be finally detected. This is the case of majority intracontinental mountains. The Western Carpathians represent exactly such kind of mountainous space, the mosaic of ranges and basins, enclosed in the outer elliptic envelope. The model of half-circular indentation has been used to identify the origin of Carpathians doubly-arcuate geometry. Within the western arc, built and rotated during this event in the Lower Miocene, morphostructural field of high complexity later developed. Driving mechanisms were compression from Adria plate and supposed reaction of the lithosphere, pushed against the East European and Bohemian massives. South-westernmost, Danube basin field, has been modeled by compression between two parallel plates. Tectonics, morphostructure and river net is in a good accord with this idea. Connected with it, the Western field represents the fan-like structure with separated ridges and basins of ray-shaped topology. The field has been modeled as extrusion with long, triangular slices. The Tatra Mts. and the Central morphostructural field are explained as two interconnected deformations, both based on shear-layers model. Such as morphology can be documented by rhomboidal pattern of the Nízke

Tatry and the Vepor Mts., also the bordering Liptovská kotlina basin. More eastward, Spiš-Gemer field could be another example of compression between two parallel plates. With the help of physical geography, this work is an attempt to analyse and visualise these structures by construction of morpholineaments and morphoareas, compare with the plastic deformation examples and to touch the question of their time dependence. The coincidence is not always ideal, but in general, preliminary results can be worth to pursue these analogies.

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HYDROLOGICAL NETWORK CHANGES CAUSED BY HUMAN ACTIVITY. CASE STUDY – NECHRANICE DAM

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Keywords: landscape changes, river network, dam, Nechranice

Human activity has huge impact on changes of the surrounding landscape. The area of North-West Bohemia is one of the most human-changed regions in the Czech Republic. The brown coal open-pit mining that has started in this region in the first half of the 20th century has the biggest influence on the landscape transfigurations. The chemical and heavy industry situated in this region is bound to the brown coal mining and requires large amounts of water. The water-dam constructions are one of the human activities that influence the natural landscape development and together with the open-pit mining is causing permanent landscape structure changes, settlement extinction and hydrological network displacements. A very significant example of these landscape changes is the water dam Nechranice and the open-pit mine Tušimice. The open-pit mine is one of the large active mines in this region supporting the power plants Prunerov I, Prunerov II a Tusimice with brown coal. All of these power plants are situated at the very edge of the coal mine. The water dam Nechranice is situated near by the coal mine and is supporting with water the surrounding power plants, the chemical industry in the region and the water is as well used for over-flooding the Lake Most hydrological reclamation. The Nechranice dam was built in 1961 – 1968 by constructing the longest rock fill dam in the middle Europe across the river Ohře riverbank. The dam itself contains almost 300 thousand m³ water. The aim of this presentation is to show the landscape change analysis in the Nechranice dam surroundings and analysis of filling the former water-bank with transported sediment.

Old maps describing the landscape and hydrological changes were used for the analysis. To cover the complex time period the map interval from the 1st military survey of Habsburg Empire to the current maps sources were chosen. Altogether maps of the 1st, 2nd and 3rd Military Survey of the Habsburg empire, Imperial imprints, State map derived 1:5000 (year 1953, 1970, 1980) were processed, digitized and analyzed. The current state of the hydrological network was derived from the ZABAGED and DIBAVOD. The old maps were georeferenced into a seamless map and the desired features were hand digitized. Based on these data the hydrological network analysis was performed and the derived contour lines were used for georelief development analysis of this area.

The important task of this project was the evaluation of the sediment amount in the former Ohře river-bank. High quality elevation data from the period before the dam construction were required to perform this analysis. The elevation information contained in the State map derived 1:5000 from the year 1953 are not suitable for this purpose as the contour lines derived from the 3rd military survey are very sparse (10 –

20m interval) and inaccurate. After a complex background research were high quality data (contour lines with 1m interval) obtained directly from the water dam management. The current dam bottom was scanned in July 2014 using the Lowrance HDS5 sonar. Altogether 57 transects in total length of 80km were scanned. The intervals in-between the transects are varying from 30 to 350m according to the scanning conditions. The obtained data were interpolated into a digital terrain model representing the current bottom of the dam. Based on the transects' density only directly scanned data were analyzed. Based on the measurements we may state that largest amount of the sediment is located by the stream-mouth in the western part of the dam. Sediment of several meters depth was located in this area.

The processed data are accessible within a web-mapping application. The user may browse through the processed maps and overlay data from different time periods. The application contains the hydrological network and georelief reconstruction as well.

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EXTREMELY STRONG WINDS IN THE TATRA MOUNTAINS IN 1968 AND 2013 – METEOROLOGICAL CONDITIONS AND SCALE OF DEVASTATION

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Strong winds (up to 100 km/h) in the Carpathians Mts. occur frequently, causing destruction of large forested areas. The occurrence of halny (foehn) wind depends on two main conditions: the direction and inclination of the 700 hPa surface over Poland, as well as on the axis of a jet stream in relation to the Carpathian Mts. (Morawska-Horawska 1992).

The exceptionally great damages produced by the halny of 6th May 1968 in the Tatra Mts. were the result of extremely high wind velocities (above 150 km/h) connected with the case when powerful axis of low troposphere jet streams at 2000–2500 m altitude was over the highest massif in the Western Carpathians. The existence of the above-mentioned situation favours large-scale stability of the pressure systems and it is assumed that decisive in the formation of these phenomena is a high-pressure blockage which hampers the movement of secondary low pressure systems (Budziszewska et al., 1970).

Whereas in the case of situation from 24 and 25 December 2013, halny wind was related with large horizontal pressure gradient between the deep low pressure system (935 hPa) with center over the British Isles and high pressure system (1036 hPa) with center over the Black Sea.

Strong winds (up to 100 km /h) in the Tatra Mountains appear several times a year. However, extremely strong winds (above 150 km/h) occur episodically and bring enormous damage in forest management. In the Polish part of the Tatra Mountains, fallen trees covered the area of 300 hectares after the extremely strong “halny” in 1968 (Minar et al., 2008). Similar strong warm wind occurred on the northern slopes of the Tatra Mountains at 2013. The destruction of forest is still estimating on this area. Regardless of the damage to the forest areas, extremely strong winds during these times resulted in the destruction of inhabited areas, causing the destruction of numerous roofs of houses.

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GEOMORPHOLOGICAL MAPPING AND RELATIVE DATING OF GLACIAL LANDFORMS IN ROHÁČSKÁ VALLEY IN THE WESTERN TATRA MTS.

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Keywords: *deep-seated gravitational slope deformation, deglaciation, geomorphological mapping, glacial landforms, relative dating, Schmidt hammer*

Geomorphological research in Roháčská valley is accomplished in order to find out the relation between glacier withdrawal and deep-seated gravitational slope deformations. Many studies suggested (e.g. Bovis 1990, Blair 1994, Hippolyte et al. 2009, Coquin 2015) relation between steepening by glacial erosion, debuitressing, stress release and triggering of deep-seated gravitational slope deformations. Research focusing on landform mapping and relative dating was performed in order to assess relation between glacier withdrawal and onset of deep-seated gravitational slope deformation in Roháčská valley. Features related to deep-seated gravitational slope deformation such as scarps, anticarps and double ridges were investigated in the surroundings of Salatínská valley (tributary valley) in detail. These landforms were mapped by GPS in the same way as other landforms in the valley (landslides, talus, debris avalanches, rock glacier, and moraines). A digital elevation model and orthophotomap were used for precise delimitation of landforms after the field survey. Schmidt hammer test was accomplished to find out the relative age of glacial (moraines and glacial polishes) and periglacial landforms (rock glaciers) in Salatínská and Roháčská valleys. The relative chronology of glacial and gravitational landforms in the Roháčská valley was established. To accomplish numerical chronology localities for ¹⁰Be exposure dating were chosen and samples were taken.

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ATLAS OF LANDFORMS OF WEST BOHEMIA

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Keywords: landforms, atlas, geomorphology, West Bohemia, geology, LiDAR

Atlas of landforms of West Bohemia is primarily meant as education material for foreign students of Centre of Biology, Geosciences and Environmental Education in Faculty of Education. In general, the landscape of Western Bohemia provides interesting examples for explanation of landforms origin and development. Online atlas is really good choice to explain how chosen landforms look, how to describe their origin, development and influence on the landforms surroundings.

The presented Atlas has two main parts. The first part is freely accessible providing general information about the landforms and landscape, while the second part is intended for students of listed subjects providing spatial data and special teaching materials. The main part of the Atlas is photo section with description where the landforms are shown. To demonstrate most significant and interesting features we used modern data from Light Detection And Ranging (LIDAR).

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RECONSTRUCTION OF THE 1770 LANDSLIDE EVENT AT THE KOZÍ VRCH HILL (N CZECHIA) AND POST-LANDSLIDE LANDSCAPE DEVELOPMENT

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Keywords: landslide, reconstruction, documentary data, Kozí vrch Hill

The České středohoří Mts. represents a region characteristic by extreme occurrence of various types of landslides, most of them concentrated along the Labe River. The landslide frequency and their significant potential social impacts in the densely inhabited valley have been the major motives for the study of their structural setting, triggers and impacts. For several decades it has been clear that understanding the structural controls and variation of meteorological triggers of the landslides must draw upon the detailed prolonged time series, which has brought attempts to create regional historical landslide databases. The opportunity is given by the use of documentary data for reconstruction of historical landslides, but this effort has been rather scarce however. The aim of this paper is a detailed reconstruction of the oldest known historical landslide event from 1770 and one of the oldest landslide events in the Czech Republic, based on the use of a complex set of documentary data. Based on our analysis, we defined the position of the landslide headscarps in the lithology of Neogene volcanoclastics and basaltic lava flows. The length of the landslide was between 600 and 700 m, and its accumulation segment (terminal lobe), which reached one third of the Labe River channel, had an approximate volume of between 800 and 900 thousand m³. The major landsliding occurred between midnight and the early morning on January 5, 1770, i.e. during the winter, which is considered to be extremely wet with frequent temperature fluctuations. The time constraint of landsliding together with notice about the movement of trees in orchards by ≈ 100 m give the approximate landslide speed of rapid to very rapid. The accumulation surface was generally flat with swamps and three major lakes, while the landslide toe was disintegrated by radial cracks. The rest of the landslide body upslope to the headscarp was deformed by transversal and radial cracks, transverse ridges and individual landslide blocks. The landslide affected few houses, the major road from Ústí nad Labem to Děčín, and agricultural land properties. Based on the multitemporal land use analyses, it is shown, that for the next two hundred years the accumulation surface was characteristic with land use patterns (agricultural land), which differ from its surrounding. The accumulation segment of the landslide was transformed by lateral erosion of the Labe River and by construction of railway and roads that diminished its height by more than 5 metres at some places.

EFFECTS OF STRESS FIELD ON WEATHERING OF SANDSTONE FORMS AND MONUMENTS IN PETRA ARCHAEOLOGICAL SITE, JORDAN

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Keywords: *sandstone, weathering, physical model, mechanical stress field, salt crystallization, Petra archaeological site, Jordan*

While majority of natural stone weathering studies are focused on granite and limestone, sandstone weathering tends to be relatively overlooked (Young and Young, 1992). Sandstone forms are important elements of landscape and sandstone is also an important architectural material all over the world (Turkington and Paradise, 2005). Salt crystallization tests were created as instructive methods measuring decay resistance of sandstone used as construction stone (Ross and Butlin, 1989). But until recently (Bruthans et al., 2014) the role of stress field caused by vertical load of rock mass affecting spatial distribution of weathering intensity wasn't mentioned as mechanism controlling sandstone weathering.

Petra archaeological site in southern Jordan is famous for its tombs and temples carved in Um Ishrin sandstone. Thanks to its size and age Petra archaeological site provides excellent opportunity to study decay of sandstone constructions dominated by salt weathering (f.e. Paradise, 2005; Paradise, 2013).

Small-scale physical models of tombs were carved in erodible locked sand of quarry wall in Střeleč (Czech paradise). Mechanical erosion of these models produced morphologies characteristic for highly eroded tombs in Petra archaeological site. Non-linear erosion affected parts of models which ineffectively transmitted stress. Specimens of Um Ishrin sandstone loaded by various axial forces were subjected to salt crystallization test. These tests proved lower weight loss for specimens subjected to higher pressure. Conducted experiments indicate that stress field may be important controlling factor during weathering of monuments carved in sandstone massif subjected to environmental conditions.

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IMPACTS OF AGE-DEPENDENT TREE SENSITIVITY AND DATING APPROACHES ON DENDROGEOMORPHIC TIME SERIES OF LANDSLIDES

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Keywords: *landslide, dendrogeomorphology, reaction wood, tree-ring eccentricity, tree sensitivity, age effects, broad-leaved trees, coniferous trees*

Different approaches and thresholds have been utilized in the past to date landslides with growth ring series of disturbed trees. Past work was mostly based on conifer species due to their well-defined ring boundaries and the easy identification of compression wood after stem tilting. More recently, work has been expanded to include broad-leaved trees which are thought to produce less and less evident reactions after landsliding. This contribution reviews recent progress made in dendrogeomorphic landslide analysis and introduces a new approach in which landslides are dated via ring eccentricity formed after tilting. We compare results of this new and the more conventional approaches. In addition, the paper also addresses tree sensitivity to landslide disturbance as a function of tree age and trunk diameter using 119 common beech (*Fagus sylvatica* L.) and 39 Crimean pine (*Pinus nigra* ssp. *pallasiana*) trees growing on two landslide bodies. The landslide events reconstructed with the classical approach (reaction wood) also appear as events in the eccentricity analysis, but the inclusion of eccentricity clearly allowed for more (162%) landslides to be detected in the tree-ring series. With respect to tree sensitivity, both conifers and broad-leaved trees show the strongest reactions to landslides at ages comprised between 40 and 60 years, with a second phase of increased sensitivity in *P. nigra* at ages of ca. 120–130 yrs. These phases of highest sensitivities correspond with trunk diameters at breast height of 6-8 and 18-22 cm, respectively. This study thus calls for the inclusion of eccentricity analyses in future landslide reconstructions as well as for the selection of trees belonging to different age and diameter classes to allow for a well-balanced and more complete reconstruction of past events.

LANDSLIDE ACTIVITY BY THE KOZÁROVCE VILLAGE (LEVICE DISTRICT, SLOVAKIA)

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Key words: dendrogeomorphology, landslide, electrical resistivity tomography, loess, Kozárovce village

The present-day complex landslide research requires application of broad spectrum of methodical approaches. Only multidisciplinary analysis can successfully solve all actual questions regarding landslide predisposition, triggers, inner structure or recent activity.

We used combination of two methods for determination of inner structure and historical activity of landslide occurring close to Kozárovce village. The landslide is of rotation type and ca 40 m long and ca 50 m wide, and is developed in the loess accumulation on the volcanic (andesite) bedrock. Geoelectrical method ERT (electrical resistivity tomography) was applied in two profiles longitudinally and across coming through the landslide area. The landslide body generally shows very low values of resistivity in comparison with volcanic bedrock or loess material lying out of landslide area. That is why, the landslide body is quite good visible in the ERT record. Based on the ERT record the landslide depth was established to 10–11 m, and rotation character of landslide movement was verified.

The historical chronology of landslide reactivations was reconstructed using dendrogeomorphic methods. Twenty two increment cores were extracted from disturbed (tilted or bended stems) individuals of *Robinia pseudoacacia* L. growing on the landslide. The identification of landslide signal within the tree ring series was realised using analysis of tree ring eccentricity (as tree reaction to stem tilting). Together 14 years with landslide activity was reconstructed, with the oldest one in 1965. The main time period with reactivation occurrence was from 1978 to 2003. The strongest landslide signal within tree ring series was identified in 1965, 1983, 1997 and 2002.

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MULTI-HILLSHADE HIERARCHIC CLUSTERING – A NEW ARTEFACT RESISTANT METHOD FOR AUTOMATIC LINEAMENT EXTRACTION

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Keywords: *morpholineaments, GIS, automatic extraction, Bohemian Forest, Central Western Carpatians*

The manual extraction of lineaments is very useful but subjective tool in tectonic geomorphology and geology. To overcome this subjectivity an automatic extraction is needed. This paper presents a new method of automatic lineament extraction and classification removing artefact effect arising from raster based analysis. A set of variously illuminated and turned hillshades in combination with hierarchic clustering of derived lineaments is a core of suggested Multi-Hillshade Hierarchic Clustering (MHHC) method. MHHC was applied in two different territories in Bohemian Forest and Central Western Carpatians. Original vector-based algorithm comparing similarity of individual lineaments confirms compatibility of manual and automatic extraction and theirs similar relations to structural data in the model areas. To improve subjectivity of directional analysis, the original algorithm was applied to plot graphs and histograms.

CHANGING RIVERS AND PLANT HABITAT OF THE FLOODPLAIN AREAS – CASE FROM THE MORÁVKA RIVER

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Key words: phytosociology, relevé sampling method, incised river channel, anabranching river channel, the Morávka River floodplain, Czech Republic

Riparian vegetation reflects character of the dynamics of streams and their conditions. Intense and temporally variable anthropogenic disturbances in the basins continuously adjust to new constrain of rivers. Especially river incision affects floodplain function. Periodical inundation of rivers was stopped. These changes could influence plant species composition of the floodplain area. Study area comprises of the Morávka River floodplain in the lowest part of the basin. The Morávka River channel has undergone a rapid incision (the original river bed has lowered as much as 8 m in the last 40 years). At some parts, the original anabranching river channel has stayed preserved. In April and May in year 2014 were analysed phytosociological reléves (10 x 10 m). Experimental phytosociological reléves were located through transversal profile close to the river channel of anabranching and incised Morávka River channel. Simpson's index (Simpson 1949) and Shannon-Wiener index (Shannon – Weaver 1949) were calculated as the most common measures of biodiversity are species richness. Analysed indices show slightly increase of biodiversity species richness in close to anabranching river channel. By contrast in close to incised river channel, calculated biodiversity species richness is slightly decreased. For evaluation of plant species composition was used canonical correspondence analysis. In area of the Morávka River with incised channel, plant species composition is determined of 29.8% by distance from the main channel. It is predisposed by decreased effect of main channel to plant habitat. In area of the Morávka River with preserved anabranching channel pattern, plant species composition is determined of 25.8% by distance from the main channel. By contrast, the relative importance here gets height above the water level. It is determined plant species composition of 34.6% in area of anabranching river channel. In area of floodplain of the Morávka River incised channel, the effect of relative height above water level is determined of 29.2%. As support information, groundwater stages of adjacent drill-holes were analysed for detection of phytosociological habitat of plant species.

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LARGE-SCALE UAV MAPPING OF SLOPE DEFORMATION IN SVÄTY ANTON-CENTRAL SLOVAKIA.

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Keywords: UAV, Slope deformation, landslide, Svätý Anton

Development of small UAS (Unmanned Aerial Systems) in last 5 years leads to their massive utilisation in different scientific disciplines. Also geology and geomorphology is not an exception. After application in fluvial geomorphology, we introduce large-scale mapping of slope deformation in Svätý Anton village in central Slovakia. The slope deformation is based on deluvial sediments and waste dump. The bedrock is created by volcanic epiclastic breccias and andesite rocks. Slope movements are known since 1962/63. Monitoring of slope movements is based on 5 stabilized points. The GNSS is used as a method of observation of mass movement. Speed of movement is several mm/ year. Aerial data acquisition was realized during one-day field campaign in autumn 2014. Compared to terrestrial LIDAR scanning, data acquisition of landslide area (aprox. 200 x 170 m) based on UAV (Unmanned Aerial Vehicle) takes about 8 minutes. The point cloud (approx. 60 mil. Points), 3D mesh, shaded relief and orthophoto are results of aerial mapping. Precise mapping allows to use dataset as a base for creating DTM or DEM and subsequently for computation of morphometric parameters.

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LANDFORM EVOLUTION IN THE REGION OF THE JIZERA AND LABE CONFLUENCE

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Keywords: geomorphological evolution, landforms, morphogenetic processes, anthropogenic impact, Labe and Jizera river confluence

The geomorphological research in the region of the Labe and Jizera River confluence is aimed at recognition of landform evolution. The landforms represent the specific record of paleogeographical history of the natural environment. Main stages of geomorphological evolution of the studied locality are presented in this study. The changes of the intensity and the type of neotectonic and climate-morphogenetic processes during the Late Cenozoic are determined by historical-genetic features and spatial arrangement of the landforms. The region of the Labe and Jizera River confluence has a great historical and archeological value. Natural evolution of the environment has been modified by anthropogenic impact since the Paleolithic Era, therefore the influence of anthropogenic impact is also included in this study.

EFFECTS OF LICHEN COVERAGE ON SANDSTONE SURFACES: QUANTITATIVE STUDY OF HYDRAULIC AND MECHANICAL PROPERTIES

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Keywords: sandstone, weathering, lichen, microorganisms, erosion

Over recent years, the effect of microorganisms on weathering of outcrop surfaces has been discussed (see e.g. Wessels et al. 1995, Chen et al. 1999, Kurtz and Netoff 2000, Carter and Viles 2004, de los Ríos et al. 2009, Smits et al. 2009, Sterflinger 2010).

Some authors claim that the weathering of minerals can be accelerated by the growth of lichen species (see e.g. Ascaso et al. 1998, Chen et al. 1999, Brehm et al. 2005). On the other hand, other studies show that lichen cover may actively protect the surface of various types of rock from weathering (see e.g. Kurtz and Netoff 2000, Carter and Viles 2004, McIlroy de la Rosa et al. 2013).

Our study is focused on effect of lichens on hydraulic and mechanical properties of locked sand. Locked sands are characterized by low tensile strength and high erodibility, therefore the effect of lichens on mechanical properties is nicely measurable.

The objective of this study was to quantify differences in mechanical and hydraulic properties between 1) surface crust of locked sand colonized by microorganisms, and 2) underlying locked sand with no evident presence of organisms.

Based on our results, existence of surface crust reduces the rate of capillary water absorption, but has no measurable effect on water vapor permeability. Microorganisms on the surface of locked sands cause higher tensile strength and it appears that protect material from erosion.

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SHIFTING THE ACTIVITY OF GULLIES AND DEBRIS FLOW TRACKS IN CULMINATION PARTS OF MID-MOUNTAIN RANGE (A CASE STUDY FROM THE HRUBÝ JESENÍK MTS.)

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Keywords: *debris flow, gully, dendrogeomorphology, the Hrubý Jeseník Mts., Keprník Mt.*

Debris flows are integral components of mid-mountain ranges in such culmination parts with suitable predisposing and triggering factors. This case study from the Keprnická highlands (the Hrubý Jeseník Mts.) is concentrated primarily on spatio-temporal reconstruction of debris flows occurring in the closure part of the Klepáčský and the Keprnický brook valleys. The other aim is to evaluate debris flow activity and sediment storage cycles from adjacent slopes and gullies and to point out in which phase of development these parts are occurring. The fundamental method is dendrogeomorphic dating of disturbed trees supported by detailed geomorphic mapping, analysis of historical aerial pictures, LiDAR morphometric analyses and SINMAP software for detecting shallow landslide instabilities.

Actual geomorphic mapping and analyses of aerial pictures found out the most active debris flow tracks in both sub-basins, but also older – nowadays stable tracks. Tree ring analysis of 172 trees revealed together 415 growth disturbances and confirmed 13 debris flow events since 1933 in the Klepáčský brook and 9 debris flow events since 1857 in the Keprnický brook according to weighted index factor (W_{it} ; Kogelnig-Mayer et al. 2011) with the peaks in 1991 and 2010. Spatial analysis of debris flow reach connected with fill-incision conditions in channels point out the development of activity both in longitudinal profile (vertical shifting, e. g. 1921-1923) and horizontal shifting in the sense of (re)activation new or older gullies between 1950s and 2000s. It seems that shifting is influenced by sediment supply conditions from adjacent slopes that are repeated in cycles according to the triggering precipitation, other role could play anthropogenic damming of gullies and main brooks in 1960s.

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RECENT SEDIMENTATION IN LANDSLIDE-DAMMED LAKES IN OUTER WESTERN CARPATHIANS

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Keywords: *landslide-dammed lake, bathymetry, lake sediments, recent sedimentation rate, flysch nappes, Outer Western Carpathians*

Modern lakes work as traps of solid flux from river drainage areas, and thus enable study of mass balances, quantification of exogenic processes and specification of their controlling factors (Einsele, Hinderer, 1998). Here I present results of 2009–2014 monitoring of the sediment accumulation in two landslide-dammed lakes in the Outer Western Carpathians. Brodská Lake originated in 1997 and is situated in Vsetínské vrchy Hills. Girová Lake originated in 2010 and is situated in Jablunkovské Mezihoří Mts. Both lakes were created due to landslide damming of a high-gradient upper-channel segment after heavy rain fall. To analyse and quantify recent processes forming the lake, I made repeated bathymetric mapping and sediment sampling of both landslide-dammed lakes (Brodská L. in years 1997, 2012 and 2014; Girová L. in years 2012 and 2014). Acquired morphometric parameters show, that both lakes are relatively small and deep (Brodská L.: lake area in 2009... 186 m², maximum depth reconstructed for 1997 ... -3.4 m, lake volume reconstructed for 1997 ... 272 m³; Girová L.: lake area in 2012 ... 207 m², maximum depth in 2012 ... -2 m, lake volume in 2012 ... 160 m³). Two types of sediments were documented: deltaic (gravels and sands) and lacustrine (silty gyttja). Donation of the material from surrounding steep slopes seems to be also important. Sedimentation rate is highly variable in the lake area. Highest rate of sediment accumulation is on the delta where flowing water is entering the lake (in Brodská Lake, maximum observed value is 121 mm/year). It is twice higher as the sedimentation rate in the deepest part of the Brodská Lake (59 mm/year). There is also lowering of the surface due to erosion observed in both lakes (in outflow area and on steep lake bottom). Thus, mean sedimentation rate ranges from 34 mm/year to 42 mm/year in Brodská Lake and is 38 mm/year in Girová Lake. These are relatively high values comparing with those acquired from fossil landslide-dammed lakes in Outer Western Carpathians, which originated in different periods of Holocene and are now completely silted (0.1–15 mm/year, Pánek et al., 2010, 2013, Smolková, 2011). This discrepancy might be caused by relatively small volume of both presented lakes as compared with runoff and sediment input to the lakes and by a low degree of modern sediment compaction. As contrary, mean sedimentation rates in studied lakes correspond very well with mean recent sedimentation rate acquired from nearby situated artificial Bystřička dam (35 mm/year in 1912–2004, Baroň et al., 2010). Estimated sedimentation rate >2 mm/year in fossil landslide-dammed lakes is restricted only to short time periods (maximally hundreds of years). Holocene sedimentation rate values are commonly lower in 1 or 2 orders of magnitude than the recent ones, indicating higher dynamics of recent exogenic processes. If contemporary

conditions will maintain, we can expect Brodská Lake to be completely filled at the earliest in 2037 (minimally 40 years of the lake existence) and Girová Lake in 2032 (minimally 22 years of the lake existence).

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VALLEY EVOLUTION OF THE BIALA ŁĄDECKA RIVER

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Keywords: Biala Łądecka river, active tectonics, Góry Bialskie, Góry Złote Mts. (Rychlebské hory Mts.), Sudetic Marginal Fault, Bohemian Massif, Lower Silesia, Geophysical research

Biala Łądecka (Biala Kłodzka) river is located in Lower Silesia (Poland) and its valley separates Góry Złote Mts. (Rychlebské hory Mts.) on the northeast from Góry Bialskie Mts. on the southwest. During last year we dealt with geomorphology research in Biala Łądecka river basin, which has a noticeably asymmetrical river basin, probably due to Quaternary tectonic activity of the Sudetic Marginal Fault. According to old research provided in this area by L. Finckh and G. Götzinger (1931), W. Walczak (1954) and A. Ivan (1966), Biala Łądecka river used to flow across the Góry Złote Mts. directly to Oderská nížina Lowland during Pliocene; currently it flows to Nysa Kłodzka Basin. Our research was focused on analysis of all available cartographic materials (geological and topographic maps), available literature and own detail geomorphological mapping of selected landforms. Spatial distribution of these landforms such as gullies, erosion trenches, dellens, alluvial plains, alluvial fans, springs, swamps, river terraces, could potentially indicate recent tectonic activity in the studied area. Moreover, stream network parameters (based on DEM data) such as changes in erosion intensity indicated in longitudinal profiles, slope gradient and Stream Length (SL) index (Hack 1973) for upper river basin were analyzed. Geophysical research (ERT and DEMP on Trzebieszowice-Biala Fault was carry out.

The results will also complete the research focused on tectonics in the adjacent areas, e.g. paleoseismologic studies on the SMF (Štěpančíková et al. 2010, 2011), monitoring using dilatometric gauges TM71 installed on the SMF (Stemberk et al. 2010), etc. Some of results will be presented.

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ACCELERATED LATE PLEISTOCENE ACTIVITY OF THE SUDETIC MARGINAL FAULT AS A SIGNAL OF ICE LOADING?

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Keywords: *paleoseismology, geophysical survey, ice loading, Pleistocene activity, Sudetic Marginal Fault, Bohemian Massif*

We combine paleoseismic trenching, geophysical survey, and radiometric dating results to study the late Quaternary history of morphologically pronounced NW-SE trending Sudetic Marginal Fault (SMF) situated at the northeastern limit of the Bohemian Massif. Eighteen trenches were excavated and twenty nine electric resistivity profiles (ERT) were performed at the Bílá Voda site to study 3D distribution of a beheaded alluvial fan on the NE block of the fault and to find the offset “feeder channel” that sourced the deposits. We interpret a small drainage of about 40-60 m to the SE of the fan apex as the feeder channel. A 2.5 m depth profile was collected for cosmogenic exposure dating from a well-preserved part of the fan (Trench P). Using a simple model that accounts for pre-depositional exposure (inheritance) and assuming no surface erosion, ¹⁰Be concentrations are well-fit with an apparent exposure age of ~12 ka. However, this is a minimum limiting age if the surface was eroded by gelifluction in the late Pleistocene. Optically stimulated luminescence yielded ages of 25.8 ± 1.6 ka of the alluvial fan deposits within the fan apex (Trench C) and radiocarbon dating 40.9 ± 2.5 ka for fault-related colluvial wedge (Trench J). Overlying, locally preserved strata that do not exhibit evidence of gelifluction yielded radiocarbon ages as old as $8.2 - 9.7 \pm 0.02$ ka (Trench R1). Assuming a ~25 ka OSL age for the base of the fan apex it gives a left-lateral slip rate of ~2 mm/yr. As the Holocene deposits do not show significant displacement, most of the recorded slip took place during Late Pleistocene with corresponding slip rate of 2.8 to 3.5 mm/yr. Bílá Voda site lies ~150 km south from the Late Pleistocene Weichselian maximum (~20 ka) ice-sheet front. Thus, we hypothesize that the slip rate acceleration was due to ice-loading. To test this, we calculated the stress induced in the lithosphere from ablation of the Weichselian ice sheet modeled as a flexing elastic plate. Models of lithosphere flexure due to ice loading suggest that failure on the SMF was promoted by

the presence of the Weichselian ice sheet, relative to an ice free state. Coulomb stress on the SMF increases by ~1 MPa during the time leading up to the LGM, then rapidly decreases as the ice sheet retreats. This modeling suggests that the most likely time for left-lateral SMF reactivation over the last 50 ka years is between ~21ka – 17ka. Our model is consistent with loading mechanisms reported from other regions due to deglaciation, but is the first documented evidence in central Europe, having a great implication for seismic hazard assessment. Research was supported by Czech Science Foundation (No. P210/12/0573) and Czech Ministry of Education, Youth and Sports (No. LH12078).

TIME-LAPSE RESISTIVITY MEASUREMENTS IN LANDSLIDE MONITORING – BENEFITS, DIFFICULTIES AND WHAT WE HAVE LEARNED SO FAR

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Keywords: active landslides, landslide monitoring, electrical resistivity tomography, time-lapse resistivity measurements, pore-water pressure, precipitations

Presented contribution is aimed at present progress in application of time-lapse resistivity measurements in monitoring of active landslides. Besides the methods of geotechnical monitoring such as inclinometry, extensometry, monitoring of ground-water regimes or measurements of pore-water pressures, repeated geophysical measurements bring a useful tool to observe changes of specific physical properties of landslide accumulation. Supposing the mechanical properties of the landslide body material as invariable in time (in terms of lithology, particle size and porosity), resistivity, as a geoelectrical quantity, represents changes in water saturation. Together with measurements of pore-water pressure, resistivity provides very valuable information on water saturation or moisture content in pores. Time-lapse electrical resistivity tomography (TL-ERT) thus brings the information on moisture changes in time. As study sites we chose two active landslides, both in volcanic landscape: i) Ľubietová landslide (Poľana stratovolcano, Slovenské stredohorie middle-mountains, Inner Western Carpathians) belonging to the Central Slovakia Neogene Volcanic Field); and ii) Čerěníšť landslide (České středohoří middle-mountains, Czech massif), Czech Tertiary Neovolcanites. Both observed landslides are active, however, in case of Ľubietová, landslide is directly endangering the Ľubietová village. Therefore it is very important to monitor the landslide behaviour. Permanent monitoring of the landslide has been going on for nearly forty years since 1977. The application of the repeated ERT measurements was performed from March 2007 to April 2011. The ERT results showed some changes in the subsurface resistivity distribution, however, the period of several months among individual measurements turned out as too long. Observed resistivity hike thus could have not been described in its development. Despite of this, ERT showed as a useful tool for observations of resistivity changes within the landslide body (Tábořík et al. 2012, Prokešová et al. 2013, Prokešová et al 2014). The survey at the other studied site, Čerěníšť landslide, has been carried out since August 2013. The locality is not situated directly nearby buildings or engineering constructions. Nevertheless, the locality is used as a testing site for the TL-ERT monitoring. The main objective of the research is to identify relations between

triggering factors and landslide activity. Thus, the variations in resistivity distribution are measured in order to acquire information on subsurface water saturation and its changes and, also, it could help, together with hydroclimatic observations, to reveal relations within the system „precipitation – subsurface saturation – mass movement activation“. Furthermore, using the monitoring of movement velocity based on repeated geodetic measurements we shall be able to determine the causal connection between precipitations, soil saturation and (re)activation of mass movements. Main goals of the long term research are i) to describe dynamics of the complex slope deformation, and ii) to reveal a connection among predispositions (tectonics, lithology), triggering factors (extreme precipitations, soil humidity changes, long-term climatic oscillations) and landslide activity. For description of a long-term landslide activity the measurements of displacements have been performed by means of i) 3-D spatial dilatometers, ii) extensometric measurements, iii) geodetic measurements and repeated laser scanning. Last but not least, the studied locality serves also as a testing site for the repeated resistivity measurements in terms of a) measuring parameters optimization, b) different electrode configurations testing, and c) data processing optimization (Tábořík et al. 2013, Tábořík et al. 2014). Research was supported by grant projects: VEGA project 1/0157/10, SGS6/PřF/2011, CzechGeo LM2010008 and GAUK 862213.

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LANDSCAPE DEVELOPMENT IN THE SURROUNDINGS OF JAVOŘÍ PILA (THE ŠUMAVA MTS., CZECH REPUBLIC)

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Keywords: *Šumava Mts., Šumava plains, Javoří Pila (old settlement), granulometry, loss of ignition, electrical resistivity tomography, elementary forms*

This research presents the analysis of the landscape development around Javoří Pila, an old settlement in Šumava plains (Šumava Mts.), close to the junction of the Javoří and the Roklanský creeks. These creeks have incised into two terraces, which are preserved 7 m above the modern floodplain. We have analysed alluvial sediments in order to differentiate the terrace surfaces and to reconstruct relative development phases of the Roklanský creek. The higher river terrace was dated to Pleistocene, based on outcrops of gravel sediments and electrical resistivity tomography imaging. Gravel sediments of the higher terrace have been probably deposited by a braided river channel during the Pleistocene. In the Holocene, the original braided river channel has been gradually replaced by a meandering river channel. Using the classification of Miall, we have identified the main evolutionary stages of river which were based on fluvial sediments analysis. In addition, the elementary forms of relief have been defined by the analysis of the digital elevation model, by verification of orthophotomaps and by field mapping.

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COUPLING BETWEEN LANDSLIDE ACTIVITY AND FLUVIAL EROSION RECORDED IN TREE RINGS AND RELIEF (WESTERN CARPATHIANS AND EASTERN SUDETES)

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Keywords: slope-channel coupling, landslide, channel erosion, dendrochronology, tree-ring eccentricity, relief evolution

We have analysed slope-channel interactions in selected 3 stream valleys in Western Carpathians and Eastern Sudetes. With the use of dendrochronological tools we have dated occurrence of fluvial erosion in stream channels – basing on wood anatomy of roots exposed in eroded banks. We have also dated the occurrence of landsliding on slopes directly above studied channels – using eccentricity of tree-rings developed in spruce stems tilted and bent by ground movements. In order to recognize cause-effect relations between landsliding and fluvial erosion we have compared their temporal variability in the last decades with precipitation record (monthly totals and extreme daily totals). Comparison have shown that in analysed valleys these three phenomena appear asynchronously – they alternate. We have determined two types of cause-effect sequences (3-8 years long) of landslide-bank erosion coupling: (1) rainfall-landsliding-erosion – precipitation causes landslide activation, colluvia are delivered into the valley floor, then narrowed valley floor is a subject of intensified erosion (2) rainfall-erosion-landsliding – precipitation causes erosion in the valley floor, then erosion disturbs the equilibrium of a slope, which causes landsliding. Obtained dendrochronological datings also show that these processes can be a subject of a feedback: once the coupling have started it can continue without appearance of heavy rainfalls. We have analysed signs of coupling visible in the relief of studied valleys. Observations indicate that described slope-channel coupling, recorded in tree-rings, in longer periods can lead to gradual widening of valley floors (due to bank erosion and removing delivered landslide colluvia) and can lead to relief evolution from V-shaped into flat-bottomed valleys. Conducted studies prove the presence of landslide-erosion coupling in studied valleys and suggest its importance for general evolution of studied mountain areas.

DETERIORATING OF WATER QUALITY IN PROTECTED OXBOWS DUE THE ORGANIC MATTER ACCUMULATION AND SEDIMENTATION

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Keywords: *water chemistry, sedimentation, water quality, organic matter, Drava-basin*

The Cún-Szaporca oxbow of 275 hectares area was finally disconnected from the Drava River channel in 1975, when the main flood defence line was built. Open water surface prevails on the oxbow over most of the year and is composed of three lakes: Lake Kisinc (20 ha), which used to be the main channel of the Drava in 1785, Lake Lanka and Lake Szilihát (together 30ha). Since 1996 this is an important water fowl sanctuary under the Ramsar Agreement. At present, during high water stages water recharge is possible through the opening of the Kisinc Sluice (Sluice no I; base level: 90.15 m above the Baltic Sea) from the direction of the Drava channel. However, this is not a satisfactory solution.

Accordingly, in the spring period the necessary total interval for filling up the oxbow to the 91.5 m level is 13–17 days, while for the 92.0 m level it is 22–26 days. The parameters necessary to fill up the oxbow are the following: in the summer season, assuming 0.2 m³ s⁻¹ inflow rate, the interval necessary to reach the second (92.0 m) level is 46–50 days. In case the discharge of the Fekete-víz allows 0.5 m³ s⁻¹ water transfer, the necessary filling time is 32–33 days.

The planners (DDKÖVIZIG 2012) set the following criteria for the regulation of water level:

Water level fluctuation should not exceed 0.5 m within a year;

Water recharge should take place step by step, in divisions;

In a year water recharge should be implemented by not more than two fillings;

The length of the filling period should remain within two weeks.

Three points in the planning concept and calculations seem to be problematic:

The success of the envisioned implementation of water recharge is rather questionable since the hydraulic connection between the oxbow bed and the neighbouring geological structure is not sufficiently clear;

The quality of inflow water is different from that in the oxbow, and even more substantially differs from that of the one-time natural recharge, from the Drava River;

The water quality parameters are not precisely known from Lake Kisinc.

After this rainy summer period water sampling campaign were realized. Our aim the investigation of the daily periodicity of water chemical properties (halobity). Thus every hour -30 cm from water table and -220cm (30 cm above pond sediments) were sampled. The changeable properies such as pH, redox potential, temperature, dissolved oxygen, were measured in the boat, or on the board. The other componennts ammonium, nitrate, phosphorus forms (total- and orto-phosphorus) KOI in the UNIV PÉcs laboratory. From the evaulation concluded that the most of chemical parameters don't follow the daily fluctuation of the environmental parameters (excluding dissolved oxygen in the tangle, next too the board). The KOI values are extremely high due the accumulation of organic material on the mud. We suppose, that after the artificial water recharge, which count only one meter plus water column, this disadvantageous parameters will not change in a right direction.

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PERIGLACIAL COLLUVIAL BLOCKY DEPOSITS FROM KAMIENNA RIVER VALLEY, KARKONOSZE MTS. (SW POLAND): NEW TECHNIQUES AND CONVENTIONAL APPROACH

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Keywords: coluvial deposits, block fields, periglacial weathering, gelifluction, pleistocene, Karkonosze Mts., Sudetes

In the Central Europe, only a few mountain ranges, which belong to the Hercynian/Variscan Orogeny Belt, reach above the timberline. Therefore, most of the coarse-grained (blocky) colluvial covers (Rubin, Balatka 1986 Růžičková et al., 2001) of the Pleistocene periglacial conditions origin are nowadays forested. Block covers can be seen as 'islands' in the orthophoto maps, i.e. the places bare of forests. However, the mapping of these landforms, by using modern techniques and GIS tools, does not give satisfactory results. Even the use of the high resolution models of topographic surface derived from ALS LiDAR data also does not solve the problem of identification and limitation of such landforms. As the experience with the use of LiDAR data proves, the resolution of this type of spatial data increased over 5 m does not correspond with the possibility to interpret the morphological features in the mountain environment (Migoń et al. 2013). It applies especially to the nonlinear objects (two dimensional topographic features), that can be mistaken for example with anthropogenic features, e.g. forms connected with tree throwing (pit-and-mound topography), or they may be defects of DEM (artifacts), that arise during the processing of the source LAS data.

Referring to the title of the conference, it should be stated, that in the case of denudational landforms within slopes (i.e. frost cliffs, tors, debris covers and block streams etc.) direct observations and field mapping should be the primary method for geomorphic studies. Field mapping allows for delimitation of the exact extent of block covers (in the sense of Demek, 1972), and defining the characteristic elements of their microrelief. Traditional geomorphic mapping may be supplemented by the geophysical techniques (GPR and/or ERT), Schmidt hammer measurements and cosmogenic dating (e.g. Be10). The application of these additional techniques allows to determine the thickness and the internal structure of cover deposits and their age.

The paper presents the results of field mapping of the coarse-grained (e.g. debris) covers, which are located on the slopes of the Kamienna River gorge at the foothill of the Karkonosze (Giant) Mountains, at the altitude ranging from 800 to 500 m a.s.l. The valley has been incised into the granite bedrock and its depth reaches from 40 to 70 m. The average inclination of the valley slopes is about 20°, and locally it rises up to 30-40°. There is a rich diversity of colluvial deposits on the valley-side slopes, which were formed under the Pleistocene climatic conditions, as a result of the destruction of

frost cliffs, rock walls and residual rocks. These are both talus slopes and scree slopes with open-work structure, consisting of loose granite blocks with diameters of 3-4 m. The large gelifluction landforms were also identified in the study area. The accumulation of large granite clasts, forming block streams, was observed in three small denudational valleys, which are hanged 10-15 m above the river-bed. In their lower, frontal parts, steps and transverse small ridges were visible, which were 3-4 m high. The thickness of the colluvial deposits in the axial part of one of the valleys reaches 4-6 meters, according to the GPR investigations. A zone of colluvial deposition which was 50-70 m wide, was identified at the foot of the steep slope in the upper part of the analyzed section of the Kamienna River in the place, where the valley widens. The colluvial cover consisted of granite blocks with an average diameter of 1.5 to 2 m (up to 3 m), which were loosely arranged one on another, and forming an open-work structure. A few single blocks were visible above this zone on the slope, as well as small rock outcrops, which were the source of rock clasts. Probably the discussed cover was formed due to the deposition of a gelifluction wandering stones, that have accumulated at the base of the valley-side slope.

The presence of the block covers descending to the valley bottom of the valley and the block streams filling in the small, hanging, tributary valleys, they both indicate that coarse-grained colluvial deposition occurred in the periglacial conditions, mainly in the younger phase of the Pleistocene. As it was indirectly evidenced by Chmal and Kasprzak (2009), the rejuvenation of river valleys within the edge zone of the Giant Mountains due to the neotectonic movements, which also includes Kamienna River valley, occurred mainly in the Early Pleistocene, in the period after the Elsterian Glaciation and prior to the Eem Interglacial. If the discussed colluvial coarse-grained covers had been formed in the Early Pleistocene, they would have been at least partly destroyed and/or eroded during the valley rejuvenation. There is no possibility to correlate the block covers with the terrace system and fluvial sediments, as they are absent in the Kamienna River valley. However, the use of radionuclide cosmogenic datings may solve the problem of the age of the analyzed covers.

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LANDSLIDE HAZARD ASSESSMENT AND PREDICTION OF LANDSLIDE CATASTROPHES WITH THE USE OF DENDROCHRONOLOGY

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Keywords: landslide catastrophe, landslide hazard, dendrochronology, tree-ring eccentricity, Outer Western Carpathians

Trees, which grow on active landslide slopes have stems deformed by ground instability. In tilted and bent stems uneven mechanical strains influence the structure of wood formed. Thus stem deformations and landslide activity are recorded year-by-year in tree rings. In our study we attempt to answer three questions: (1) can tree-ring eccentricity be used to determine the level of landslide hazard on forested mountain slopes? (2) can tree-ring eccentricity be used to determine the temporal changes in the level of landslide hazard on a certain slope? and by this (3) is it possible to predict landslide catastrophes and provide efficient warning against them with the use of tree-ring eccentricity?

We have studied tree-ring eccentricity among Norway spruce growing on a landslide in Milówka village (max 1020 m a.s.l., Carpathian Mts, southern Poland, Central Europe). In consequence of heavy rainfalls in May-June 2010 the landslide, formerly considered as stable, was abruptly activated. In 2012-13, in the area affected we have taken 180 cores from 45 spruce trees (4 cores from each tree). We have found that in sampled trees not only the heavy landsliding in 2010 was recorded, but also: (1) symptoms of older landslide catastrophe from >50 years ago were detected, (2) average frequency of minor events in 1945-2010 was determined as high (up to 4,5 events per 10 years), (3) symptoms of slope instability during 10-20 years before 2010 catastrophe, increasing especially in 2002-2010 (initial landsliding). Thus analyses of eccentricity are a promising approach for determining landslide hazard and warning against risk of catastrophic landsliding.

LAND DEGRADATION BY SOIL EROSION AND LAND USE IN KEDIDA GAMELA WOREDA, ETHIOPIA

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Keywords: soil, erosion, land use, land degradation, Ethiopia

Ethiopia is one of the most environmentally problematic countries in the Sub-Saharan belt. The principal environmental issue in Ethiopia is land degradation in the form of soil erosion, gully formation and soil fertility losses. The land and water resources of the country are highly threatened by over cropping, overgrazing and over reliance on fuel wood. The denuded and degraded landscape together with the human community is considerably vulnerable and exposed to high risk. In case of continuation of this development the landscape would be destroyed, that could bring negative impact on agriculture and population as well.

The project “Taza Sustainable Livelihood Development Program” supported by Caritas Czech Republic is focused on soil erosion assessment and proposal of erosion control measures in the Southern Nations, Nationalities and People’s Region State, in Kedida Gamela woreda. The study area is characterized as mountainous with slopes ranging from 5-70 %, where land use is predominantly cereal-pulse-based annual cropping mixed with livestock farming. The high-intensity erratic rainfall in association with steep slopes, frequent tillage practices and deep soil depth led to severe soil erosion in the area. The fieldwork has been carried out in detail, i.e. geomorphological and land use mapping of current state and soil survey, including taking of disturbed and undisturbed soil samples.

The aim of the study is to propose erosion control measures for soil protection and revitalization of damaged sites using a technical measures (gabions, dams, terraces, etc.) and management measures (choice of suitable vegetation - crops, trees, solving the system of access roads, etc.) and thus set up sustainable land use and farming in order to prevent further erosion.

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