



# Geomorphological proceedings 21

Book of abstracts

State of geomorphological research in the year 2023

Most (Czechia), 18 – 21 April 2023



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The contributions are without language and content corrections!

Ústí nad Labem 2023

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# USING SATELLITE IMAGES FOR VEGETATION DYNAMIC DETECTION IN RIVERINE LANDSCAPE

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Vegetation dynamics is one of the most important components in the river system. Riparian vegetation directly affects sedimentation and biodiversity alongside the river channels which is crucial parameter for river management. In this study different classification approaches were applied for monitoring vegetation formation on the floodplain of the Danube River. Automatic classification of satellite data was applied for identification of the vegetation response to succession and human impact in the riparian zone. The method is focused on temporal and spatial vegetation changes, explaining the effect of environmental parameters on vegetation dynamics, identifying the effects of different environmental parameters and human impact on vegetation spectral response, and monitoring vegetation health before and after revitalisation in Danube side arms.

**Keywords:** vegetation dynamics, classification of satellite data, river system

**Acknowledgements:** This research was supported by the Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences (02/0086/21)"

# SYSTEM FOR AUTOMATED PROCESSING OF IMAGE RECORDS FROM THE TM-71 DILATOMETER NETWORK

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The paper presents the results of the two-year TAČR GAMA2 project, which aims to solve the problems associated with the mass evaluation of a large amount of image data obtained from the TM-71 dilatometer network. The actual reading of the sensor and transmission of image data was already realized automatically, but further processing still depended on the interpretation of image elements by the operator. In the context of the sensor's capabilities, this method of data processing was unacceptable and degraded the instrument's ambitions to become a full-fledged geotechnical device. The new software solution is based on the use of scripting language and database languages to create a comprehensive tool package enabling the robust solution the problem mentioned. The system SAMR3D enables fast autonomous image interpretation into time series format, data storage, subsequent calculations, data visualization and sharing via web interface.

**Keywords:** automated processing, the TM-71 dilatometer network, image data

POŽÁRY ROCK FIELD LABORATORY IN CENTRAL CZECHIA - NEW  
INSIGHTS ON ROCK BEHAVIOUR FROM MULTIPARAMETRIC  
MONITORING

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Understanding the spatial variations in the rock mass is essential for delineating areas prone to rockfalls. Several attempts are also underway to characterize rock mass properties using remote sensing techniques using IRT cameras. To deepen the knowledge on this topic, a natural laboratory has been established in the former granodiorite quarry in Požáry in Central Bohemia, Czechia. Several different monitoring methods were applied, including an in-depth borehole thermometer, meteorological station, induction crackmeters, foil tensometers, IRT camera campaigns and stable ERT profiles allowing repeated measurements. These were coupled with the analysis of rock samples' geotechnical parameters in the laboratory (descriptive properties, dynamic elastic properties and K<sub>ic</sub> fracture toughness). The results show a high variability in rock properties and weathering rates within a small area of the rock mass. In addition, different rock material properties were found to correlate with the thermal behaviour of the rock mass during cooling (Cooling Rate Index - CRI). Several different monitoring methods were used in conjunction with laboratory analyses in the Požáry field laboratory to gain new insights into the behaviour and internal properties of the weathered rock mass. Future research will focus on numerical modelling to predict the behaviour of the rock mass in a changing climate, specifically due to changing temperature gradients and precipitation patterns.

**Keywords:** rockfalls, monitoring, Požáry field laboratory

# GEOMORPHOMETRIC ANALYSIS MADE ACCESSIBLE WITH AI AND PROGRAMMING LANGUAGES

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Geomorphometric tools are commonly used in geomorphological research for analyzing digital elevation models (DEMs). These tools are typically integrated into Geographical Information Systems (GIS), with well-known examples including commercial software like ArcGIS and open-source software like QGIS, GRASS, and SAGA GIS. Additionally, lesser-known tools like WhiteBox can provide alternative options for geomorphometric analysis.

Python and R libraries can also be used for geomorphometric analysis, making it possible to analyze large areas and multiple sites at once, and aiding in the reproducibility of results. With the latest developments in Artificial Intelligence, chat bots like ChatGPT can produce substantial parts of code, which lowers the barrier to coding and allows geomorphologists with less programming experience to tackle more complex tasks in Python or R.

The purpose of this poster is to demonstrate alternative approaches to geomorphometric analysis and showcase the capabilities of using AI in this field. By exploring these alternatives, researchers can gain new insights and potentially improve the reproducibility and efficiency of their work.

**Keywords:** geomorphometric analysis, AI, alternative approaches

RELICT ROCK GLACIERS OF THE WESTERN TATRA MTS., WESTERN  
CARPATHIANS - EXPOSURE AGES AND PALEOENVIRONMENTAL  
IMPLICATIONS

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Relict rock glaciers are often used as indicators of postglacial evolution of mountain relief that can provide a proxy record of past environmental conditions. In this paper, we present the results of exposure dating of eight rock glaciers in the Western Tatra Mts., Western Carpathians, together with a reconstructed decline in the mean annual air temperature (MAAT) and the lower limit of discontinuous permafrost. The rock glaciers stabilized at 1376–1819 m asl during the Late Glacial period from ~16.5 ka (Greenland Stadial 2.1) to 11 ka (beginning of the Holocene). The results suggest that the determined decline in MAAT and the lower limit of discontinuous permafrost in the dated periods were smaller than previous studies suggest. The comparison of our results with other paleoenvironmental proxies imply that the elevation indices derived for the rock glaciers likely underestimate the past temperature declines as well as permafrost extents and raise questions about their regional validity for paleoenvironmental reconstructions.

**Keywords:** exposure dating, paleoenvironmental reconstructions, the Western Tatra Mts.

**Acknowledgement:** The research was supported by the Charles University grant agency (project number 1528119).



# VALIDATING A STATISTICAL MULTIVARIATE MODEL FOR LANDSLIDE SUSCEPTIBILITY ASSESSMENT IN BROWN COAL OPEN-CAST MINES AND ITS IMPLICATIONS FOR RECULTIVATION PLANNING

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The challenges posed by ongoing climate change have significantly altered how policy makers and societies envision the future of coal mining regions. In the EU, the decarbonization effort has been recently articulated by the European Green Deal (2019), which puts forward an essential question of how to deal with the sites that will be affected by this transformation process. We argue that how to reclaim and reuse disturbed mining areas so that they are safe for use by society is essentially also a task for environmental geomorphologists, who should take this opportunity and responsibility for defining eventual risks associated with mine landforms and the reuse of the mines. Mining companies have a duty to ensure that the affected areas are reclaimed. From a technical and economic point of view, the most appropriate alternative is often to flood the residual pits. However, the flooding of residual pits entails many risks which must be investigated before filling begins. In this context, the environmental risks associated with anthropogenically created slopes are an understudied and underestimated issue. The most significant hazard associated with open pit brown coal mines are slope movements, namely various types of landslides. Hence the requirement for a comprehensive tool to assess mining and post-mining areas for landslide susceptibility. In this paper, the newly developed tool is presented that is based on a multiparametric modelling (based on 2010 data) combining mining area-specific parameters with a landslide inventory map. Overlaying the parametric maps with the inventory map produced a site-specific landslide susceptibility map. The validation of the model was conducted with the data obtained during the 2022 remote sensing campaign, resulting high precision digital elevation model, and with the new landslide inventory. Comparison with inventoried slope deformation verified the ability of the model to capture sites prone to landslides. The next research steps will focus on upscaling of the model and its implementation into the reclamation practice.

**Keywords:** susceptibility to landslides, statistical analysis, open-cast mines

# STUDY OF CONTRIBUTING AREAS OF THE CRITICAL POINTS IN LOCALITIES WITH THE OCCURRENCE OF FLASH FLOODS

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Flash floods are one of the most destructive types of floods (Borga et al., 2014). The impact of flash floods depends on the causative rainfall but also on the physiographic parameters of the catchments (Šercl, 2009; Borga et al., 2014; Halášová and Brázdil, 2020). Therefore, the main goal of this study is to analyze the physiographic parameters of contributing areas of the critical points, which have been hit by flash floods in the past. The database of flash floods occurrence in the years 2000–2020 was created for the study area of the Zlín region, which follows the database of flash floods done by Halášová and Brázdil (2020) in Moravia and Silesia for the period 1801–2000. Identification of localities, where flash floods are dangerous for built-up areas, was done by Drbal et al. (2009) by the methodology of critical points. For 37 of the chosen contributing areas of the critical points which have been hit by flash floods in the past, a database of physiographic parameters and land use has been made. The attention was focused on the statistical evaluation of physiographic parameters, which have been determined as high-risk parameters, causing the formation and a dangerous course of flash floods. The analyzed physiographic parameters are the area of a river basin, the slope of the basin, the basin's shape coefficient, the length of the talweg, the longitudinal slope of the talweg, proportion of arable land, forest area, maximum altitude, Melton index, and CNII. A cluster analysis, Principal component analysis, and factor analysis were used for a statistical evaluation. Cluster analysis established four clusters with similar characteristics among the groups. Principal component analysis and factor analysis established the quality of the variable's representation and the relationship between the variables themselves.

**Keywords:** flash floods, critical points, the Zlín region

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# CAN THE MOLDAVITE-BEARING DEPOSITS HELP FOR THE RECONSTRUCTION OF THE PLIO-PLEISTOCENE PALEODRAINAGE IN SOUTHERN BOHEMIA?

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The area between Novohradské Mountains and the Třeboň and Budějovice Basins – the Novohradské Foothills (in the south of the Czech Republic) is known for the occurrence of moldavites. These tektites are abundant in fluvial Koroseky sands and gravels or Vrábče beds. The age of those deposits is generally unknown and have been given a wide range - from 14.8 Ma to Pleistocene. Some authors have preferred the younger age of deposits (Bouška a Konta,1990; Ševčík et al.,2007). However traditionally (Zebera,1967; Trnka a Houzar,2002), it has been supposed that those sediments was deposited by unspecified Miocene-Pliocene streams, which differed from the Pleistocene or current stream network. This study focuses on reconstructing the paleostreams, which deposited the moldavite-bearing sediments, and their relationship to present streams. Based on a review of the deposits' occurrences, a connection between moldavite-bearing sediments and deposits of the present watercourses, Vltava, Malše, Stropnice and Svinenský, is proposed. The link between moldavite-bearing deposits and the current streams were further supported by analyses of river geometry (longitudinal profiles, stream gradient) and terrain morphology (valley floor ratio, basin asymmetry). It is suggested that the moldavite-bearing deposits were sedimented during the Pliocene or Pleistocene by predecessors of the present streams. The occurrences of particular fluvial deposits and changes in terrain morphology and river geometry can be traces of changes in the river network and the dynamic evolution of local relief induced by tectonic activity during the Pliocene and Pleistocene.

**Keywords:** moldavites, fluvial deposits, river network changes

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INTERPLAY AMONG VEGETATION, LARGE WOOD AND CHANNEL  
MORPHODYNAMICS IN THE PRESERVED MEANDERING REACH OF THE  
ODRA RIVER, CZECHIA

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Both scientists and practitioners had previously underestimated the role of living and dead vegetation in shaping river channels for a considerable period of time. However, since the beginning of the 21st century, research in the field, laboratory experiments, and numerical modelling have provided strong evidence of the effects of riparian woody vegetation and large wood on the erosional and depositional processes of river channels and their planform geometry. In this contribution, we aim to demonstrate the long-term morphological impact of vegetation on a meandering channel of the Odra River upstream of the city of Ostrava, which is approximately 30-45 meters wide. Trees growing on the channel banks effectively reduce erosion rates, compared to banks without woody vegetation. However, when a tree is recruited to the channel by lateral erosion, its stability over several years is necessary for its potential morphological impact. Trees delivered from the outer meander banks change their orientation against the flow from perpendicular to parallel, and they are often transported downstream within a few months or years. Large wood pieces that are stable usually have a parallel orientation with a thalweg and are located in the widened parts of the channel or the outer meander banks, with preserved root wads and/or main branches. These pieces have the potential to promote sediment deposition, leading to the development of middle bars or lateral floodplain accretion, and they likely also decrease bank erosion rates if they are deposited on the outer meander banks. We also found some subfossil large wood, which may act as 'hard points' in the floodplain and slow its turnover rate. In contrast to research carried out in anabranching river patterns, we did not observe frequent occurrences of tree resprouting or significant seedling impact on stabilizing bars. This lack of observation may be attributed to the regularity of relatively high flow depths (up to 2-3 m) and high flow velocities occurring multiple times a year, which can prevent the establishment of willow patches on bars. Additionally, the future heterogeneity of biogeomorphic impact in the study area may be influenced by the presence of invasive plants such as *Impatiens glandulifera* and the increasing population of European beavers.

**Keywords:** morphological impact of vegetation, Odra River

# ANALYSIS OF HISTORICAL CHANGES IN PLANFORM GEOMETRY OF A MOUNTAIN RIVER TO INFORM DESIGN OF ERODIBLE RIVER CORRIDOR

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The analysis of changes in planform geometry of the Biała River during the last 130 years was used to diagnose hydromorphological river degradation and thus to verify the need of river restoration through establishing an erodible river corridor. Outcomes from the analysis was then used for delimiting the erodible corridor and predicting the potential for future river widening in the corridor. Using topographic maps from 1878, 1935 and 1962, aerial photographs from 1967, 1977 and 1987 and orthophotomaps from 1998 and 2009, changes in the extend of the river active zone and in the structure of geomorphological units were analysed. As a result of river channelization followed by channel incision, during the study period, the width of the Biała was reduced to 16%–57% of its width in 1878. The river narrowing was associated with a reduction in the proportion of channel bars in the total river width and nearly complete elimination of islands. All these changes demonstrated the degradation of hydromorphological integrity of the river and the need for its restoration by allowing free channel development in an erodible corridor. The belt of the river migration during the last 130 years identified on the basis of overlays of the river position from all dates was ~5 times wider than the contemporary river. This justified delimiting the erodible river corridor on a substantially larger area of the valley floor than the area of the river in 2009. In 2009 the river was narrower than the largest river width recorded between 1878 and 1998 along nearly the whole length of the study river sections. This indicates that the concentration of flood flows in the narrow channel, increasing their unit stream power, is a factor increasing the potential for future bank retreat and channel widening in the erodible corridor of the river.

**Keywords:** river corridor, analysis of changes in planform geometry, Biała River



"FIRST RESULTS OF THE ANALYSIS OF THE COLLAPSE OF A SANDSTONE  
PILLAR "MICHELIN" IN TEPLICKÉ SKÁLY ROCK CITY"

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On the early morning of 12th of November 2021, a 10 m high corner rock pillar called "Michelin" collapsed on the touristic track at Krápníky in Teplické skály rock city. The pillar toppled and disintegrated into 8 large blocks and smaller debris which rolled along a short slope. Fallen blocks reached the distance of almost 30 m away from the cliffline, partly destroying a wooden footbridge. As the event occurred in a low season and in night hours, it did not cause any injuries or fatalities. However, this case illustrates that the rock slope failures pose a threat to local communities and visitors.

In this contribution, we provide a detailed insight into this event, discussing the likely controls, triggers and mechanisms of failure. We demonstrate that the rockfall was controlled both by the original rock pillar morphology (a wider part standing upon a thin stem) and protracted chemical alteration of sandstone. The total volume of the rockfall was estimated to over 50 m<sup>3</sup>, weighing approximately 120 tons, most of which is formed by 8 large blocks.

According to the performed analyses and measurements, the studied rockfall was a consequence of long-term weakening of the rock pillar situated in the exposed and precarious corner position, combined with its narrow and weak base. Dissolution of matrix in the rock led slowly towards its stability decrease. Structural and tectonic controls in the form of joints and weakened zones along bedding planes form the detachment planes, predisposing disintegration of the pillar and separation of the individual blocks.

The likely trigger, however, was the sudden drop of temperature on the days preceding the event, which resulted in frost expansion of frozen water from previous rainfall and consequent loss of internal stability of the sandstone body. Computer modelling of the event revealed that the mechanism of failure was toppling, with the lowermost sandstone compartment acting as a pivot.

**Keywords:** sandstone pillar, analysis of failure mechanisms, Teplické skály rock city

# THE ODRA RIVER: 83 YEARS OF DEVELOPMENT AND CURRENT PERCEPTION OF GRAVEL BAR VEGETATION

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In regulated river reaches, gravel bars are vulnerable habitats that are prone to degradation. We analysed spatiotemporal trends in gravel bar morphodynamics and vegetation cover in the 77 km reach of the Odra River over 83 years (1937-2020), and assessed public perception of gravel bars in regulated and natural river environments. Sixteen sets of aerial photographs or orthophotos were processed and used for complex map analysis of gravel bars in regulated and natural reaches. An online public survey was conducted using two sets of images (regulated/natural) in unvegetated and fully or partially vegetated condition. Respondents rated the photographs in terms of vegetation, recreation, naturalness and aesthetics.

We identified two main periods of bar vegetation dynamics: in the 1937-1990/1994, bars consisted predominantly of unvegetated gravel areas with a balanced vegetation cover. In addition, the total bar area fluctuated strongly over time and was visibly influenced by floods. The 1999/2000-2020 showed a gradual increase in vegetation due to lack of disturbance by floods, and the extent of gravel bar area was more consistent. Most bar areas were associated with high meander amplitudes, wide channels and natural river reaches, while a significant reduction in bars was observed in regulated reaches. Respondents of the public survey strongly preferred vegetated gravel bars and bars in natural river reaches, while unvegetated bars were suggested to be removed or vegetated. We highlight the shift of increasing bar vegetation over the last 20 years and the negative public perception of unvegetated bars.

**Keywords:** analysis of gravel bars, Odra River

SEMI-AUTOMATED IDENTIFICATION OF THE BRONZE AGE BURIAL  
MOUNDS - HIDDEN ANTHROPOGENIC LANDFORMS IN THE  
AGRICULTURAL LANDSCAPE

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With the availability of LiDAR data with high precision, it is possible to identify some archaeological features for larger geographical areas by semi-automated methodology in GIS environment. In the territory of the Hronská pahorkatina hilly land (Slovakia) with suspected anthropogenic features forming Bronze age burial mounds, prevailing in georelief as summits of 10-20 m diameter and 1-10 m elevation gain within the already eroded agricultural land we prospected the possible locations for archaeological research. On available digital elevation model from high precision LiDAR data it was possible to identify 124 similar shapes as summits possibly forming burial mounds in the current georelief. Further prospected historical maps revealed different number of summits on the same area, 143 apex points marked as peaks in the second military survey (1819-1869) and 316 apex points recorded as summits on maps from the first military survey (1764-1787). We also used automated method for summit identification using GRASS GIS r.geomorphon module and further we processed the basic python script for peak identification in deep learning tool in ArcGISPro to detect these features (semi)automatically and even more summits was distinguished. However fully automated method for their determination is still unattainable and needed to be compared with different sets of historical maps or DEM. Further different maps revealed very different amount of these features in the same area and so it is for further research why on some maps these features are visible, but on others not and if it is connected to the tillage erosion or more to the different maps' quality and precision.

**Keywords:** Bronze age burial mounds, semi-automated identification, agricultural landscape

**Acknowledgement:** The paper was created as part of the scientific project no.2/0052/21 " Land surface topography – a source of data on the tectonic evolution of the Western Carpathians in the Pliocene-Quaternary period" financed by the Slovak VEGA Grant Agency.

# ONE-YEAR GROUND MICROEXHALATIONS TEMPERATURE TRENDS ON LANDSLIDES IN MORAVIAN-SILESIA BESKIDS

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Last year on this conference, we presented half-year monitoring of the ground microexhalations on selected landslides in the Moravian-Silesian Beskids (Outer Western Carpathians, Czechia), covering the cold season of the year 2021/2022. Now, we would like to complete these results by the warm season. We visited eight sites once a month, soon after sunrise, and used a dual RGB/thermal camera to image the surface of the ground microexhalation and the surroundings. Monitoring started in November 17, 2021 and was finished on November 11, 2022. Geographically, monitored locations can be classified into two groups (~27 km away from each other): Radhošť ridge (Salajka cave entrance, Zárýje 1, Zárýje 2 and Metodějka cavities) and Ropice massif (Ropice 1, Ropice 2, Šindelná 1 and Šindelná 2 cavities). All locations' ground microexhalation temperature trends show clear half-year seasonality, with relatively low temperatures during winter months and a shift to higher temperatures in May 2022. During the winter, most of the locations were distinctly warmer than their surroundings. Only one location (Ropice 1) showed an inverse temperature trend. From April 2022 to August 2022, the temperature dropped substantially below the surroundings. We observed a distinct difference in the warm-season trend between the two geographical groups, which could be explained the time difference in monitoring (we switched the group location every two weeks) or local environmental conditions (slope aspect). There is also discrepancy between the absolute levels and their variability of microexhalations and the environment. We believe this is due to the underground's changing size and composition managing divergent air and heat circulation.

**Key words:** ground microexhalation, landslide, temperature, Beskids

Acknowledgement: Research was supported by the University of Ostrava Project SGS02/PřF/2023.

GEOPHYSICAL IMAGING OF THE SZCZELINIEC WIELKI AND  
SZCZELINIEC MAŁY MESAS IN THE STOŁOWE MOUNTAINS (SW  
POLAND)

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We conducted geophysical measurements in October 2019 and 2020 using electrical resistivity tomography 2D in two sandstone mesas in Stołowe Mountains (SW Poland). We carried out three measurements in sections with a length of 995 m, 335 m and 795 m. Our goal was to image the geological structure, including the recognition of the tectonics of these massifs and the thickness and base shape of the Cretaceous sandstone layer on a complex of fine-grained sedimentary rocks. The resulting inversion models depict bedrock up to a depth of 180–200 m (in the case of the most extended measurement sections). We used both smooth and robust inversion methods for optimal results and experimented with damping factor settings to unambiguously determine the lithological contact between sandstones and underlying fine-grained rocks. Inversion models make it possible to distinguish individual sandstone blocks of different thicknesses, varying in Szczeliniec Wielki from about 30 to 60 m. Inversion models also allow the determination of several main fault lines. The topo-lineaments on the terrain surface supported the tectonic analysis, interpreted with LiDAR-based DTM. To better illustrate the situation, we made three-dimensional models.

**Keywords:** geophysical imaging, electrical resistivity tomography 2D, Stołowe Mountains



MAPPING OF ROCK LABYRINTHS EFFECTED BY ALS DATA PROCESSING:  
THE SZCZELINIEC WIELKI AND SZCZELINIEC MAŁY MESAS, STOŁOWE  
MTS, POLAND

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Rock labyrinths are one of the most spectacular landforms and often the main tourist attraction of mountain massifs. However, difficulties related to accurate cartographic mapping of such areas mean that most maps of rock labyrinths are highly generalised or just an artistic vision of the rock formations' pattern. The indicated issues concern two sandstone mesas: Szczeliniec Wielki and Szczeliniec Mały in the Stołowe Mountains (SW Poland). In 1948, based on geodetic measurements, the first map of Szczeliniec Wielki was made available to tourists (Czeppe 1949). However, this plan, reproduced in all further sources, is highly generalised and misrepresents the orientation of the most significant rock fissures. The rock labyrinth of Szczeliniec Mały, as a nature reserve under strict protection, has never been cartographically imaged. We create new maps of these areas, using our experience in analysing high-resolution digital terrain models derived from airborne laser scanning (ALS) (Kasprzak and Migoń 2015, Jancewicz and Porębną 2022). We offer visualisations based on manual processing of LiDAR point clouds, which gives better results than automatic point cloud classification algorithms and thus enables obtaining more detailed images of rock labyrinths. Processed ALS point cloud with a minimum density of 4 points/m<sup>2</sup> (on average 9 points/m<sup>2</sup>) was delivered in 2021 by the Head Office of Geodesy and Cartography in Poland ([geoportal.gov.pl](http://geoportal.gov.pl), public domain).

**Keywords:** rock labyrinths, cartographic mapping, Stołowe Mountains

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## GEOPHYSICAL ARCHITECTURE OF TECTONIZED VOLCANIC BODIES NEAR FLYSCH THRUST FRONTS (OUTER WESTERN CARPATHIANS)

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Teschenite association rocks (TAR) represent a specific type of mostly alkaline igneous rocks which form an almost 100 km long belt of discontinuous rock bodies within the Outer Western Carpathians (OWC) in the territory of Czechia and Poland. At present, a detailed mineralogical, geochemical, and stratigraphic analysis or dating of the volcanic formations is available, but basic structural and spatial relations characterizing TAR bodies and their origin are missing due to the poor exposure of TAR and lack of borehole data. A drill-hole- and outcrop-data-calibrated geophysical survey has proven to be a powerful tool for the interpretation of spatial extent and subsurface structure of TAR. At two type localities of TAR in Czechia (sites Staré Město and Bruzovice), a geophysical investigation combining ground conductivity mapping (CM) with profile measurement of electrical resistivity tomography (ERT), gravity survey, and magnetic survey was performed. A joint interpretation of the geophysical data served to determine the spatial extent (up to 500 m long and 40 m deep), geometry, and structural features (often fault-bounded with highly anisotropic heterogeneous structure of *mélange* character) of the studied TAR bodies. The interpreted magmatism of the study area included a stage of intrusion and extrusion of magmatic bodies in the Early Cretaceous, followed by a phase of fold-thrust deformation during the tectonic shortening of the area from the Late Cretaceous to Oligocene times. The resulting highly anisotropic rock mass consisting of TAR and its country rocks structurally controls the subsequent post-tectonic gravity-driven deformation.

**Keywords:** Teschenite association rocks, geophysical survey, Outer Western Carpathians

## TESTING OF METHODOLOGIES FOR ASSESSING SEDIMENT TRANSPORT AND CONNECTIVITY IN SMALL FORESTED WATERSHEDS

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Higher production and intensive transport of sediments in the inhabited mountainous watersheds together with natural hazards increase the risk and the value of potential damage. In small forested basins, streams are usually unmeasured, and it is impossible to use remote sensing methods. Sediment transport assessment here is time-demanding, costly, and usually requires professional expertise. In this work, we test a new methodology for sediment supply and transport assessment and a well-established method the Effective Catchment Area (ECA) in two headwater catchments, Hučivá Desná and Upper Moravice in Hrubý Jeseník Mts. (Czech Republic). Based on technical documentation, freely available data sources, and field mapping we evaluated the basin's potential for sediment production, risk related to sediment transport, and lateral sediment connectivity. For Upper Moravice, the potential production of sediments and risk associated with sediment transport and deposition are low. In the case of Hučivá Desná, sediment productivity potential is lower medium, and risk is medium. Based on the used methodology, the river manager of Hučivá Desná stream should consider preparing a study of sediment transport in the future. The new methodology that we tested offers the possibility of an effective basic evaluation of the sediment transport regime and connectivity without measurements and extensive physical geographical knowledge. It could be a suitable support tool for river managers in the case of decision-making in the field of finance and project planning.

**Keywords:** sediment supply and transport assessment, Hučivá Desná and Upper Moravice in Hrubý Jeseník Mts.

SANDSTONE GEOMORPHOLOGY OF THE HEJDA HILL, BROUMOVSKA  
VRCHOVINA, CZECHIA.

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Mt. Hejda (641 m a.s.l.) is a tabular hill (mesa) located in north-eastern Czechia within the Broumovská vrchovina (Middle Sudetes). It is built of sandstone caprock of Cretaceous age which overlies a series of fine-grained rocks. The hill shows outstanding diversity of sandstone landforms, but they have not been described in detail. Therefore, systematic geomorphological mapping, supplemented with the analysis of derivatives of LiDAR DTM, was attempted to provide an insight on the complex relief of the mesa. Its upper surface is inclined towards the southwest. The deep valley of Zlomová rokle that runs in the NNW-SSE direction divides it into two parts of distinctly different morphology. The western part is not very diversified whereas the majority of the eastern part is strongly dissected, hosting diverse sandstone landforms at various spatial scales and building a large rock city. Within the rock city, as well as along the eastern and northern rim of the top surface, rock walls exceed 15 m in height. Cleft-and-valley systems follow an orthogonal joint network, extending in the NNE-SSW and NNW-SSE directions. On exposed rock surfaces many weathering micro-forms are present, such as honeycombs, tubes and rock windows. The outer slopes of Mt. Hejda are mantled by a block cover of varying density. The bottoms of many valleys and canyons are also filled with boulders. Within the boulder fills, with the thickness exceeding 5 m, boulder caves occur, providing suitable conditions for the development of root stalagmites. The floors of the caves are often covered by sand sheets and fans, which are an evidence of subsurface transport of mineral material from the top surface of the mesa. These observations allow us to conclude that, notwithstanding the presence of mass movements, non-catastrophic processes play an important role in the geomorphic development of Mt. Hejda.

**Keywords:** sandstone landforms, geomorphological mapping, Mt. Hejda

# HOW TO IDENTIFY AND EVALUATE THREATS TO GEOMORPHOLOGICAL HERITAGE?

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Geoconservation is an action of conserving and enhancing geological, geomorphological, hydrological and soil features and processes. Particular geoconservation measures are very often applied to protect important geodiversity sites (including the geomorphological ones). Nevertheless, despite established legal protection and related geoconservation measures, threats to these sites coming out from the multiple use and human society demands can arise and reaching a compromise can be difficult. In this contribution, a two-level threat assessment is applied and discussed. The first level of threat assessment is based on the already used criteria within geosite/geomorphosite concept and corresponds to the degradation risk evaluation. The second level is represented by Risk Assessment Matrix, which is commonly used in Environmental Impact Assessment, regional development and project planning and may be viewed as a useful tool for assessing the threats to geomorphological heritage as well. Using both approaches provides a complex view on the threats to geodiversity and geoheritage in a study area and allow to propose particular measures that could contribute to the balance of the different demands and more effective geoconservation management in the study area. The methods are applied on different sites and their advantages and limits are discussed.

**Keywords:** geoconservation, geodiversity, geoheritage, site assessment, risk analysis, degradation risk

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# GEODIVERSITY – CULTURE RELATIONSHIPS WITHIN THE CONCEPT OF GEOSYSTEM SERVICES

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This contribution aims to analyse the links geodiversity – culture within the concept of geosystem services. Based on the definitions of culture and analysis of geosystem services schemes, it was possible to catch reflections of geodiversity-culture relationships not only within cultural and knowledge services, but also within supporting and provisioning services. Moreover, the geodiversity – culture connections are reflected in every day's life and language, thus a quick insight into these topics is also presented. While some aspects of geodiversity – culture relationships have already been investigated more thoroughly (e.g. building stone and architecture, or geotourism and geoeducation), other aspects remain unexplored (e.g. geodiversity – culture links in geo-toponyms, heraldry, myths, language, sense of place). Focused attention and further research is also needed in the case of societal development, citizen science projects and participative research. Anchoring the geodiversity – culture relationships within the concept of geosystem services may provide a framework for future studies and may contribute to the better understanding of protection and sustainable use not only of geoheritage, but entire geodiversity. Also, it can serve as a basis for integrated management, conservation and promotion of heritage which is always more effective than conserving, managing or promoting particular landscape elements in an isolated way.

**Keywords:** geosystem services, local identity, building stone, heritage, geodiversity, culture

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# FAST MEANDER BANK RETREAT IN THE ODRA RIVER DETECTED BY UAV-SFM SURVEYING

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For the evaluation purposes of biogeomorphic interactions in meandering rivers, we are performing repeated UAV mapping of selected meander banks in Odra River meander belt. Study area is located southwest from Ostrava City (Czechia). Main goal of the UAV surveying is to detect short-term rates of meander bank erosion in different settings, given by presence, type and amount of riparian vegetation and in-channel large wood. Here we present results from two meanders, located close to each other (250 m). Meander 01 (49.7541303N, 18.1888158E) is characterised by no riparian vegetation (except of grass) and no large wood. 166 m long section was photographed on 27/6/2022 and 21/3/2023 (time difference ~9 months). Meander 05 (49.7535658N, 18.1841861E) is characterised by sparse riparian vegetation (mostly shrubs) and high amount of large wood. 65 m long section was photographed on 7/10/2022 and 29/3/2023 (time difference ~5.7 months). Between first and second survey during winter two larger floods were detected in Odra River. Using overlapping photos from UAV, we created detailed digital surface models and orthophotos for each survey in Agisoft Metashape Professional software. Meander 01 section reveals bank edge horizontal retreat up to 3.5 m in some parts. Rate of horizontal retreat seems to be related to local plan curvature of the meander. Through the whole surveyed section, erosion was dominant with mean linear rate of 1.6 m. Meander 05 section reveals bank edge horizontal retreat only up to 1 m in some parts. Again, erosion was dominant through the whole section with the mean linear rate of 0.5 m. Lower erosional rate in meander 05 section could be explained by its short length and position in a straighter part at the end of the meander curve.

**Key words:** bank retreat, UAV-SFM, Odra River

Acknowledgement: Research was supported by the Czech Science Foundation Project 22-17474S.

# DEGLACIATION OF THE LAST NORTH AMERICAN ICE SHEET COMPLEX

Invited speech

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The last North American Ice Sheet Complex (NAISC) had an area and volume roughly similar to present day glaciation in Antarctica and was the largest contributor to the sea level lowering of about 120 m at the Last Glacial Maximum. It consisted of three main ice sheets: the Laurentide, the Cordilleran, and the Innuitian, with the last one connecting it to the Greenland ice Sheet. These ice sheets were of vastly different scales; the Laurentide was an order of magnitude larger than the other NAISC constituents. This size played a role in the course of the ice sheet deglaciation. The Cordilleran Ice Sheet was severely affected by the warm Bølling–Allerød period and its remnants disappeared shortly after the end of the subsequent Younger Dryas cold period. In contrast, the size of the Laurentide Ice Sheet meant that its deglaciation was spread throughout the Early and Middle Holocene, with the resulting Baffin Ice Cap retreating into the modern-day Barnes Ice Cap over the Late Holocene. The pace and pattern of deglaciation is reconstructed from quantitative geochronology, where cosmogenic exposure dating has in recent years complemented the longer existing and more numerous series of radiocarbon ages. Ice dynamics, i.e. fast ice flow events and their effects on the ice sheet configuration, are reconstructed from the preserved glacial geomorphological record and also by numerical ice sheet models. These same models are being used to predict the future behaviour of the modern-day ice sheets in Greenland and Antarctica that are bound for significant mass loss under all but the most optimistic future climate scenarios. Reconstructing the demise of the last ephemeral Pleistocene ice sheets provides an insight into the processes of deglaciation at the time scales of thousands of years and an opportunity to train the numerical ice sheets models in order to gain more robust predictions of the future fate of the ice sheets in Greenland and Antarctica.

**Keywords:** deglaciation, quantitative geochronology, North American Ice Sheet Complex



CONSTRAINING ESCARPMENT RETREAT IN SANDSTONE TABLELANDS  
USING COSMOGENIC SURFACE-EXPOSURE DATING (STOŁOWE MTS., SW  
POLAND)

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The sedimentary tableland of the Stołowe Mountains in south-west Poland has developed upon a succession of alternating strong quartz sandstone units and much weaker mudstone/marl complexes. Following the general model of landscape evolution in layered tablelands, long-term escarpment retreat is assumed as the principal pathway of geomorphic change. Our previous research demonstrated that block release from the cliffs is mainly via in situ disintegration or localized fall to the cliff base, whereas catastrophic long run-out rockfalls were of minor, if any significance. Thus, the current position of sandstone boulders within the sub-caprock slopes is considered to approximate the position of cliff lines in the past, with negligible subsequent boulder displacement. However, until recently the rates of escarpment retreat remained unconstrained. To fill the gap, cosmogenic dating of boulders using <sup>10</sup>Be was applied on a representative slope of the mesa of Mt. Szczeliniec Wielki, along a 400-m-long transect from the rock cliffs to the footslope. Seventeen boulders were sampled and three samples were collected from the contemporary cliff lines. The dates obtained cover the time span of the last 100 ka, hence nearly the entire last glacial period and the Holocene. In general, the dates show systematic increase downslope, with the most distant boulder yielding the age of 99 ka. This translates into an average retreat rate of 4.18 m/1000 yrs. However, rates of retreat varied over time and there was clear acceleration of escarpment retreat in the latest Pleistocene and early Holocene, suggesting an important role of environmental transition from cold and dry to humid temperate climate. Unblocking of groundwater circulation concurrent with the decay of permafrost and increasing efficacy of mechanical weathering were likely the key driving factors.

**Keywords:** sandstone tablelands, cosmogenic surface-exposure dating, Stołowe Mountains

# FACTORS CONTROLLING MACROPLASTIC DEPOSITION IN A MOUNTAIN RIVER

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The processes of macroplastic storage in mountain rivers are currently unexplored and it is unknown how river morphology and different surface types of river areas affect them. Therefore, we started the investigations of macroplastic debris stored in several river areas with different vegetation cover and on wood jams in a channelized, single-thread reach and an unmanaged, multi-thread reach of the Dunajec River (Polish Carpathians). On the basis of our observations, exposed river sediments and herbaceous vegetation stored significantly lower amounts of macroplastic debris (0.6 and 0.9 g per 1 m<sup>2</sup>) than wooded islands and wood jams (6 g and 113 g per 1 m<sup>2</sup>). The amounts of macroplastic debris stored on wood jams exceeded 19, 129 and 180 times those found on wooded islands, areas covered with herbaceous vegetation and exposed river sediments. Wooded islands and wood jams covering 16.7% and 1.5% of the multi-thread reach stored 43.8% and 41.1%, respectively, of the total amount of macroplastic stored in that reach, whereas these surface types were practically absent in the channelized reach. Consequently, the unmanaged, multi-thread reach, 2.4 times wider than the neighbouring channelized reach, stored 36 times greater amount of macroplastic per 1 km of river length. Our study demonstrated that the storage of macroplastic debris in a mountain river is controlled by channel management style and resultant river morphology, which modulate river hydrodynamics and a longitudinal pattern of the zones of transport and retention of macroplastic conveyed by river flow. We emphasize future research directions that should consider in more detail the role of wood debris in capturing plastic from floodwater.

**Keywords:** macroplastic storage, investigations, investigations, wooded islands and wood jams, mountain river

# THE INFLUENCE OF LITHOLOGY AND TECTONICS ON THE FORMATION OF THE RIVER NETWORK, THE ORAVA RIVER, SLOVAKIA CASE STUDY

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The current georelief of the Western Carpathians is largely modelled by fluvial processes. Their spatial organization is expressed by the river network. Its character is influenced by a wide range of factors, in addition to climatic variations, primarily the lithology of the environment and active tectonic processes. Especially in areas with young active tectonics, such as the Western Carpathians, it is often problematic to distinguish the influence of these factors from each other. The development of geoinformatics and the increase in the quality of digital models of relief (DMR) have enabled the development of a number of new analytical geomorphometric methods, aimed, among other things, at estimating the intensity and dating of the youngest, especially vertical tectonic movements. The aim of this paper is to test the possibilities of identifying the impact of young tectonics in the Orava River basin. The studied area is located at the border of the Outer and Inner Western Carpathians and has a varied lithological composition (Paleozoic and Mesozoic of the Tatra-Fatra Belt of core mountains, the Pieniny Klippen Belt, Paleogene of the flysch of the Outer Carpathians, Inner Carpathian Paleogene). The analysis is based on the extraction of various parameters expressing the variability of the hypsometry of individual sub-basins and longitudinal profiles of water courses. We correlate the values of the parameters extracted from the DMR with the lithological properties of the basins, expressed using zonal statistics tools.

**Keywords:** river network, impact of young tectonics, Orava River

**Acknowledgement:** The paper was created as part of the scientific project no. 2/0052/21 " Land surface topography – a source of data on the tectonic evolution of the Western Carpathians in the Pliocene-Quaternary period" financed by the Slovak VEGA Grant Agency.

# HISTORICAL PHOTOGRAMMETRY-DERIVED DIGITAL SURFACE MODELS TO ANALYZE THE MORPHOSTRUCTURES OF THE FREMRINAMAR RIFT, NORTHERN ICELAND

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We here propose a study focused on characterizing the architecture of the Fremrinamar rift, which is one of the seven volcanic systems that accommodate the plate spreading in Northern Iceland.

The Fremrinamar rift has a total length of 13 km and a width between 8 to 9 km. Considering its dimension, it has been necessary to design a methodology to identify and characterize all the structures remotely. Also, the analysis of slip profiles identifies a useful tool to detect the direction in which the rift, and so the deformation, is developing.

We reconstructed a Digital Surface Model (DSM) and an orthomosaic, with a resolution of 2.07 and 0.52 m/pixel respectively, applying photogrammetry processing to different sets of historical aerial photos, freely available through the National Land Survey of Iceland. We first mapped the Fremrinamar rift at a scale of 1:50.000, identifying 1128 extension fractures, 766 normal fault scarps, and 146 eruptive fissures.

We then focused our study on the analysis of slip profiles to evaluate the propagation direction of the rift. We selected only normal fault scarps with a length greater than 2 km, identifying 3 symmetrical slip profiles and 58 asymmetrical ones, 33 showing a propagation direction towards the north and 25 towards the south. We were not able to classify 13 slip profiles, due to severe erosion of the scarps.

This study allowed us to recognize a general propagation direction toward the north of the Fremrinamar rift, consistent with the general propagation of the deformation in northern Iceland, with an important component of faults developing towards the south, generally located near volcanic edifices and eruptive fissures.

**Keywords:** volcanic systems, Fremrinamar rift, Northern Iceland

# DENDROGEOMORPHIC DATING OF GULLY EROSION IN NORTHERN MORAVIA AND DETERMINATION OF ITS ANTHROPOGENIC PREDISPOSITIONS

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Gully erosion is a worldwide issue that is often caused or accelerated by inappropriate land management. The research deals with incision of gullies on slopes of the Zlatohorská Highlands in northern Moravia. The present gully system has developed in glacial sediments of Pleistocene age. One of the causes of accelerated gully erosion are considered to be anthropogenic interventions, mainly melioration measures, or natural piping that cause concentrated subsurface runoff. Dendrogeomorphic methods were used to determine the development of the gully system. In selected gullies a total of 34 cross-sections were taken from the roots of Norway spruce (*Picea abies* (L.) Karst), European hornbeam (*Carpinus betulus* L.) and Sycamore maple (*Acer pseudoplatanus* L.). Trees respond to erosion processes by changing the anatomy of the cells in the newly grown root rings. When we determine the time of anatomical change onset, we are able to identify the year of erosion processes. To determine predispositions of gully erosion a geophysical survey with the use of Ground Penetrating Radar (GPR) was carried out. A total of 7 GPR profiles were conducted in the agriculture field above the gully system. The analysed data shows that the oldest dated erosion event occurred in 1985 in the western part of the gully system. Gullies located near the pasture significantly expanded around 2010, with a mean erosion rate of 10.45 cm/year, with nearly 115 cm of material being removed since the root was exposed. The last identified major gully incision occurred in 2014 as a response to intense rainfall event. The geophysical survey confirmed the presence of subsurface structures (possibly the melioration measures in the area) and their possible connectivity to the gully system. The combination of concentrated subsurface and surface runoff is considered to have a significant effect on the expansion of gullies in the present.

**Keywords:** gully erosion, dendrogeomorphic dating, Zlatohorská Highlands in northern Moravia

# RECOGNITION OF MORPHOLOGICAL DIVERSITY OF VALLEYS IN SANDSTONE AREAS – THE EXAMPLE OF STOŁOWE MTS

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In Central Europe non-availability of reliable topographic data at small spatial scales, dense forest cover and poorly accessible boulder-filled canyons hindering fieldwork, were formidable barriers to any progress in understanding the controls of valley network (Migoń 2020). Whereas the crucial role of fluvial processes as the main factor in creating valley network in general is universally assumed, the question remains whether this assumption is valid for areas with specific lithology and structure, such as platform sandstone areas, given that subsurface processes have already been demonstrated to play an important role in their evolution (Duszyński et al. 2018).

One of the examples can be Stołowe Mountains (SW Poland), divided into three morphostructural levels, differentiating in geological settings, relief and geomorphic processes. As such it may be representative case to present morphological diversity and variety of valley systems in contrasting settings. The relatively young fluvial morphology of Stołowe Mts was not yet a subject of broader study, nor evolutionary concepts were proposed (Pulinowa 1989).

No protocol exists to analyse characteristic medium-scale sandstone landform using DTM while wide opportunities for relief parametrization are available. The main effort has been made towards the development of a methodological approach that can be widely used for morphological comparative analysis. Simple measures of valley form and pattern were supplemented by LiDAR DTM analysis, found to provide valuable insights into the nature of concave landforms and their diversity.

**Keywords:** sandstone areas, morphological diversity, Stołowe Mountains

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LONG-TERM LANDSLIDE IMPACTS AND ADAPTIVE RESPONSES IN  
RURAL COMMUNITIES: USING HISTORICAL CASES TO VALIDATE THE  
CUMULATIVE CAUSATION APPROACH

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The assessment of landslide impacts provides key information for understanding the hotspots of landslide vulnerability and risk, but it has mostly relied on accounting of immediate social and economic losses, while neglecting the long-term implications for local development and respective post-disaster adaptive responses to landslide events. In this paper, we propose and validate an alternative approach that focuses on landslide impacts in terms of their long-term effect on functional operation of communities and municipalities. We apply a cumulative causation model on historical case studies in rural areas of Czechia Central Europe using the wide array of written and iconographic documentary data. Based on the validation through the typologically diverse multi-case study, we assert that re-focusing the current research on the long-term implications of landslides for local development provides valuable insights to understand drivers of community adaptive responses, and clarifies the actual effects of landslide hazard on functioning of socio-ecological systems.

**Key words:** landslide, impact, rural community, cumulative causation, documentary data

## REGULARLY ORIENTED COMPLEX LINEAR LANDFORMS IN CENTRAL EUROPE: A DETECTIVE STORY

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Parallel linear landforms, frequent phenomena in many places on the Earth's crust surface, were systematically assessed in the large area of central Europe (nearly 3,000 km longitudinally and 2,000 km latitudinally). Several variously oriented large systems (networks) of such topographic features fairly regularly pervade the region (in total, about 30,000 items have been estimated). Our study using the remote sensing data outlines their occurring spatial distribution, mostly based on considering complex surface geometries or directional trends (including chaining of landforms of different types) instead of simple linear elements (valleys, slopes, ridges) commonly applied during automatic extraction procedures. Usually, general trends of some important regional fault systems served as primary directions for a searching for analogous surface elements in their surroundings. However, most of the linear landforms do not correspond to geological boundaries as the topographic features of all the distinguished directions are dispersed across many of regional geological units. But the elongated element clusters (zones) can correspond with significant geological structures (basins, mountain ranges or their margins) and some linear surface features fairly parallel current spatial limits of young sedimentary formations. A plenty of other natural phenomena are closely associated with the linear landform systems: regionally orientation and detailed shapes of river and valley networks, dense block segmentation of the topographic structure or location of concentrated surface erosion, locally water gaps, saddles, cuestas, anomalously shaped meanders, river terrace risers, land slide or even cirque elements. Thus, the linear networks have strongly influenced upper parts of the Earth's crust, in various geological or topographic settings and in a wide interval of spatial scales of structures. Cases of linear elements are presented also for the Czech Republic and, specifically, for the Eger Rift area.

**Keywords:** parallel linear landforms, remote sensing data, central Europe



## CAVE PEARLS: THE HIDDEN TREASURES OF MINES

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Cave pearls are a fascinating geological formation in caves and abandoned mines worldwide. These small, smooth, rounded pearls are formed through calcification, where mineral-rich water slowly drips onto a small object and gradually forms a hardened layer around it. As more layers form, the pearl grows, ranging from a few millimetres to several centimetres.

Cave pearls can be found in various environments, including limestone caves, lava tubes, and abandoned mines. They are often found in underground bodies of water, where the slow dripping of water over time forms these unique geological features.

Several examples of cave pearls are found in caves and mines in Czechia. One such example is the Litultovice mine located in the Nízký Jeseník and the štola Mír in the Vysočina region, where cave pearls have been discovered and are currently being researched.

The study of cave pearls is essential in understanding the geological history and mineral content of the caves or mines where they are found. The formation of cave pearls is a complex process. It provides insight into the mineral composition of the surrounding rocks and soils, the quality of water in the cave or mine, and the precipitation rate. In addition, cave pearls can indicate changes in the environment, particularly in water quality.

In conclusion, cave pearls are a fascinating geological formation providing valuable insight into the geological and environmental history of caves and mines. The examples of Litultovice mine and Štola Mír in the Czech Republic show the diverse range of environments where cave pearls can be found and their potential for further research.

**Keywords:** cave pearls, mines, Litultovice mine and Štola Mír in the Czech Republic

# DETERMINATION OF PORE SIZE DISTRIBUTION IN POROUS ROCKS BY NON-NEWTONIAN FLUIDS

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Pore space properties of geologic materials are of substantial scientific and industrial interest, as they are interlinked with many of their mechanical, transport and hydraulic properties. In geomorphology, the characteristics of the pore space – including pore size distribution – are considered a key factor in susceptibility of the rocks to various weathering processes. Multiple techniques are employed for the determination of the pore size distribution within porous materials, none of them is without disadvantages. Mercury intrusion porosimetry is probably the most popular and widely used in geomorphologic studies, despite increasing restrictions on the use of the mercury.

Within the last decade, there has been a growing interest in the use of non-Newtonian fluids for determining the pore size distribution of the porous materials. The principle exploits the behaviour of non-Newtonian fluids whose viscosity changes with shear rate. As a result, saturated flow of different fluids under different hydraulic gradients is distributed differently in the pore space. Thus, conducting several saturated flow experiments with different fluids and/or under different hydraulic gradients allows – using a numerical model – to determine an approximation of the pore size distribution.

Our goal is to test utilization of the method to determine the pore size distribution using saturated flow experiments with low-concentration water-xanthan solutions (<2 g/l) under relatively small hydraulic gradients (<5). We have now completed a set of laboratory experiments for three types of sandstone, and we compare the obtained pore size distribution curves with the conventional mercury intrusion porosimetry. The presented approach is low-cost, easy-to-use and can serve as a non-toxic alternative to mercury intrusion porosimetry in various geomorphological studies.

**Keywords:** pore space properties, susceptibility, weathering processes, non-Newtonian fluids

Acknowledgement: The research is funded by the Czech Science Foundation [21-27291S].

# GEOMORPHOLOGICAL EVOLUTION OF THE LABE AND JIZERA CONFLUENCE AREA IN THE QUATERNARY

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Neotectonic movements and climate-morphogenetic processes determined the landform evolution of the Bohemian Massif in the Upper Cenozoic. My research objective was to discover the key phases of the geomorphological development of the Labe and Jizera confluence area in the Quaternary. Current landforms in the region provide a reliable record of paleogeographical changes in the natural environment. For this reason, it was possible to carry out a detailed historical-genetic analysis of the landforms. Special attention was paid to the influence of neotectonic activity and morphogenetic processes on the changes in the drainage pattern. The morphostratigraphical system of the river terraces was updated and applied as a primary timeline.

The location and the depositional character of the river terraces were used to determine the changes in direction of the paleo-river flows in the main periods of the landscape evolution. The degree of river incision between several accumulation phases of the river terraces development and the extent of backward erosion through the valleys of the Labe and Jizera tributaries reflect the changes of the erosional basis caused by the neotectonic and climate-morphogenetic processes. Geomorphological analysis revealed that the majority of the relics of fluvial deposits in the Labe and Jizera confluence area are much younger than reported in the previous studies. Originally extensive and currently already considerably eroded III. river terrace of Labe was formed in the Elster glacial period (Cromerian complex c). The conspicuous Jizera alluvial cone developed during the aggradation phase of the VII. river terrace in the Upper Pleistocene. Down-slip tectonic movements along the Labe fault zone, which caused the current asymmetry of the Labe valley, reached up to 14 m even before the beginning of the Holocene.

The presented research in the area of the Labe and Jizera confluence contributes to the determination of significant changes in the landform patterns of the Bohemian Massif during the Quaternary, especially by reconstructing the morphogenetic history of river valleys.

**Keywords:** landforms, historical-genetic analysis, Labe and Jizera confluence

STRESS FIELD CHANGES IN CENTRAL EUROPE SINCE LATE MIOCENE TO DATE AS DETERMINED FROM VOLCANIC ROCKS AND EXTENSOMETRIC MEASUREMENTS IN THE BOHEMIAN MASSIF, CENTRAL EUROPE

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The landscape evolution is very often affected by tectonic activity, which is driven by the stress field acting and also by its changes over time. Unfortunately, very little is known about behaviour of the stress field during Cenozoic time. The contribution presents the results of stress field reconstruction within the W part (Komorní Hůrka volcano) and NE part (Rychlebské hor Mts. – Travná Gallery and Lutynia Tertiary volcano) of the Bohemian Massif in Central Europe since Late Miocene to date and its implication to the fault kinematics, dynamics and potential activity within the region. The classical methods of paleostress were used and applied on stria on slickensides datasets measured in the dated volcanic rocks and on present-day observed 3D fault movement dataset measured by extensometers - the TM-71 gauges in Travná gallery (Rychlebské hory Mts.). The results show significant changes of the stress field parameters during Cenozoic time.

**Key words:** stress field reconstruction, tectonic activity, landscape evolution

# LANDSLIDE-INDUCED CHANGES IN TREE-RING ANATOMY: A NEW DIRECTION OF DENDROGEOMORPHOLOGY?

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The dendrogeomorphic dating of past landslides can be limited by the speed or magnitude of movements, as they are sometimes too small to induce growth responses in trees standing on unstable slopes. As a result, movements of low magnitude are generally assumed to remain undetectable in standard macroscopic analysis of growth disturbances in tree-ring series. To close this gap and to enlarge the suite of approaches available for the dendrogeomorphic detection of landslide activity in growth-ring records of trees, this study focuses on the detection of wood-anatomical growth responses in trees following low-magnitude landslides. Anatomical growth responses of five individuals of common spruce (*Picea abies* (L.) Karst.) growing on a monitored landslide have been analyzed in this study on a total of 200 tree rings from 40 increment cores extracted at two vertical levels of tree stems. Analysis included seven anatomical parameters commonly used in quantitative wood anatomy, with a focus on the year 2017 year during which the landslide body moved by 8 mm (prior to the start of the growing season) according to extensometer records. We report that mean tracheid lumen area (TLA) decreased significantly due to landsliding, whereas the mean number of traumatic resin ducts (TRD) and rays increased significantly after the occurrence of the landslide. By contrast, the intensity of stem tilting was visibly too small to induce the formation of compression wood but strong enough to induce larger number of rays, which are known to enhance stability as well. We also realize that the low intensity of the landslide movement also resulted in rather localized anatomical anomalies along the stem, with detected responses decreasing in intensity with increasing distance from the ground. We conclude that anatomical responses of *P. abies* trees can be used to detect past activity in low-magnitude landsliding and that this new proxy can thus extend the applicability of tree-ring approaches to landslide research and to the detection of events that have hitherto remained unidentified in reconstructions.

**Keywords:** landslide, wood-anatomical growth, dendrogeomorphology

3D PALEOSEISMIC TRENCHING COMBINED WITH 3D GEOPHYSICS CAN  
REVEAL COMPLEX FAULT STRUCTURE: EXAMPLE OF MARIÁNSKÉ  
LÁZNĚ FAULT (WEST BOHEMIA)

Štěpančíková, P.<sup>1)\*</sup> – Fischer, T.<sup>2)</sup> – Rockwell, T.<sup>1,3)</sup> – Tábořík, P.<sup>1)</sup> –  
Stemberk, J.<sup>1)</sup> – Karousová, M.<sup>2)</sup> – Šíroký, J.<sup>2)</sup> – Hartvich, F.<sup>1)</sup> – Sana, H.<sup>1)</sup> –  
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We performed paleoseismic study studying generally NNW-SSE trending Mariánské Lázně Fault (MLF), which is situated in the western part of the Bohemian Massif (Czech Republic, Central Europe). The MLF is morphologically pronounced and controls the eastern limit of the Cheb-Domažlice Graben for a length of 100 km and of the Cheb basin in its northern portion. The Cheb basin is a half-graben filled with Oligocene to Plio-Pleistocene fluvio-lacustrine sediments and volcanoclastics and is famous for Pleistocene volcanism, abundant present-day occurrences of mantle-derived CO<sub>2</sub> emanation, and probably fluid-driven earthquakes swarms (max. ML=4.6). The hypocenters of the swarms are aligned along NNW-trending fault of the Nový Kostel focal zone, which however shows no morphological expressions. Paleoseismic trenching was carried out at Kopanina site in Cheb basin, where the NW-trending MLF controls Krušné hory Mountains foothill and where it intersects the NNW-trending Nový Kostel focal zone. The trenching revealed repeated surface-rupturing earthquakes on the MLF with different kinematics, while the youngest earthquakes in Holocene were strike slips. To obtain any horizontal offset we perform 3D trenching (seven backhoe trenches and six hand-dug micro-trenches), which revealed a complex structural set-up with oblique faults and deformation probably as a result of right-lateral transpression during the Late Quaternary. The trenching was preceded and also accompanied by 2D and 3D geophysical survey, which comprised 3D GPR (with 25 – 50 cm interval lines), DEMP (dipole electromagnetic) mapping, and 2D and pseudo-3D electric resistivity profiles. The results revealed horizontally offset sedimentary bodies, which are well reflected in 3D geophysics at a greater (meters) scale and with best resolution obtained by 3D GPR. On the other hand, trenching and even micro-trenches enabled to reveal smaller (centimeters) offsets. Thus, combining 3D trenching and 3D geophysics appeared to be a very useful way to display fault characteristics, especially in strike-slip regime.

**Keywords:** paleoseismic study, 2D and 3D geophysical survey, Mariánské Lázně Fault

## APPLIED GEOPHYSICAL SURVEY AS A COMPLEMENTARY TOOL FOR DENDROGEOMORPHOLOGICAL RESEARCH?

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Dendrogeomorphology is a specialized interdisciplinary field that studies the response of trees and forest vegetation to various geomorphological processes. Using dendrogeomorphology, we can date many of such processes, which is certainly a great asset of this method. In addition to determining the age of the resulting geomorphological forms, we are also able to determine the frequency of occurrence of a particular process in both space and time and thus determine its recurrence. In addition, not only dating is important, but also the degree of response of trees and wood mass to the processes studied. However, it is useful to combine dendrogeomorphology with other geoscience disciplines to deepen knowledge or to confirm hypotheses formulated on the basis of the tree trunk studies. Geophysical methods then provide crucial information on the subsurface, which are essential both for (i) understanding the situation below the Earth's surface and (ii) studying the root systems, very important parts of the trees studied. The presented contribution provides a basic overview, however, based on our own experience, of the use of geophysical methods in the dendrogeomorphological research as well as in the investigation of tree root systems. Alongside the examples of the successful use of applied geophysical methods in particular case studies, the contribution also compares the results and effectiveness of various geophysical methods used in the selected dendrological applications. The evaluation of the measurement efficiency is therefore very important for determining the optimal measurement methodology for different dendrological tasks and an overall development of the field-based research techniques applicable e.g. in dendrogeomorphology, agroforestry or forest botany. Furthermore, geophysical surveying represents a completely non-destructive and non-invasive way of acquiring information on the subsurface. The assessment includes 3D electrical resistivity tomography, 3D electromagnetic imaging and 3D ground penetrating radar.

**Keywords:** geophysical survey, dendrogeomorphology, tree root systems

## DENDROGEOMORPHIC SURVEYS OF NATURAL HAZARDS IN THE PELOPONNESE (GREECE)

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The eastern Mediterranean is a hotspot of geomorphic hazards, but the activity of gravitational processes in mountainous areas is largely unexplored. We carried out dendrogeomorphic research in the Helmos Mountains (Northern Peloponnese, Greece) to determine the timing, spatial extent, and hydrometeorological triggers of debris flows and snow avalanches. Specifically, we sampled increment cores from 182 trees (Greek firs, black pines, and oriental planes) at three sites. We compiled 118-year chronology (1904–2021) with seven debris flow event years and only one severe debris flow occurring in the 1970/1971 dormant period at a site incised in moraine and glacial deposits. Similarly, seven snow avalanche event years were identified in the period 1854–2021, with one major event in 1997/1998 at the second site. At the third site (debris flow network incised in rockslide body), frequent debris flows were reconstructed over the last 20 years, with the most recent high-magnitude events in 2018/2019 and 2019/2020. Extremely wet conditions in February–March 1971 followed by rain-on-snow precipitation were considered as the most likely trigger of the analysed debris flow event using data from nearby meteorological stations and the ERA5 reanalysis. The snow avalanche event was deciphered in the spring of 1998, when heavy snowfall over three days (62 cm) was followed by rapid snowmelt due to high average temperatures (6–11 °C). Strong convection was identified during 10–11 January 2019 with high rainfall totals (76 and 44 mm, respectively) falling on melting snowpack. We conclude that the abundance of snow is a crucial factor in the geomorphic activity in the study region and that the temperature fluctuations and rain-to-snow transitions are the leading factors for the debris flows and snow avalanches to occur.

**Keywords:** geomorphic hazards, dendrogeomorphic research, Helmos Mountains (Northern Peloponnese, Greece)



# WORLDWIDE DISTRIBUTION OF PUBLISHED DEEP-SEATED GRAVITATIONAL SLOPE DEFORMATIONS CASES

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Large-scale slow-moving deep-seated gravitational slope deformations (DSGSDs) are common but not highly investigated phenomena around the world. There is an evidence that most of the biggest terrestrial catastrophic rock slope failures (collapses) appeared in areas which are affected by DSGSDs. Case studies of ongoing and collapsed DSGSDs as well as associated deep-seated landslides presented in scientific papers are numerous, describing large variability of DSGSD types and behaviors. Taking into account different goals of investigations in published papers, different field conditions, ongoing technological development of remote sensing and geologic tools and no standardized approach regarding the terminology, we are facing many problems related with understanding of these complex mass movements. Still it is relevant to better understand the spatial distribution of deep-seated deformations and their collapses worldwide. In some mountain regions such as Alps, Carpathians or Apennines, DSGSDs are mapped and analysed since the late XIX century. Recent availability of high resolutional spatial, monitoring and geologic data gives even more ways to investigate mass movements in such areas. However in many regions of the world (e.g. Himalaya, Andes, Caucasus Mts.), DSGSD phenomena remains aside comparing with more hazardous landslides or rockfalls. Here we shortly present the current situation about DSGSDs and their collapses investigation around the world based on published case studies.

**Keywords:** deep-seated gravitational slope deformation, spatial distribution

**Acknowledgement:** Research was supported by the University of Ostrava Project SGS02/PřF/2023.

SCREE – TALUS SLOPES OF THE KRUCZE MOUNTAINS (CENTRAL SUDETES) – AN EXAMPLE OF THE INFLUENCE OF ASPECT ON THE DIVERSITY OF WEATHERING AND DENUDATION PROCESSES IN THE PERIGLACIAL ENVIRONMENT

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The Krucze Mountains are characterized by low altitude (700–890 m a.s.l.), but as are other ranges of the Central Sudetes, which are built of Permian volcanites (rhyolites), significant relief energy (200–300 m) and steep slopes with exceeding more than 30°. On these slopes, there are crags and debris covers – scree/talus. The best example of this is the complex of forms located within the culmination of Krucza Skała (681 m a.s.l.). Debris covers also lie on the southwestern slopes of deeply incised valleys. These are steep straight slopes, on which, however, there are no rock outcrops and crags. In the lower parts of these slopes, there are currently active debris landslips associated with road undercuts.

GIS analysis showed that the location of scree slopes in the Krucze Mountains corresponds to the criteria specified by Iwata (1987) for Richter–type slopes. Scree slopes in the Krucze Mountains were created in a periglacial environment on slopes with a solar aspect with annual total insolation (ATI) of over 1900 kWh/m<sup>2</sup>. On these slopes, there was intense physical weathering associated with frequent frost cycles and gravitational movements like dry debris avalanches. On the steep cold slopes, exposed towards the north (ATI: 900–1150 kWh/m<sup>2</sup>) there are sandy–clay debris loam covers. They represent the conditions of a periglacial environment suitable for microgelivation and solifluction rather than macrogelivation and dry debris avalanches.

Similar examples of screes, on slopes with southern and southwestern directions, can be found in the Sudetes at various altitudes on steep mountain slopes or valley sides (Traczyk 2008, 2011, 2014). Their common feature is that they are mostly built up of resistant rocks, but strongly fractured and thus susceptible to physical (frost) weathering. This analysis leads to the general conclusion that in addition to the asymmetry in the distribution of periglacial forms and covers associated with wind (windward – leeward slopes) facete (e.g. Prosová 1963), in the Sudetes there are examples of solar asymmetry (warm – cold slopes).

**Keywords:** weathering and denudation processes, GIS analysis, Krucze Mountains (Central Sudetes)

## REMOTE SENSING OF LAST GLACIAL SORTED PATTERNED GROUND

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Sorted patterned ground is an abundant feature in past and present periglacial landscapes that greatly affects landscape and ecosystem dynamics and is also a valuable indicator of past permafrost and climate states. However, it has so far been investigated mostly by field methods, which is usually challenging due to high time requirements and poor pattern visibility from a ground perspective. Here, we demonstrate that region-wide high-resolution DEM and aerial photographs with a resolution of 0.5 m and 0.2 m, respectively, allow to reliably map and analyse large sets of last glacial sorted nets at one site in the Krkonoše Mts., Czech Republic, and to determine many of their geometric parameters, which would be difficult in conventional field surveys. Basic remotely sensed parameters such as length, width, and diameter of the sorted nets differ by less than ~13 % from the field-based values measured at the same study site, whereas the height is ~35 % lower. Most remotely sensed parameters of the sorted nets typically require ~30–100 observations for the absolute percentage error to be constantly below 5 % of the mean parameter value. It can be expected that a higher-resolution DEM would further reduce both the deviations and the number of observations needed. Besides that, the remotely sensed diameter of the sorted nets can also be used to estimate the thickness of the past active layer over permafrost, which was nearly 1 m at the study site during the Last Glacial Maximum and the mean annual air temperature likely declined by at least ~5–8 °C compared to the modern climate. Consequently, remote sensing can bring a wealth of new information on sorted patterned ground and its characteristics, and aid in past permafrost and climate modelling.

**Keywords:** sorted patterned ground, remote sensing, Krkonoše Mts. (Czech Republic)

**Acknowledgement:** The research was supported by the Czech Science Foundation, project number 21-23196S.

# POTENTIAL OF RESTORATION OF GEOMORPHIC HETEROGENEITY TO SUPPORT BROWN TROUT POPULATIONS

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It is well known that during the last few centuries the majority of European streams and rivers have lost their natural character. Impacts of anthropogenic activities are reducing the possibility of prospering self-sustainable populations of many fish species, making them one of the most threatened groups of vertebrates. In response to this decline, a high number of restoration projects has grown in the last few decades, aiming mostly on support of the Salmonidae family, especially brown trout (*Salmo trutta*). Based on knowledge about brown trout physical habitat requirements in various stages of life, many restoration efforts were based on improving degraded geomorphic heterogeneity. Although not much long-term monitoring of the connection between restoration of instream habitat and brown trout populations were made, there are some key messages, which can be highlighted. This paper briefly summarizes basic knowledge about habitat preferences of brown trout, its link to geomorphic heterogeneity and describes basic measures for supporting fish populations through improving instream geomorphology.

**Keywords:** geomorphic heterogeneity, brown trout, rivers

# LITHOLOGICAL VARIATIONS OF COARSE-GRAINED SEDIMENT OF THE Odra RIVER AND THEIR RELATION TO DOWNSTREAM GRAIN-SIZE VARIATION

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The framework of sediment (dis)connectivity provides important insight into the links between channel morphology and sediment sources. One of the possible methods to assess longitudinal (dis)connectivity is to study downstream variations in the size of coarse-grained sediment. From a general point of view, the size of bed material indicates gradual downstream fining by increasing distance from headwaters. This can change abruptly with the input of sediment from the tributaries or by lateral erosion of the alluvium. The lithological composition is another parameter that greatly influences the dynamics of the sediment. The Odra River flows between two lithologically distinct mountain ranges, namely the Nízky Jeseník Mts., generally formed by greywackes and slates, and the Moravskoslezské Beskydy Mts., formed by flysch sediments, such as sandstones and claystones. In our approx. 77 km-long study reach, the river is supplied by seven major tributaries, from which 3 left-sided originates in forefields of the Nízky Jeseník Mts. and 4 right-sided flows from the Moravskoslezské Beskydy Mts. We measured the grain-size of the surface layer of the 15 gravel bars using the Wolman method with 100 randomly selected particles. The grain-size data (>2 mm) did not show significant downstream fining, but rather a gradual increase in sediment calibre with major fluctuations in the 25th and 75th percentile (14 - 29 mm and 25 - 42 mm respectively). We confronted this finding with the lithological provenience of 50 randomly selected particles that were collected from the same bars. Variations in sediment size reflected changes in the lithological composition of bars, when the gradual increase in grain size may be linked to the dominance of sandstones and quartzes on certain bars (total occurrence > 55%).

**Keywords:** sediment connectivity, downstream fining, meandering river