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HUMAN INFLUENCE ON CHANNEL AND ISLAND DEVELOPMENT ALONG THE DRÁVA RIVER, HUNGARY – CROATIA

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The hydro-morphological status of the Dráva River changed significantly during the last two centuries as the result of engineering works. In the 19 – 20th centuries channel regulations and hydroelectric power plants were built on the river. The aim of the presented study was to evaluate the morphological effects of cut-offs, revetment and groynes constructions, and building and operation of hydroelectric power plants on the morphology of the river, focusing on the development of islands. The parameters of the islands and the morphometry of the channel were investigated using maps, satellite images and field measurements. The measurements were carried out on the lowest, 236 km long section of the Dráva River, between the Mura River and Danube River.

During the studied period (1882 – 2007) the number of the islands increased continuously (from 242 to 295), though their total area reduced (from 6 178 ha to 2 654 ha). It could be explained by the change in type and development-way of the islands. The large floodplain islands merged into the floodplain, but the new islands formed of bars are much smaller. The decline of islands is represented by the decreasing number of islands in the thalweg and the increasing number of osculating or amalgamating islands. In this environment the spatial distribution of the islands also altered, as the space between the braids increase. As the hydroelectric power plants reduce the water levels, the side-channels got relatively higher and they lose their water and sediment supply. Therefore the side-bars melt into the islands, thus they will have rounder shape.

The channel of the Dráva River became narrower (513 m to 256 m) and more uniform. Before the engineering works the upper section of the river was wide, and several islands and bars developed actively in the anatomising channel. On the lower section the channel was sinuous, less islands and bars were formed in accordance with the decreasing sediment load and slope downstream. In the 19th c. the channel became straightened by cut-offs, and it soon became braided due to the high sediment discharge and slope. However, in the 20th c. the hydroelectric power plants trapped the sediment and the water, and the groynes closed the side-channels, and the main channel becomes more uniform and the thalweg more pronounced. Nowadays the greatest amount of sediment is supplied by bank failures (max. bank retreat: 4.7 m.y⁻¹) Therefore, as the islands osculate and merge to the bank and lateral erosion accelerates, the channel becomes sinuous.

Key words: the Dráva River, human impact, fluvial island, channel pattern change

USING RADIAL BASIS FUNCTION WITH A MULTI-QUADRIC OPTION FOR OBSERVING CHANGES IN RIVER CHANNEL MORPHOLOGY

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Radial Basis Function has been shown as the most effective method to reconstruct smooth, manifold surfaces from point data and to repair incomplete meshes. The method is used for sophisticated imaging in medicine or manufacturing. This presentation explores its application on randomly spaced data in fluvial geomorphology and in ecotechnical engineering, where the detailed observation of changes to the river bed can be crucial in choosing the right approach for management of fluvial-related problem. Randomly spaced elevation points were measured on a lowland river in England before and after high flow events in winter 2009/10, using a surveying station and gridded in SURFER using the Radial Basis Function with Multi-Quadric Option. Extrapolated data were consequently blanked, sliced into multiple cross-sections and subjected to a three-dimensional analysis to calculate volumetric changes of sediment gain or loss. Three methods were employed to obtain the true volumes: Extended Trapezoidal Rule, Extended Simpson's Rule and Extended Simpson's 3/8 rule.

Key words: data gridding, land survey, river bed elevation, river engineering, fluvial processes, sediment

LANDSCAPE EVALUATION OF THE DRAVA RIVER FLOODPLAIN

Opportunities for ecological agriculture

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The Ecopoint or Green-point system was introduced in Lower Austria, which is much more than an agricultural land evaluation, or support system. In our country, the program has not yet taken root, even though at the theoretical level and in the example of model farms, the researches exploring the opportunities of the system have begun. Our study area is the central part of the Drava River plains Ormánság, which is one of the unnecessarily (apart from recent past) over-shadowed areas of Hungary with a wide natural, social and tourism potential. Therefore, our purpose – in accordance with the aims of the Ós-Dráva Program serving the rise of the region – is to prepare a complex classification of land, exploring and analyzing the area's primarily agronomic characteristics. Based on these results, our objective is to explore the implementation and application opportunities of the Austrian Ökopunkte-system theoretically and then practically, through the activities of a model farm.

Our work would like to support the economic growth and the sustainable land management of the area. Geomorphological research of the areas along the Dráva River in the middle of the 20th century started with the primary objective of clarifying the evolutionary questions the young depression area. Based on the results of previous geological, geomorphological and hydrological research we would like to continue this work, but the ultimate goal of this would be landscape evaluation. The Lower Dráva River section, along the Croatian border represents Central Europe's last remaining river landscape, with the variety of river bed types and natural river forms where the major part of the area is part of the Danube-Dráva National Park and protected by the Natura 2000 Program. The broader field of research is Ormánság, which in a narrower sense covers the given section of the river and the surrounding floodplain in geomorphological sense.

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Key words: ecological agriculture, sustainable land evaluation, the Dráva River floodplain, Green-point

THE RESEARCH METHODS OF MUDFLOWS IN THE REPUBLIC OF ARMENIA

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Today, the issue of mudflows has acquired a global importance. The intense growth of cities and towns in Armenia will continue, so the solution of anti-mudflow protection, fight against erosion and mudflows are a priority. To develop methods for research and assessment of mudflows, comprehensive engineering-geomorphological and engineering-geological surveys must be accompanied with empirical observations of mudflow processes. Only then will the analysis of the obtained data give the opportunity to define the appropriate methods for engineering-geomorphological research, select the key criteria, which would mudflows from the complex array of mudflow processes. The engineering-geomorphological research, carried out by Professor Soghomon Balyan in one of the mudflow foci in the Republic of Armenia, namely, in the Vedi River basin, could be regarded as exemplary for this kind of researches. After the detailed study of drift formations and lithological-morphological qualities, the attention was paid to the features, which play an important role in mudflow role in mudflow formation. They are: a) granulation-metrical composition; b) the degree of compression; c) the degree of saturation; d) filtration qualities; e) weight by volume.

These date served as base for engineering-geomorphological mapping, which can be used today in carrying out this kind of researches of mudflow processes.

Key words: mudflow, engineering-geomorphological mapping, river basin

GENERATIONS OF MEANDERS OF THE JIU RIVER IN THE LOWER SECTOR (SOUTH-WEST OF ROMANIA)

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The aim of this study is the complex monitoring of the Jiu River bed in terms of geometry and complexity of meanders in its lower sector (on a length of 77 km).

The detailed analysis of the lower Jiu sector meanders completes the geomorphologic knowledge of rivers in Romania, starting from identifying and determining the type of meanders, and the obtained results present the indices concerning their age and migration rate (wavelength 1 977 – 4 721 m, meanders amplitude 511 – 2 862 m, the mean radius of curvature 270–997 m and the sinuosity index from 0.87 to 2.17).

Another aim of this study is the identification of the evolution features of the Jiu River, the relationships between some hydrological factors of control (liquid flow and suspended sediments - annual average values) and the generations of meanders (actual or open meanders and incised meanders or paleomeanders) distributed in two sectors: Podari – Padea sector and Padea – Danube confluence sector.

In addition, our concern is motivated by the fact that in the last two years there were analysed the landslides and subsidence on the right slope of the Jiu River (next to Bâzdâna and Drănic localities), strongly eroded and in close connection with the meandering of the watercourse.

Key words: meanders, morphological parameters, paleomeanders, actual meanders, lower sector, the Jiu River

CONTEMPORARY HUMAN IMPACT ON THE HYDROMORPHOLOGICAL STATE OF MOUNTAIN STREAMS (POLISH CARPATHIANS)

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Contemporary human influence in mountain areas manifests itself as visible changes in the natural habitat of rivers and streams as well as in their immediate environment. Human interference in the habitat of mountain streams may modify the hydromorphological state, which is understood as a collection of natural and anthropogenic features. The hydromorphological state of rivers is a reflection of their habitat quality and is dependent not only on the number of natural and anthropogenic features, but also on mutual proportions.

Research was conducted in the valleys of the Jaszczce Stream and Jamne Stream, which cut the southern slopes of the Gorce Mts. (the Polish Western Carpathians). The Gorce Mts. are mid-sized mountains (600–1 300 m a. s. l.). It is a wide mountain range that is characterized by steep slopes deeply cut with the tributaries of the Raba River and the Dunajec River (the drainage basin of the upper Vistula River). The studied streams are the left tributaries of the upper section of the Ochotnica River, which is a tributary of the Dunajec River.

The aim of this article is to evaluate the hydromorphological state of the Jaszczce Stream and Jamne Stream, which are located in similar physical and geographical environments of the Western Carpathians. The streams display a similar level of human interference in their valleys. The level of human interference in the valleys of mountain streams can affect the quality of the hydromorphological state. The evaluation of the hydromorphological state of the studied streams was based on a list of natural and anthropogenic features prepared according to the British River Habitat Survey (RHS) method. The studies based on the RHS method allow collecting around 400 parameters that characterize the hydromorphological state of a particular river section. The obtained material can be used to calculate the synthetic indices (HQA and HMS) that result from many individual basic parameters, and which allow a numerical evaluation of the hydromorphological features of a river.

The hydromorphological state (quality of habitat) of upper sections of the Jaszczce and Jamne streams is the least changed by human activity. The middle and lower sections of studied streams are the most transformed by channel modifications, mainly bank reinforcements and reprofiling. This is mostly the result of the type of land development in narrow valley floors of streams (numerous and dense infrastructure). Because of the development of construction, humans have interfered in channels to protect the created infrastructure and buildings from the results of floods.

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Key words: hydromorphological state, the Jaszczce Stream and Jamne stream, human impact, Polish Carpathians, RHS method

**EVOLUTION OF LANDSLIDES IN TRIBUTARIES
OF THE CZARNY DUNAJEC RIVER (PODHALE AREA)
AFTER VIOLENT RAINFALL AT 28 JUNE 2009
(WEST PODHALE REGION)**

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Mass processes including landsliding processes are common phenomena in the Outer and Inner Carpathians. Geological structure (alternation of sandstones and shales), sculpture of field (inclination of slopes) and fields covers (forests, grasslands) are features that affect the evolution of landslides. Violent rainfall could be an impulse for start-up of landsliding processes.

The presented data concern the landslides occurring on slopes of small tributaries of the Czarny Dunajec River in the Podhale Basin, built of Eocene-Oligocene siliciclastic turbidite successions. Almost fifty landslides have been observed in this region (near Witów village) after violent and short-termed rainfall (2 hours) with precipitation *ca* 140 mm which took place 28 June, 2009. The landslides differ from each other in dimensions and amounts of transported material.

Taken into account these differences, the author suggest that 1/ inclination of slopes together with 2/ features of turbidite sediments, dominated by shales, and 3/ differences in forestation of the region were the main factors contributing the landsliding processes. Most landslides on steep slopes have formed independently of sediment inclinations. The largest landslides (with the highest amounts of redeposited material) have formed in the forested areas; the weight of trees was a factor favoured their creation.

Key words: landslides, violent rainfall, flysch sediments, the Podhale Basin

THE MAP OF GEOATTRACTIVENESS – A NEW TYPE OF GEOTOURISTIC MAP. CASE STUDY – THE CENTRAL SECTOR OF THE BUCEGI MOUNTAINS

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The touristic attractiveness of the relief represents the totality of the landforms with a value for the touristic activity, which could attract flows of tourists. The map of geoattractiveness is a new type of geotouristic map, which we propose as an instrument of decision for tourists. It is based on other special maps as: the geo-touristic map and the map of geomorphodiversity.

The chosen space, the central sector of the Bucegi Mountains, imposes within the Southern Carpathians (the central branch of the Romanian Carpathians, with altitudes which often exceed 2 000 m) by the variety and complexity of the relief (denudational, structural, petrographic, glacial, fluvial-torrential, periglacial, gravitational), by the multitude and diversity of relief forms which become important due to human perception (geomorphosites), but also by the practising of different types and forms of tourism, due to its accessibility and its well developed infrastructure.

The map of geoattractiveness is done in several stages:

- **The accomplishing of the database**, necessary both by field campaigns (detailed mappings of the forms of relief, the inventorying and evaluation of geomorphosites) as well as by the existent materials (specialised literature, cartographic materials – touristic, geological, geomorphological, topographic maps, as well as ortophotoplans from several editions);
- **The analysis** of the geomorphodiversity map ($Gmd = \sum EgXn/S$, where Gmd = geomorphodiversity index; Eg = the number of landforms; n = the number of the genetic types of landforms; S = area (in sq. km);
- **The mapping of geoattractiveness** (this parameter is given by the formula: $Geattract = Gmd + 50XN/S$), where $Geattract$ = geoattractiveness; Gmd =geomorphodiversity; N = number of geomorphosites; S = area (in sq. km). The values obtained for geoattractiveness in the analysed area/space are very high, and they are not uniformly distributed in the territory. They may form the basis for conceiving some geotouristic paths in this area.

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Key words: geoattractiveness, geomorphodiversity, geomorphosites, the Bucegi Mts., the Carpathians, Romania

GEOMORPHOLOGICAL INFLUENCE ON THE TIMBERLINE COURSE AT THE BABIA GÓRA MOUNTAIN

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The upper (alpine) timberline is the hypothetical line, represent climate driven limit of closed-canopy forest. The summer temperature is usual the main factor designates this boundary. Such theoretical potential timberline (PTL) is defining by line joining the highest location of dense forest and in reality, is significantly modified by the multi-factorial interactions of abiotic conditions. This real line - empirical timberline (ETL) designates the detailed limit of forest as imposed by all environmental factors. The local position and character of empirical timberline can be use as a record of particular factors (climate, geomorphic processes and orography, soil and human impact) govern it course. The difference between location of PTL and ETL can be employ to measure the strength of such influence. This method was tested at the Babia Góra Mountain to specifically identify the influence of geomorphological features on the timberline ecotone. The Babia Góra Mountain (Babia hora) is the highest, single peak of Western Beskidy and massive with best-developed timberline ecotone in that region. Both potential and empirical timberline was defined based on the aerial photos taken in 2009 and verified during field surveys. The recent PTL is located at average elevation of 1 400 m a. s. l. and shows relatively small changes - the lowest point on this line (1 294 m a. s. l.) is located on the northern slope and the highest (1 510 m a.s.l.) on the southern. This confirms the climate as main factor driving the course of potential timberline. The average elevation of empirical timberline is lower (1 372 m a. s. l.) whereas the local variation is higher (from 1 110 m a. s. l. on the N slope up to 1 510 m a. s. l. on the S slope). Two compared boundaries are also characterised by different length. The PTL has length of 15 400 m and complex course of ETL results in line almost 2.4 times longer (36 176 m). To identify the predominate local influences which drive the timberline, the PTL was split in 74 sectors (30 on the N and 44 on the S slope) of similar length (~200 m) and the character and morphometry of both type of timberline was analysed. The detailed geomorphological map (1:10 000) and ground coverage analyses was also employed.

Although most of the changes of the studied ecotone are related to land use modification, resulted from complex history of that region. It is safe to assume that timberline is relatively undisturbed for last 100 years (mostly result of protection). Recently the climate and other natural factors play the key role in the shaping the course of the timberline. The main natural, non-climatic influences are related to geological and geomorphological features. Within this domain two types of timberline was identified: i) locations where course of the PTL and ETL is similar (elevation differences smaller than 10 m) – stable, orographic timberline (2 % of the total length of ETL), ii) sectors where recent processes, mainly debris flows and avalanches, lower the ETL significantly (elevation differences greater than 30 m) (38 % of the total length of ETL). This suggests two types of influences – first originated from the geological and geomorphological history and stable for long time, and second strongly related to the recent geomorphological of mass monuments and snow avalanches.

Key words: timberline, the Babia Góra Mt., geomorphological processes

PLEISTOCENE CRYOPEDIMENTS AND CRYOPEDIPLAINS OF THE MORAVIAN-SILESIA CARPATHIANS (CZECH REPUBLIC)

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The Moravian-Silesian Carpathians are the westernmost member of the Western Carpathians in the south-eastern part of the Czech Republic. Extensive low-angled foot surfaces are reported from many parts of the Moravian-Silesian Carpathians. Imported part of this group of landforms represents Pleistocene cryopediments and cryopediplains. Cryopediments (Wako 1963) are gently inclined erosion surfaces developed at the foot of valley sides or marginal slopes of geomorphological units by cryogenic processes in cold climates of the periglacial morphogenetic zone, mostly with presence of permafrost. Cryopediments vary in angle from as much as 8 – 100 in their upper sections to as low as 10 in their lower sections. Their dimensions also vary, the smallest may be some tens of metres in width, while others exceed over 1 km in width. Usually, the bedrock lies near to the surface of the cryopediment or only very thin veneer of surficial material mantles the cryopediment. Thus cryopediments are rock-cut transportation surfaces which truncate geologic boundaries. Cryopediments develop by activity of complex of cryogenic processes whereby frost action, nivation and other processes extends the cryopediment upslope by a process of cryopediment backscarp retreat. Cryopediments usually initiate below initial slope irregularities (breaks of slopes), which favour snow accumulation in lee position. Then, a complex of cryogenic processes beneath the snow bank bounded on presence of the thaw water from the melting snow (in an otherwise dry periglacial conditions) lead to steepening and retreat of the backscarp. The geological conditions of the Moravian-Silesian Carpathians required the presence of permafrost during the origin and formation of cryopediments. There is evidence that the permafrost thickness reached at least 220 m during the cold phases of the Pleistocene (Růžicková and Zeman, 1992).

Coalescence of several cryopediments produced a cryopediplain. It is a relatively smooth bedrock surface with gently concave profiles. The largest cryopediplain developed by coalescing many cryopediments at the foot of the Central Moravian Carpathians in the Hillyland Pracká pahorkatina. This cryopediplain is a complex rock-cut surface which truncates Neogene deposits (clays, sands) of the Carpathian foredeep and also soft flysch rock of the group Outer Carpathians overthrusts.

Discussion. T. Czudek (2011) proposed that cryopediments develop by two different modes of cryogenic processes – backwearing and downwearing. According the study of cryopediments of the Moravian Silesian Carpathians the principal and the most important process in formation of cryopediments was backwearing of backscarps. The slight downwearing could take place during the coalescing of cryopediments and formation of the cryopediplain.

H. French (1996) supposes that cryopediments are inherited landforms and cold-climate processes acted on pre-existing pediment morphology. It could be true in some cases because the Pliocene pediments are widely distributed landforms in the Moravian-Silesian Carpathians. But the most cryopediments and cryopediplains of the Moravian-Silesian Carpathians are Middle up to Late Pleistocene landforms because they occur in lower position in respect to the highest Pleistocene river terraces and are bounded on low river terraces or directly on the valley bottoms.

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Key words: Cryopediment, cryopediplain, the Moravian-Silesian Carpathians.

USE A GIS TECHNIQUES TO IDENTIFY AREAS TO CONSIDER WHEN DESIGN THE FIRST ROMANIA RAILWAY BASAL TUNNEL

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As a response to criticism regarding the pollution of mobile sources, a positive change of the railway transport can be noticed lately at European level, both for passengers railway transport and especially for goods railway transport, by inaugurating the high speed railways and implicitly by enhancing the transport capacity of the main railway axes. In the mountainous areas, the technical parameters with implication in the increase of the circulation speed are mainly connected to geology and tectonics, the relief configuration, the values of declivities and the presence of the actual geomorphologic processes. The construction of some basal railway tunnels (able to replace the present peak tunnels) has proved to be a major technical solution for the most important trans-alpine mountain railway connections (St. Gottard, Lotschberg, Brenner). These resolve mostly the technical problems on the one hand, but they also reduce the environment impact in areas of great anthropic pressure, on the other hand. In Romania, the most important trans-Carpathian track, both from the point of view of the numbers of transited railway garnitures, as well as from the point of view of the traffic volume, is the Prahova Corridor. This represents the railway which has been successively improved by the doubling of the track, electrification and some post-war rehabilitation, which however did not succeed to significantly increase the commercial speed and implicitly the transport capacity. Thus, the increase of the circulation speed along the Pan European Corridor IV can be achieved by the reducing of declivities (from 35 ‰ to maximum 20 ‰), the increase of the curves' compasses (from 220 m to minimum 700 m), by the construction of a basal tunnel between Azuga North and Timisul de Sus South. By the achieving of this tunnel on a length of 5 700 metres we propose, a series of deficiencies could be solved, deficiencies related to the presence of some present geomorphologic processes which repeatedly affect the railway to the north of Predeal, the decrease of the declivities which would raise problems of circulation safety and premature depreciation of the rolling stock, but also the increase of the circulation speed from 65 km.h⁻¹ at present, to 140 km.h⁻¹, with a consequence in the diminution of the circulation time between Bucharest and Brasov from 2h 05 minutes to 1h 40 minutes. The analysis of the relief was done with GIS and AutoCAD instruments, by processing the train's numerical model, of numerous cartographic materials and of several field campaigns. The result of the study constitutes solutions with regard to the configuration of the proposed track, the values of horizontal and vertical curves, the positioning of the north and south portals, the placing of the construction management and of the sound-absorbent panels in regard to residential areas, but also solutions of relocations of present constructions and connection to the existing transport infrastructure, according to European standards. At the same time, based on a proper method, the most convenient areas for placing/ locating the embankments, cuttings and viaducts (with all the afferent technical parameters) were identified, forming, in the end, a database which can finally prove to be extremely useful for construction engineers.

Key words: railway basal tunnel, Pan European Corridor IV, GIS techniques, the Prahova Valley, Romania

POST-FAILURE SURFACE CHANGING ON A DANUBIAN BLUFF IN DUNASZEKCSŐ, HUNGARY

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Between Budapest and the southern border of Hungary on the along west bank of the Danube River, there is an approx. 200 km long valley, which is bordered by a 20 to 60 meters high steep bluff. The high bluffs are situated only on the right bank of the river due to the westward migrating flow direction and the lateral erosion of the Danube River. A particular combination of geologic, hydrologic and geomorphic factors is responsible for the landslides along the bluffs of the Danube River.

Former studies investigated active sections and those were close to urban areas. Geoengineering and geomorphic maps were edited, restricted areas were designed against development and engineering installations were built.

In the last few years, the researchers focused on the currently active landslide at the Dunaszekcső Vár Hill that is endangered initially cottages, but nowadays the dwelling houses. The first period of the recent evolution of bank failure started in 2006 with surface cracks and finished with a 222 m long landslide on the Eastern part of the Vár Hill on 12/02/2008. Second period started in early 2011, when a new meridional crack was founded on the South-eastern part of the Vár Hill.

Recent survey dates was measured in 5×5 m network, where the intersections were designated with a 1 m long and 12 mm on diameter steel picks. A new base point was built on the background of the Vár Hill from steel rod reinforced with concrete. This base was controlled from a geodetic point at Dunaszekcső with Topcon FC 250 GPS and other stabile points (e.g. concrete top of the former water reservoir) of the Hill using Sokkia SET 630 RK3 total station. Collected data was mapped and analyzed under Grass 6.4 and QGIS 1.7.4.

After an almost yearlong monthly surveying a significant vertical and horizontal displacement can be observed. The vertical displacement of the stabile background (central part of the Vár Hill) is under detection error limits: ± 6 mm, but East to crack the value significantly decreasing: -26 to -131 mm. The new block also displaced horizontally. It moved to North approx. 10 to 27 mm, while to East approx. 11 to 65 mm.

According to base plan of an ancient Roman fortress (Lugio-Florentia) on the Vár Hill a small branch of the former river is presumable. Significant activity of sliding bluff was not verifiable from 2nd till the end of 19th century as other Roman ruins show in the edge of Mezőföld loess plateau.

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Key words: landslide hazard, bank failure, total station, the Danube River, Hungary

A PROPOSAL FOR A GEOTOURISTIC TRAIL IN THE PRICOPAN RIDGE, THE MĂCIN MOUNTAINS (DOBROGEA, ROMANIA)

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The Pricopan Ridge, component unit of the Măcin Mountains hercynic chain, is situated in the North-Western part of the Dobrogea Plateau, respectively in the South-Eastern Romania. The extended aerial exposure of the Măcin Mountains (since the Upper Carboniferous) to the action of the modelling processes (mainly weathering) has led to the appearance of a particular morphology – unique at national level – represented by residual inselbergs, bornhardtts, castle koppies, tors, exfoliated rocks, taffoni, block fields etc.

The educational nature of the morphology resulted through the weathering processes and the spatial concentration of various forms in the Pricopan Ridge are favorable factors for the achievement of a geomorphological itinerary. Thereby our study aims to propose a geotouristic trail in order to capitalize the morphology of the Pricopan Ridge through tourism activities (geotourism).

Based on the detailed geomorphological map (realized at scale 1:5 000) and multiple field campaigns we established the geotouristic trail. For the proposed trail we made both a qualitative and quantitative analysis (based on the assessment of the morphometric parameters). Using GIS techniques we created a complex longitudinal profile of trail on whose basis we calculated: the total length, the distances between the main geotouristic objectives, the level difference between the main points of interest, the declivity etc. The obtained data were used to determine the travel time and the difficulty level of itinerary. Based on the morphometric analysis and geotouristic objectives we proposed touristic planning of trail (including viewpoints, interpretative panels, camping places, resting places etc.). The favourable locations for placing the touristic planning elements were established during the field campaigns by taking GPS points. In the laboratory, all the proposed planning elements and the geotouristic points of interest were mapped, based on the geomorphological map. By simplifying the geomorphological map we created the geotouristic map in order to highlight the morphologic heritage of the Pricopan Ridge.

The importance of our results consists in fact that our planning proposal are not require major interventions in the Pricopan Ridge morphology, their implementation being feasible.

Key words: geotouristic trail, geomorphological heritage, geomorphological map, geotouristic map, geotourism, the Pricopan Ridge, the Măcin Mountains

SURFACE EXPOSURE DATING OF ROCK SLOPE FAILURES IN NORTHERN ROMANIA

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The glaciated Romanian Carpathians are prone to rock slope failures (RSFs). Several RSFs have been investigated in the northern part of the country, especially in the Rodna Mountains, where the RSFs are up to 1.6 km². These failures reflect the combination of high relief, lithological and structural controls. As the temporal pattern of paraglacial adjustments is unknown in these areas, the surface exposure dating method was employed in 3 locations. Preliminary data suggest that the RSFs are associated with areas subject to the over-steepening by glacial erosion during the Last Glacial Maximum (LGM) and the subsequent loss of support after deglaciation. The exposure dates are a good indicator of how slow/fast the steep slopes of the Rodna Mountains respond to gravitational stresses.

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Key words: the Carpathians, the Rodna Mountains, surface exposure dating, rock slope failure, glacial, paraglacial, geomorphology

SHEET AND RILL EROSION HAZARD WITHIN DRAINAGE BASINS IN HILLY REGIONS (ROMANIA)

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The design of models for determining the physical soil erosion has been accomplished in several stages, the longest stage being the one of the *simple models*. The results obtained in more than forty years of research on experimental runoff plots enabled ultimately the elaboration of the *Universal Soil Loss Equation* (USLE, Wischmeier & Smith 1978). The equation has been tested afterwards through numerous researches, leading to the development of some improved *empirical models* or even *physically based models using empirically derived factors* (MUSLE, RUSLE, Morgan-Morgan-Finney, ANSWERS, AGNPS etc.). The present paper is based on the *Universal Soil Loss Equation*, more precisely on its version adapted to the specific conditions of Romania (Moțoc et al. 1979), and on its application using the GIS technology. For the analysis, drainage basins situated in the intra-Carpathian plateau units (the Hârtibaciu Basin and the Săsăuș Basins) and in the extra-Carpathian hills (the Olteț Basin and the Mislea Basin) were selected. The Săsăuș and the Mislea Basins have certain morphometrical (area of cca 250 km²) and morphographical similarities, and the results on soil erosion are known (Alexandru et al., 2012). The Hârtibaciu and the Olteț basins, having areas above 1 000 and 2 400 km² respectively, are situated in different geological and physical-geographical conditions, which also reflect onto the erosion values. As a result of the analysis, the estimated mean soil loss has values of 0.6 t.ha⁻¹.year⁻¹ for the Săsăuș and Mislea Basins, 1.5–2 t.ha⁻¹.year⁻¹ for the Hârtibaciu Basin and 2.3 t.ha⁻¹.year⁻¹ for areas within the Olteț Basin, values which indicate a rather reduced soil erosion hazard, confirming the field reality. Nevertheless, in all drainage basins there are areas of variable sizes which present high or very high erosion hazard, conditioned by soil erodibility and the lack of vegetation. The comparative study on drainage basins gives special emphasis to the causes which imprint different features onto the land susceptibility to physical erosion and as well as onto the rainfall aggressiveness.

Key words: physical soil erosion, drainage basins, GIS technology, hilly regions, the Carpathians, Romania

MORPHOMETRY AND AEOLIAN ACTIVITY OF THE SAND DUNE AREA IN INNER SOMOGY, HUNGARY

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Inner Somogy, in SW Hungary, is covered by 2–30 m thick aeolian sand deposits. A complex system of parabolic dunes and elongated ridges was formed by northerly winds during the Pleistocene. According to earlier researches (Marosi 1970, Lóki 1981), the aeolian activity terminated in the Late Pleistocene and since the surface of the dunes was stabilized by vegetation. The aim of the research was to characterise the aeolian forms of Eastern Inner Somogy and to study the spatial distribution of the different classes. By applying OSL dating, the development history of the region could be reconstructed.

A total of 4 837 dunes and 1 685 negative forms were identified on 1:10 000-scale topographic maps. Based on their morphometric parameters, a database was built using ESRI ArcGIS 10. As a first step, the positive forms were classified based on their curvature, separating the groups of elongated-straight ridges and crescent forms. This last group was further divided based on their arc length: hummocks, small, medium, and large-size parabolic dunes. These groups were further divided considering the amount of sand supply during their formation (as filled, partially filled an unfilled). The negative forms were classified based on their area, relative depth, roundness and position. The groups of blowout holes, longitudinal blowouts (troughs) and deflational pans were created.

Altogether, 16 OSL samples were collected from the different classes of positive forms. The largest parabolic dunes developed in the Older Dryas (15 – 17 ka ago), and the medium-sized dunes developed in the Younger Dryas (12 – 14 ago). The smallest forms date back to the Boreal Phase (8 ka) and historical times (0.2 – 0.3 ka).

Key words: dune morphometry, OSL dating, aeolian research, Somogy

FLASH FLOODS RISK MANAGEMENT IN ALGERIA: LESSONS LEARNED FROM RECENT EVENTS IN BISKRA REGION

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Biskra is one of the Algerian regions most affected by flash floods. With an arid climate this region has experienced several violent flash floods. The most damaging were the events occurred in April 1949 (26 dead, 44 injured and 2 missing), November 1971 (3 dead, 14 injured), and April 2004 (3 dead, 9 injured). Aside from the human losses these floods also had considerable economic damages.

The low hazard frequency is contributing to a low perception of the flash flood risk by citizens and public authorities. However, population growth, shifts in land use (e.g. expansion of agricultural lands, buildings construction, development of structures) and changes in the riverbed morphology are increasing the vulnerability to flash floods which can have catastrophic consequences if an extreme event occurs in the future.

The research developed allowed (i) the design of systematic procedures to record flash flood events with different magnitude is a GIS data base that will support landscape planning and risk management; (ii) highlighting the factors governing the appearance and characteristics of this type of hazard (iii) establishment of a flash flood hazard map and a management plan; (iv) identify the importance of vulnerability assessment to reduce the risk.

The results of the research are fundamental to inform Algerian institutions on disaster risk reduction.

Key words: arid regions, flash flood, natural hazards, risk management, vulnerability, Algeria

LATE GLACIAL AND HOLOCENE FLOODPLAIN DEVELOPMENT ALONG THE LOWER SECTION OF THE TISZA RIVER, HUNGARY

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Abandoned channels are the key-forms in reconstruction of the fluvial paleo-environment, as the size of the channel and the grain-size of the sediment refer to the paleo-hydrological conditions, and by dating their sediments the age of fluvial activity could be determined. Along the lower section of the Tisza River the cyclic paleo-discharge changes and tectonic activity resulted in periods of incision and deposition, leading to the development of floodplain levels on different elevations. Between the two most marked floodplain levels there is 4-5 m height difference with a sharp and easily recognizable rim. The size of the paleo-meanders and point-bars in the two levels are very different. The aim of the research is to give a geomorphological description of the two floodplain levels and to determine the OSL age of the fluvial forms, thus to define the time and conditions of the incision.

The alluvial forms of the floodplains were identified using satellite images and a detailed digital elevation model. The morphometry of the meanders were determined under ArcGIS 9.0 software. The paleo-discharge calculations were made applying the equations of Timár and Gábris (2008) and Sümeghy and Kiss (2011). From the point-bar systems of paleo-channels OSL samples (14) were collected, from the sandy material of the oldest and youngest point-bars.

On the higher floodplain sections remnants of huge meanders were identified. Their average channel width is 0.6–1.0 km, thus the bankfull discharge of these large paleo-meanders ($6\text{--}8\ 000\ \text{m}^3\cdot\text{s}^{-1}$) was almost ten times greater than the same discharge value of the recent Tisza River ($800\ \text{m}^3\cdot\text{s}^{-1}$). The preliminary OSL ages reflect that this upper floodplain was active 12–14 ka ago. The lower floodplain could be divided into three zones based on its fluvial forms. Large paleo-channels remained just on the northern and on the southern parts, but in between the intensive overbank accumulation probably buried these forms. On the low floodplain the channels have different size and their age also differs. The large meanders ($W = 0.6\text{--}1.0\ \text{km}$) were active ca. 9–14 ka ago, whilst the smaller ones ($W = 0.3\text{--}0.7\ \text{km}$) are 4–9 ka old. Thus the paleo-discharge probably varied within large range ($500\text{--}8\ 000\ \text{m}^3\cdot\text{s}^{-1}$) during the evolution of the low floodplain.

The data suggests that the incision which created the lower floodplain level happened at the end of the Late Glacial and early Holocene (10–12 ka). The discharge reduction refers to the role of climatic change in the process of incision, however tectonic activity had also played important role, as it is reflected by the geomorphological units of the lower floodplain.

Key words: fluvial activity, OSL dating, incision, the Tisza River

GIS ANALYSIS OF THE HRON RIVER TERRACES WITH REGARD TO THE ŽIARSKA KOTLINA BASIN

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River terraces are typically Quaternary phenomena along most of Slovakian major rivers. In this paper we deal with the river terraces of the Hron River using the database from geological maps 1:50 000 and the base topographic maps 1:10 000. The database from Hron source to Tlmače was made in GIS environment and the altitudes of particular terraces were added into the attribute tables. The longitudinal profiles of the Hron River terrace levels were constructed. The special attention is given to the Žiarska kotlina Basin where the river terraces are well preserved especially on right bank of the Hron River. The database of Quaternary thickness in the Žiarska kotlina Basin was created using the data from more than 270 boreholes. The interpolations in GIS environment were used to estimate the spatial changes of Quaternary thickness within the Žiarska kotlina Basin. The position and relative altitudes of terraces were compared with the role of tectonics, which can be notable also in occurrence of landslides and gullies.

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Key words: river terraces, GIS, the Hron River, tectonics, Quaternary

MORPHODYNAMIC ASPECTS OF THE HIGH TATRAS' ALPINE LAKES CLASSIFICATION

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The submitted contribution contains the concept of alpine lakes classification based on morphodynamic manifestations of siltation and deposition of the High Tatras alpine lakes. The current database consists of 85 alpine lakes, while each lake is assigned a hydrographic, morphometric, morphodynamic and landscape-ecological variable. Attributes of variables are represented by 20 data, representing the basis for establishment of the classification algorithms with the intention of knowing interactions between the potential material accretion of individual morphodynamic processes and selected environment variables. Potential infilling and siltation was established as a sum of partial potentials values, numerically expressed on a basis of empirical knowledge and observation of occurrence and dynamics of individual processes. The most important sources of sedimentation material are delta region proluvial accumulation of inflows, fluvial-proluvial accumulation of permanent or occasional streams and material of scree currents. The common factor of these processes is the amount of rainfall water in drainage basins of individual alpine lakes during the year. The results of discriminant analysis showed that the intensity of potential infilling and siltation of alpine lakes closely corresponds with the altitude and tarn depth. The second discriminant function is weighted by the altitude, but also by the relative elevation of drainage basin and alpine lakes depths.

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Key words: alpine lakes, morphodynamic processes, discriminant analysis, the High Tatra Mts.

GEOMORPHOLOGICAL CHARACTERISTIC AND SIGNIFICANCE OF DRY CONSTRUCTED TERRACE STONE WALLS ON ABANDONED VINE -PLANTATIONS IN THE TOKAJ BIG-HILL

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In this study the southern side of the Tokaj Big-Hill was surveyed where one of the largest continuous terraced hillsides of Hungary could be found.

To describe temporal changes of cultivated vineyards and cartographic analysis of geomorphological conditions inside of the terraced slopes historical maps, aerial photos (from 1957, 1981 and 2000) and GIS software as Quantum GIS 1.7, Arcview 3.2, and Erdas Imagine 8.5 were used. On base of aerial photographs and field surveys terraced surfaces in extension of 1.16 km² and retaining walls, stone-heaps marking field boundaries ("obalas") and roads in total length of 90.9 km could be identified, which means a density of human constructed, stone built landscape elements 779 m/ha. Largest part of total surveyed terraced surfaces and highest density of dry stone walls were found on surfaces with 25 – 35 % and 35 – 45 % slope grades. Examining the distribution of terraced areas by surface elevation showed that most of terraces (45.5 %) were constructed in elevation between 200 and 250 m a. s. l. but also significant part of them (31.6 %) were built in height between 150 and 200 m, and (26.6 %) between 250 and 300 m a. s. l. The time of abandonment could be also established by the application of historic land use databases: most of terraced vineyards (55.5 %) were abandoned between 1940 and 1960, which is the time of plantations reconstruction after the devastations of phylloxera disaster, and at the time of the introduction of industrialized cultivation of vineyards. The average height and width of the retaining walls are 1.29 m and 0.74 m. In a total length of 3 143 m retaining walls were measured in the field and sectioned as intact, partially fallen, and totally (until their bottom) fallen sections. We found that 2 219 m (70.61 %) of the walls was intact, 661 m (21.05 %) was partial fallen down and 262 m (8.34 %) totally (until their bottom) fallen down. In average the ratio of totally or partially fallen sections could be determined in 29.39 m/100 m.

Since terraces are abandoned and walls disrepair the dry constructed stone walls falling apart, they cannot fill up their soil retention function which could cause significant sediment and nutrient accumulation on lower lying areas.

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Key words: terraced slopes, dry constructed stone walls, slope processes, vineyard abandonment, Tokaj

RECONSIDERING RAINFALL THRESHOLDS FOR LANDSLIDE OCCURRENCE EVENTS UNDER SCARCE DATA CONSTRAINTS. EXAMPLES FROM A HILLY AREA IN SOUTH-WESTERN ROMANIA

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Rainfall thresholds for the initiation of landslides have been at the core of investigations both worldwide and for regions in Central and Southern Europe. Most commonly used are the empirically-derived thresholds taking into account different combinations of precipitation measurements.

A great challenge is posed by trying to relate landslide events to the triggering factor represented by rainfall in areas characterised by scarce data. This paper addresses the issues of establishing relationships between landslide events and rainfall in a scarce data region of Romania. The highest certainty expressed by the available data can be narrowed down only to a monthly temporal resolution. Since the knowledge is being constrained, at present, by data availability and precision, the instruments used worldwide for identifying rainfall thresholds at a finer scale (i.e. daily, hourly) had to be adapted, in this study, to the coarser monthly scale. Intensity – duration and other frequently used types of threshold-charts were adapted in order to plot the landslide events as function of monthly variables.

At this relatively coarse scale, monthly landslides events can be interpreted as multiple occurrence events. The paper argues that in case of such multiple events, the analysis should be conducted by differentiating among groups of maximum homogeneity, whereas one of the means to separate such groups should be *magnitude*. In expressing the magnitude of landslide clusters, some particular descriptors are recommended (Crozier and Glade 1999; JTC-1, 2008). In this way, different thresholds, based on which occurrence probabilities could be calculated, can be established for each of the different categories of magnitude of the multiple landslide events.

Landslide information – stored in a database – was obtained from local official documents and local newspaper reports. Rainfall data was preprocessed to account for spring snow melting and losses through evapotranspiration (effective precipitation).

Such studies undertaken at a coarser time scale could constitute a first step in acquiring knowledge on the relation between landslide and rainfall and could later on help in better understanding the scale dependency of the phenomenon - by comparing responses obtained at different time scales.

Key words: multiple occurrence landslide events, magnitude, effective precipitation, rainfall thresholds, temporal scale, scarce data region, South-Western Romania

RECONSTRUCTION OF PALAEO-HYDROLOGY AND FLUVIAL ARCHITECTURE AT THE OROSHÁZA PALAEO-CHANNEL OF THE MAROS RIVER, HUNGARY

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Several studies have addressed the impact of climate change and tectonic activity on fluvial systems. When investigating these systems palaeo-hydrological and geomorphological data on abandoned channels can yield valuable results. The main aim of our work was to reconstruct morphological conditions at the Orosháza palaeo-channel and to estimate the bankfull discharge which characterized the channel during its formation. There are several equations predicting bankfull discharge on the basis of planform parameters, but these only work for meandering rivers. In case of braided channels flow reconstruction can only be made by using cross-sectional parameters. The Orosháza palaeo-channel provided the means of a comparative analysis in this respect. By a sudden pattern change both meandering and braided reaches, supposedly having a very similar bankfull discharge, around $2\,400\text{ m}^3\cdot\text{s}^{-1}$, could be simultaneously studied. Planform parameters and present cross-sections were determined on the basis of a high resolution DEM, while original cross-section parameters were assessed using sedimentological and geophysical methods. Based on sedimentological data, channel pattern transition was mainly driven by intensive bedload accumulation at the edge of the Maros River Alluvial Fan (MAF). The subsequent sediment extent varies from 0.5 m to on some part of paleo-channel till 1.6 m. Slope differences could not be evened out due to an avulsion close to the apex of the fan. Concerning discharge calculations a good agreement was found between a region-specific planform based equation and the cross-section based Grauckler-Manning equation. Values determined for the braided and meandering reach were also in a good correspondence. Consequently, the presented approach is suitable to determine the discharge of other braided palaeo-channels on the MAF and elsewhere.

Key words: morphological reconstruction, hydrological reconstruction, sedimentology, geophysics, discharge equations

ASSESSING CHANGES IN DYNAMICS OF CARPATHIAN RIVERS USING SPECTRAL ANALYSIS

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Spectral analysis is a standard technique developed for revealing potential, hidden periodic components in processes represented by time series data. The goal is achieved by subdividing the variability of a time series into components having different frequencies. In that context, the periodic component is considered as a deterministic part, and if revealed in hydrologic data, should be related to natural cycle.

The difficulty in successful usage of spectral methods in geophysics arises from many factors. High quality and sufficient data is often mentioned in the first place. Low accuracy of data caused by observational and dynamical noise – inevitable in environmental series – may effectively obliterate the dynamics of the investigated processes. On the contrary, the impact of averaging and aggregating on deterministic information contained in geophysical data is rarely noticed. It can be shown that such procedures cause the loss of determinism in the examined series. Hence, for spectral analysis daily data is preferable to monthly, or yearly basis.

In the paper, by means of Fast Fourier Transform (FFT), the spectral analysis of daily discharge from the Raba River and a few its tributaries was conducted, in order to compare and evaluate changes in dynamics of the Carpathian rivers caused by diverse natural and human impacts in the last forty years of 20th century. Thus, the research is focussed not on revealing and validating hidden periodic components in river discharges, but on benefits from observing variability of the flow dynamics in frequency domain instead of time domain in various periods of 1961–2000.

Before running an analysis, all the data was standardized to zero mean and unit variance, in order to obtain comparison of the results. It turned out that one year periodic component, which signifies regular dynamics – dominates in the whole forty year period in three investigated sites of Raba River, and in the majority of examined shorter periods (5 or 10 years) within the 1961–2000 years in other locations of the Raba Basin. On the contrary, in one (1971–1980) out of four decades, this 1-year periodic component is neglected, which may indicate different climatic impact in that decade. It can be also observed that in some sites (small mountain tributaries) this component is rarely present and there is no other dominant periodicity – which indicates irregular dynamics. Although the Raba Basin is medium-sized, about 1.5 thousand km², the differences in topography, shape of sub-catchments, soil type, the land cover and use are significant across the basin. The explanation what causes the disappearance of one-year component in a specific location is still an open question. It can be attributed to natural physical conditions in a particular area, undertaken human interventions or climatic impacts and requires further explanations.

Independently, if one presumes that a strong periodic component in flows means more natural dynamics of the river as a common view, the conducted analysis may facilitate the determination of reference conditions for a particular river.

Key words: river dynamics, periodic component, determinism, the Raba River Basin, the Carpathians, Poland

TRANSPORT OF SUSPENDED SEDIMENT IN THE BYSTRZANKA STREAM CATCHMENT (POLISH FLYSCH CARPATHIANS) UNDER CONTINUALLY CHANGING ANTHROPO-PRESSURE

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Fluvial transport reflects processes that take place in the natural environment of a catchment. The transport of suspended sediment is the predominant form of fluvial transport in many mountain areas. In the majority of streams and rivers, the transport of suspended sediment throughout the year is very uneven and is limited to the periods of floods. Researching the changeability of the transport of suspended sediment is difficult due to the complexity of the process. The process is influenced by climate conditions, geological structure, terrain relief, slope, shape and surface of a catchment, vegetation coverage, ground humidity, and the density and arrangement of the networks of valleys and roads. Human activity disturbs the natural conditions of material delivery.

The main purpose of the study was to determine regularities in suspended sediment, as well as temporal and spatial variability of suspended sediment transport in the small flysch catchment of the Bystrzanka Stream (13 km²) under changing anthropopressure in the period 1970–2011. The study area is located within two geomorphological units of the Carpathians (the Low Beskids and the Carpathian Foothills). Over the last 40 years, many changes have been observed in the Bystrzanka Stream catchment in terms of land use, i.e., a decrease in arable land area and an increase in grasslands area. The appearance of meadow vegetation on arable lands limited the surface runoff and slopewash. As a result, the amount of fine-grained material that reached the valley bottom from slopes used for agriculture was limited. This does not mean, however, that the amount of suspended sediment transported in the stream has to be less. The increased population in the studied area simultaneously led to a greater density of roads, which are a significant source of suspended sediment transported in the stream.

The study of suspended sediment conducted over 40 years showed that the fine-grained material transported in the stream is derived mainly from the channel, landslides, roads, and areas of engineering works. The Beskid tributaries play a significant role in the delivery of suspended sediment as well.

The study showed that the decrease of arable land area in the period 1970–2011 did not explicitly cause the decrease of amount of suspended sediment transported in the Bystrzanka Stream. The relation between the total area of arable land and the transport of suspended sediment is disturbed by human activity related with engineering work in the stream channel, in the valley bottom and on the slopes and with increased density of roads. They mask the natural morphogenetic processes and slow land use changes.

Key words: suspended sediment, land use changes, anthropopressure, the Bystrzanka Stream catchment, Flysch Carpathians

THE DYNAMIC OF THE CONCENTRATION AND TRANSPORT OF SUSPENDED AND DISSOLVED MATERIAL IN THE BYSTRZANKA STREAM DURING DIFFERENT TYPES OF FLOODS

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The transport of suspended material in stream is short-lived and limited to the period during high discharge. Suspended sediment shows a positive correlation with flow rate. The transport of dissolved material is continuous, but its dependence on the discharge is negative.

The aim of the analysis is compare two types of fluvial transport in a small Bystrzanka Stream flysch catchment (13 km²), during different floods caused by: snowmelt, downpour, continuous rainfall and mixed genesis. The Bystrzanka Stream catchment represents features of beskid and foothill landscape. Beskid part (altitude 550 – 753 m a. s. l.) is largely covered by mixed forest (the dominance of fir and beech), foothill part (altitude 450 – 550 m a. s. l.) is used for agriculture, where dominated small plots (less than 1 ha) cultivated as a meadow. In the last 40 years in the Bystrzanka Stream catchment area were observed fundamental changes in the land use structure, consisting of the three-fold decreasing of arable land area to grassland area increasing.

The detailed analysis related to changes in the concentrations of suspended and solid material and especially selected ion: HCO₃⁻ and Ca²⁺ (autochthonic ions in the soil and geological substrate), Cl⁻ (concentration dependent on the input of pollutants) and electric conductivity (SEC) as a good indicator of the total mineralization. Calculated loads carried out during selected floods and compared with the annual values. The intensity of geomorphological processes results from the background intensity outflow from the catchment, rainfall intensity or intensity of disappearance of snow cover. The results of analysis from the last few years (since 2000) compared with the results published in the research article of A. Welc (1973, 1979, 1985, and 1988).

Key words: fluvial transport, suspended material, dissolved material, Polish Flysch Carpathians, the Bystrzanka Stream catchment

MICRO-FORMS CREATED BY LOWLAND AGRICULTURE AND THEIR EFFECT ON OVERLAND FLOW

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Ridges and furrows are the most common forms created by ploughing on low relief plains, which develop parallel to the main direction of tillage. On these areas artificial canals are also common, as they support the irrigation or drainage of the fields. The spoiled material of the canals is usually deposited along them, creating relatively high canal berms.

These micro-forms influence the surface run-off conditions of a plot, as they act as overland flow paths or barriers depending on their orientation, resulting in the development of excess water. The goals of the present research are to evaluate the spatial distribution and morphology of forms created by tillage and canal maintenance, and to study their effect from the point-of-view of blocked drainage and excess water build-up. For the evaluation detailed LiDAR DEM was applied.

The ridges on the studied plough-fields were formed since the land privatisation (ca. 20 years) and their height is already 0.19-0.26 m. The ridges block the overland flow and facilitate the development of excess water on 14 % of the study area. Along 85 % of the canals canal berms appear. Their average height is 0.38 m (max: 1.4 m) and width is 17 m (max: 60 m). Considering the height of the canal berms, they have considerable effect on overland flow, especially due to the low relief of the area.

The data suggests that (dis)connectivity could develop within an agricultural plot as the higher parts of the plot could be disconnected from the lower parts by ridges, and the canal berms disconnect the plot and the artificial drainage system. Regarding overland flow, ridges and berms disconnect the plots from their drainage canals (buffer function), and in the natural drainage routes they act as barriers. The disconnectivity function of the studied forms increases over time and as a result of intensive tillage. Therefore, they will play a more and more important role in altering overland flow and developing excess water hazard.

Key words: tillage, ridge and furrow pattern, buffer, barrier, canal berm

IMPORTANCE OF SPLASH IN SOIL EROSION IN THE BYSTRZANKA STREAM CATCHMENT (POLISH FLYSCH CARPATHIANS)

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The denudation system in Flysch Carpathians is determined by i.a. processes of splash and sloopewash. The study was conducted in the Bystrzanka Stream catchment (13 km²), located on boundary of two geomorphologic units (the Carpathians Foothills and the Beskid Niski Mountains). Research of surface run-off and soil erosion has been started at the beginning of '70s. Intensity of processes of modelling slope was conducted on the experimental plots of different land use. Processes of surface run-off and soil erosion are depended on weather conditions, vegetation, soil structure or ground state.

The main purpose of research conducted in 2012 was to investigate the splash during selected rainfalls in the summer hydrological half-year. The results were related to surface run-off and erosion on the slope. Measurements was conducted on the experimental slope used as bare fallow and meadows (slope 11°, SW exposition), and on flat area with bare fallow. The material was collected by cups with diameter of 75 and 110 mm. In addition, the vertical board has been used to measure the height of splash.

It was found the correlation between the intensity of precipitation and splash. There was also a significant impact of slope on the splash. Splash on bare fallow is much higher than in the meadow. Applied methodology of the study allowed the determination the maximum range of soil material from the splash in present environmental conditions, depending on the type of precipitation.

Key words: splash, soil erosion, Carpathian Flysch, the Bystrzanka Stream Catchment, experimental plots.

LATE PLEISTOCENE DEGLACIATION OF THE ŽIARSKA DOLINA VALLEY, WESTERN TATRA MOUNTAINS, SLOVAKIA

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Results of detailed geomorphological mapping combined with air photographs analysis, and Schmidt-hammer rebound values, were used to estimate mutual position and relative ages of moraines and rock glaciers in the Žiarska dolina Valley, the Western Tatra Mountains, Slovakia. Four separate morphosystems are present at different positions in the Žiarska dolina Valley starting from the valley outlet to the highest cirques, which represent successive phases of deglaciation. A steady increasing tendency in Schmidt-hammer *R*-values can be observed for measurement sites found along the valley axis. The lowest geomorphological position and the lowest overall *R*-values (40 – 41) were noted for the Last Glacial Maximum (LGM) moraines, deposited in the lower part of the valley. Mean *R*-values obtained for successive Late Glacial re-advance moraines and relict rock glaciers (LG-1, LG-2, LG-3) (45.5, 52 – 56 and 62, respectively) show a distinct increase in the up-valley direction. Geomorphological relations combined with results of the Schmidt-hammer rebound values point to three episodes of rock glaciers formation in the Žiarska dolina Valley. Two older episodes were attributed to the LG-2 stade, in turn the last activity of the Tatra's rock glaciers was connected with a pronounce cooling during the LG-3 stade. The oldest rock glacier system has evolved beneath small cirque glaciers (ice-cored rock glaciers), and advanced beyond the limits of glaciers position, and override their terminal moraines. In contrast, the youngest rock glacier system represent talus-derived rock glaciers and protalus lobes, which preserved only in the highest part of the Velké Závraty cirque.

Key words: Late Pleistocene, deglaciation, Schmidt-hammer test, the Western Tatra Mountains

RENEWING KARST SPRINGS AFTER SUBSURFACE MINING

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Our research area is located on the western part of the Transdanubian Midmountains. The mid-mountain range was built up by Mesozoic calcareous sediments that related karst water system was developed during the past.

After the early years of opencast coal and bauxite mining, underground mines were opened to reach the subsurface coal layers from 1950s. The karst water level effected and hazarded the underground mining activity, therefore karst water was pumped out to sink water level below the coal and bauxite layers. In spite of local pumping effects were regional. The yield of the karst water was up to 300 m³ per minutes. The average original karst water level reached to 178 m a. s. l. before the mining started. And it was only around 50 – 60 m a. s. l. in early 1990, when most of the mines were closed. Some of the karst springs (e.g. Fényes Springs at Tata) and lakes (e.g. in cave of Tapolca) dried up or their discharge decreased (e.g. Lake Hévíz, hot springs at Budapest). After the mines closed the karst water level has been raising. Consequently inactive karst springs started to work and settlements, infrastructure and edifices are hazarded nowadays.

Our aim was to identify the origin of spring waters were found on the research area in 2010 and clear their connection to the karst water level.

DGPS supported geomorphic mapping methods were used to determine exact altitudinal position of springs. We measured chemical components of spring waters were measured to prove their karstic origin. The vertical position of springs was compared to the original karst water level using Grass GIS.

Karst water samples contain 345.5 – 394 mg of HCO₃⁻, 99.5 – 146.7 mg of Ca²⁺, 33.6–41.4 mg of Mg²⁺ per litre that fits to the average mineral content of karst water springs in the study area.

A red sludge disaster occurred on 4 October 2010, when a waste storage reservoir retaining wall collapsed. The caustic sludge flowed down through the valley of the Torna Stream and flooded three villages. This red sludge reservoir also lied with 15-20 metres below the original karst water level. According to the scientific report on the damaged reservoir, the extreme high ground water level was blamed for disaster. The karst water level seems to reach recent ground water aquifers on the bottom of the valleys around Ajka.

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Key words: karst water and spring, subsurface mining, Transdanubia, Hungary

ANTHROPO-MORPHOLOGICAL IMPACTS ON SURFACE DEVELOPMENT IN A FOOTHILL REGION OF THE MECSEK MTS.

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The geomorphic and morphometric studies play a significant role in the research of landscape forming effects of Mankind, and their relation to the recent development of relief. The prime goal of this study is to investigate the extent of the modification effect of the anthropogenic factor on the evolution of a sample terrain.

On the study area, a catchment of the south foothill of the Mecsek Mts. observed a special morphological situation, where a supposed capture was proved using geoinformatic methods. It developed during the subsidence of the Pécs Basin and the evolutionary history of pull-apart basins linked to strike-slip faults of the Mecsekalja Dislocation Zone. Anthropogenic activities have had a significant impact to the recent image of the capture. Furthermore, it is also interesting to observe that during the historical time the land use matched to the comparative advantages related to the morphological conditions.

Former studies analysed neotectonic impacts on this area, but the anthropo-morphological elements have not been related to the recent geomorphic processes, or to neotectonics. Classical geomorphic and morphometric analysis were used to study and prove anthropogenic impacts, such as field trips, morphological sketches, analysis of drop curvature. Archival sources were also studied to filter anthropogenic effects and mapping them.

During the research the relation between recent surface development and human activity was proved together its relevance and actuality. This knowledge can contribute to prepare projects for extended area, assessing problems, risks and hazards for preventing disasters.

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Key words: capture, anthropogenic geomorphology, drop curvature, the Mecsek Mountains, foothill region

DELTA FORMATION IN DAM-RETAINED LAKES ON MOUNTAINOUS RIVERS, THE VISTULA RIVER BASIN, POLAND

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The largest morphological impact of a valley dam is observed along the upper backwater reach just below the river mouth, where the current, drained of its carrying energy, deposits vast quantities of material. Deltas forming in this part of artificial lakes are classified as hyperpicinal because the flood flow density of the river is almost always greater than in the lake. The fluvial material therefore drops near the bottom of the lake and forms a density current. Delta growth rates in dam-retained lakes depend as much on the volume and granularity of the supplied sediment material, as on the lake's capacity to permanently retain the sediment. The shape of deltas in these water bodies is influenced by the valley floor morphology and also by relationships between seasonal fluctuations in the lake's water level and the annual river water and suspended and bedload supply pattern.

The study aims to explain the conditions of delta development in large dam-retained lakes in the Carpathian part of the River Vistula Basin in southern Poland. Particular attention was paid to the possibility of delta development under the influence of mutual interaction between the seasonal cyclicity of the water level fluctuation in the lake and the seasonal differences in the water and material supply from the river.

The fastest growing deltas form in a long and deep valley lakes featuring a slow water exchange cycle and large amounts of material, mainly suspended. Nearly all of the deltas considered in this study are of the low-energy type, as they mainly consist of sandy and dusty material. There is a difference between deltas forming in lakes with high water level fluctuations and in lakes with a more stable water level with the former forming a longer, smoother longitudinal profile without a discrete boundary between the topset, foreset and the bottomset. Such a fuzzy boundary is caused by a cyclical shifting movement of the zone with the most intensive processes of alternating deposition and erosion which occurs at the boundary of the permanently submerged and periodically exposed part of the delta.

Deltas in dam-retained lakes located in mountains should be regarded as unique forms because of their size, growth rate and certain morphological properties. Delta growth rates follow the patterns of silting up of lakes. The quantities of deposition in deep lakes diminish with time and reflect the reduction of the volume of material retained within the delta. Assuming a theoretical useful life of dams in the studied deep lakes at between hundreds and thousands of years the lakes should be almost entirely filled with deposits, mostly delta deposits up to the actual dam at the end of that period. Deltas in dam-retained lakes with high water level fluctuations, regardless of their growth rates, differ from deltas in water bodies with a stable water level. The seasonal amplitude of water level fluctuations, sometimes exceeding ten meters and the mismatch of this parameter with the variation in the water and material discharge by the river make the longitudinal profile of the deltas in dam-retained lakes more elongated and evened-out than that of deltas in natural water bodies.

Key words: dam-retained lake, delta development, delta deposits, the Upper Vistula Basin, the Carpathian Mountains

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

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

Key words: landslide slopes, colluvium, subsurface water circulation, springs, chemical denudation, the Babia Góra massif, the Western Carpathian Mountains

USE OF PIEDMONT SECTION OF THE VISTULA RIVER IN SOUTHERN POLAND TO EXAMINE THE EFFECT OF RIVER CHANNELIZATION ON FLOOD RISK

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The paper presents various problems concerning the flood risk along the piedmont section of the Vistula River, Southern Poland, channelized since the middle of the 19th century. It is part of the mainstream discussion of the effectiveness of existing river channelization methods. The following problems are analysed: (1) current state of flood risk, (2) the rate of river flow, and (3) changes in flood risk since the start of channelization efforts with respect to changing channel geometry and changing rates of river flow reflecting the effects of channelization work. Substantially increased discharge in a channelized river may be considered as a stable feature. This means that the river is effectively reducing the quantity of water available for flooding the inter-levee zone. This statement is the basis for analysis of changes in flood risk in the river studied. An assessment of changes in flood risk for the piedmont section of the Vistula River cannot be categorical. Some changes in discharge help reduce flood risk, while others increase it. This paper is mainly based on a large-scale maps, State Hydrological Survey data and fieldwork conducted by the authors.

Key words: river channelization, inter-levee zone, flood risk, piedmont section of the Vistula River, southern Poland

THE RABA RIVER – THE RIVERBED EVOLUTION IN THE PAST AND NEW PERSPECTIVES

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The morphology of the Carpathian river channels have changed over the last few decades. The channel pattern has changed from braided to sinuous and rivers have tended towards incision. River training is the main reason for these channel transformations.

The research was conducted on the Raba River reach between Lubień and Myślenice (Polish Flysh Carpathian Mts.). This river reach was channelized, straightened, shortened and narrowed. Especially huge modifications relate to reconstruction of Zakopianka road in the narrow valley bottom between Stróža and Myślenice in 2004. The river has incised by more than 0.5 m thereafter. Flood plains have been narrowed as well. Upstream from this reach, the project of restoration of the natural character of the Raba River has been implemented since 2010. The project involves a series of works including creation of a free migration corridor of the Raba River channel, reconstruction of the desired biological structure of floodplains and lowering the existing dams in two Raba's tributaries: the Krzczonówka River and the Trzebuńka River.

The purpose of this publication is to analyze and explain the Raba River channel changes caused by different engineering works. The authors attempt also to predict the changes in the Raba River channel morphology due to different river restoration works.

The results of simulation of riverbed evolution of the Raba River before and after river training carried out by 1D models RubarBE are analysed and discussed. Results of computation obtained by the model are verified by field observation carried out in 2001 before project execution, and in 2004, after the river training. The trends of erosion and deposition correspond to the field observation.

The topographic maps and aerial photos from various years were used to identify the general changes in the Raba channel morphology. The contemporary structure of the Raba River channel was studied in 2013 during river channel mapping project. A total of nine cross sections were surveyed in 2013: six in the Raba River reach between Stróža and Myślenice and three in the Trzebuńka stream downstream from the existing dam. These cross sections were compared with the cross sections surveyed in 1970, 2000, and 2004 in order to estimate the rate of channel incision. Material samples were collected at some cross sections and grain size distribution was than analysed. The cross sections and sediment samples will be monitored for potential changes caused by restoration work in future data collection trips.

Key words: river training, river restoration, channel system change, Polish Carpathian Mountains

RESPONSE OF A MOUNTAIN BEDROCK-ALLUVIAL RIVER IN FLYSH GEOLOGICAL SETTING TO CONTEMPORARY ENVIRONMENTAL CONDITIONS (CASE STUDY THE TOPLA RIVER, SLOVAKIA)

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The term “mountain river” is now frequently applied to any stream which has a gradient $> 0.002/m$ along the majority of its length (Wohl 2000). In addition to steep slopes, mountain streams are generally characterised by: high boundary roughness and resistance provided by coarse clasts and bedrock, high spatial and low temporal variability in bed surface morphology, and highly turbulent flow. Streams are generally sediment supply limited, but are often characterised by episodes of high sediment load. They contain a relatively high proportion of bedload which interacts with, and forms, the channel substrate. Lateral confinement in mountain rivers means that streams are highly connected to adjacent hillslopes and as such, are recipients of any hillslope generated material. Such lateral confinement also limits slope adjustment through lateral movement, and adjustments in vertical dimension can dominate (Chin, 2002). Relative bedrock incision based on differences in rock properties limits the rate of base level changes which in turn controls and segments longitudinal profiles (Sklar and Dietrich 2001).

The presented talk is focused on the geomorphic response of the 72.5 km long segment of the Topľa River (115 km in total length, 1506 km² of catchment area situated in the north-eastern Slovakia, average annual discharge 8.08 m³·s⁻¹ at mouth, Strahler ord. 4 – 7) as a less regulated and laterally unconfined/partly confined mixed bedrock-alluvial cobble/gravel-bed river with flysh geology to contemporary environmental conditions. A complex, hierarchical, spatial and synthetic approach is followed by application of the River Morphology Hierarchical classification, which was presented by Lehotský (2004). The geomorphic research of the Topľa River channel was based on the distribution of the channel planform, cross-section and longitudinal morphometric and hydraulic parameters, which were obtained from the analysis of the remote sensing imageries and from the field-measurements. These are complemented by the mapping of the bedforms, which are quasi homogenous in terms of processes (degradation, transfer, aggradation) and material (alluvial, bedrock, deluvial, anthropogenic). A special attention is dedicated to the assessment of step-pool morphology in the Topľa River headwater. The morphodynamical characteristics of the river channel are presented through the assessment of the erosion and accumulation flood effects. The assessment is based on the quantification of the extent of bank erosion and newly accumulated coarse-grained bars. These bars were also analysed by surface gravelometry. The input and in-channel connectivity of coarse-grained sediments from non-alluvial sources was evaluated in selected localities. Finally, the differentiation of the processes of erosion and accumulation processes and bedforms is interpreted by means of the sediment waves concept.

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SPELEOGENESIS OF CREVICE-TYPE CAVES (OUTER WESTERN CARPATHIANS)

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The occurrence and development of crevice-type caves is one of the most spectacular phenomena during the progression of slope failures. Crevices are common manifestations of disintegration of anisotropic flysch rocks in the area of Outer Western Carpathians. There were several caves investigated in Slovakia and Czech Republic between years 2010 and 2013 in order to survey their extent together with documentation of their morphological peculiarities, to determine types of mass movements responsible for their creation and to define the way of their speleogenesis. The crevice-type caves have been formed by various processes of gravitational slope movements: spreading, translational sliding, toppling, back rotation, horizontal rotation, sagging. The survey involved description of shapes of corridors, structural measuring, comparison of subsurface cavities with surface trenches and sinkholes using a DEM combined with cave maps and construction of typical cross-sections of cave corridors, using a data from the structural measuring. Surface topography above cave systems were measured by geodetic total station. For the determination of types of mass movements responsible for genesis of individual crevice-type caves was used method, which relies on the fact, that changes of dip and direction of discontinuities between in situ rock mass and gravitationally transported blocks reveal mechanisms of particular slope processes. By comparing the disturbed bedding planes of two opposite walls together with the crevice width measurement, the vertical and sagging-type of movements was also discovered. For additional information about the subsurface structures in the vicinity of cave systems were performed 2D and 3D electrical resistivity tomography measurements. According the results the predispositions, genesis, types of processes leading to the caves formation, succession phases and morphological types were revealed.

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Key words: crevice-type caves, slope deformations, Outer Western Carpathians, flysch

LANDFORMS, WATER AVAILABILITY AND LAND USE IN FLOODPLAINS

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Floodplains are generally regarded as flat surfaces of minimum geomorphological diversity, good water supply and flexible land use. The investigations in the floodplains of two rivers in Hungary (the medium-size Kapos River and the somewhat larger Dráva River), however, show that variations can be remarkable in all the three aspects. The abandoned (cutoff) channels of decomposed peat fill strongly diversify both topography and groundwater levels. After occasional flood waves drought can cause severe damage to agriculture. The present-day large-scale farming is not the optimal use of the majority of floodplains. The studies on floodplain morphometry, hydrogeomorphology, soils and groundwater conditions aim at designing optimal floodplain management, a compromise between the conflicting interests of land users. The findings of the research allow the delimitation of floodplain segments according to their rehabilitation potential (as complete restoration of natural conditions is not possible any more). River regulation resulted in a profound fragmentation of the landscape pattern, which could be remedied by the restoration of a riparian vegetation belt, able to function as an efficient buffer zone and ecological corridor. Soil mapping and landscape ecological analyses in the embayments of the Kapos River floodplain have revealed that a land use pattern better suited to soil distribution and the restoration of habitats could lead to a more compact patch configuration and a denser mesoregional ecological network.

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Key words: floodplains, oxbows, backswamps, peat bogs, groundwater, Histosols, agriculture, Hungary

ESTIMATING REGIONAL LANDSLIDE RISK IN THE BAIIA MARE DEPRESSION, NORTHWESTERN ROMANIA

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The need for a landslide risk map at the administrative level of the Maramureș County from Northwestern Romania has been expressed both by the Inspectorate of Emergency Situations and the regional and local administrations. As a starting point in answering this issue, the following study sets as its main goal the generation of a landslide risk map for the Baia Mare Depression, an area of 600 km² from the south of the Maramureș County. The landslide processes occurring in this territory are mainly associated with the sedimentary Pannonian lithologic unit and affect the stability of roads and human settlements, both urban and rural. Signs of landslide activity are visible in the landscape, but are often ignored or not recognized as a threat. This leads to costly stabilizing measures after damage occurrence, whereas the prediction and prevention measures are still in an initial stage. Therefore, the aim of our study is to identify the main areas with high landslide susceptibility and to estimate the risk being determined by these processes. We employ a qualitative landslide risk assessment based on the heuristic method described in the Romanian legislation in order to estimate the potential damage caused by landslides in the studied area, at regional scale. The results are validated using mapped landslides and the risk estimation is based on recent events from the Baia Mare Depression, where associated costs are known.

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Key words: landslide, risk assessment, regional scale, the Baia Mare Depression, Maramureș, Romania.

NATURAL RISKS GENERATED BY MASS MOVEMENT PROCESSES IN THE UPPER AND MIDDLE SECTORS OF THE STREI VALLEY

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With an area of over 1559 km² and a triangle shape, the upper and middle sectors of the valley Streiului stands out as a well-individualized natural entity, mostly with a basin aspect, included almost entirely within the area of the Southern Carpathians, except the north-western part that belongs to the Western Carpathians. In the south-east, south and north-west is surrounded by the subdivisions of the Retezat - Godeanu Mountains Group (Retezat Mountains, Piule Iorgovanu Massif, Godeanu Mountains and Țarcu Mountains), in the north by the Poiana Rusca Mountains and in the north-east by the Sureanu Mountains. From the administrative point of view, within its boundaries there are included 10 communes, dominated by one town, Hateg.

In this study, we have analyzed the natural risks generated by the mass movement processes (landslides and river bank failure). The landslides have been identified at the level of the geomorphological units included in the study area, beginning with the second half of the 20th century, but a factor based analysis was performed only in the first part of the 21st century. In some cases, for some areas affected by such processes stabilization works were carried out between 1970-1990, but modifying the land use and thus destroying an equilibrium even so unstable, the works performed led to the expansion of the affected areas.

We identified over 200 areas with active, stabilized or reactivated landslides (Livadia, Baru commune; the right slope of the Streiului valley between Ponor and Pui, Fizesti, Sacel, Sampetru, Ciula Mica, Ciula Mare, Livezi, Boita, Tustea, Hateg, the right slope of Streiului valley at Baiesti etc.) Most of them occurred at the foot of the slopes the Hațegului Depression, due to the dominant lithology and favored by the landforms morphometry.

At present, the processes continue to extend and to take out from the agricultural circuit large areas. Consequently, we considered to make an objective landslides hazard assessment, following the steps from a legal framework, in order to use the results in territorial planning studies.

Special attention should be paid to bank erosion when it comes to rivers deepened in unconsolidated rocks with high banks (over 3 m) frequently affected by bank failure. This marks the lateral migration of some rivers at high discharges.

The analysis was performed at the level of the smallest administrative unit, as all necessary measures in case of emergency are taken here. What is more, necessary funds for risk management are managed at this level. At the end of the analysis, we obtained a wide range of risk values. In the case of the administrative units with piedmont relief, such as: Rachitova, General Berthelot, Banita, Pui, Baru etc. we identified areas with high risk. There is a single administrative unit with low risk, i.e. Totești, located in the flattest area of the Hațegului Depression.

Key words: natural risks, mass movement processes, landslides hazard assessment, factor based analysis, the Strei valley

MORPHODYNAMIC FEATURES OF ACTIVE SLOPES NEAR ĽUBIETOVÁ: A ROLE OF TECTONICS IN GRAVITY DEFORMATION PROCESSES

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Our contribution presents a complex study (temporal and spatial) of gravitational deformations in the Ľubietová territory. The hierarchical system approach is applied to investigate one of the most active subsystems in the context of the whole supersystem. In our case the basic system corresponds to a paradynamic gravity-fluvial system represented by the watershed of the Hutná Stream. Its most active subsystem is the system of gravitational deformations (including the largest landslide reactivation from 1977). The highest order “supersystem” refers to a neotectonic system of the territory.

Evidently, all dynamic processes have certain temporal and spatial scales. The neotectonic “supersystem” relates to processes considered in a time scale of several million years and studied within the spatial scale of 1:50 000. The gravity-fluvial system is studied in the scale of 1:10 000 in the range of 10^5 - 10^6 years. The most detailed temporal (few decades) and spatial (1:5 000) scales are used for the subsystem of active slope deformations at a selected slope. The vertical scale (in our case expressed in meters to kilometers) plays also an important role in study of geomorphological processes. All the spatial hierarchies are mutually related (not deterministically). Specifically, the processes of smaller extent can be characterised in the context of those occurring at larger scales.

The central topic of our contribution relates to the specific slope including the largest deep-seated landslide body (the Ľubietová landslide) in the area. As the most conspicuous and the most active element of the slope deformations subsystem, the Ľubietová landslide and neighbouring gravitational and neotectonic features were studied in detail by means of geodesy, remote sensing (including airborne laser scanning), geophysics (electrical resistivity tomography) and fieldworks (geological and geomorphological mapping). Specifically, a possible role of neotectonic processes in the evolution of gravity deformations in the area is considered.

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Key words: landslide, gravity-fluvial system, neotectonics, morphodynamics, spatio-temporal scale, Ľubietová

NEW INSIGHT INTO THE STRATIGRAPHY OF MORAINES IN THE STUDENÉ DOLINY VALLEYS, THE HIGH TATRAS, SLOVAKIA

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During several cold phases of the Quaternary, local mountain glaciation occurred in the High Tatras. The fossil existence of mountain glaciers is nowadays documented by presence of alpine type of relief with geomorphological evidence of glaciers. Based mainly on morphostratigraphy of moraines, three main glaciations using alpine nomenclature named as Mindel (corresponded with MIS 12), Riss (MIS 6 - 10) and Würm (MIS 5d - 2) have been recognized (e. g. Lukniš 1973, Klimaszewski 1988). The character of the older glaciations, in the area represented only by glacial-fluvial deposits, is more difficult to distinguish (see e. g. Lindner et al. 2003).

The aim of this paper is to determine the number of glaciers' oscillations based on relative dating of moraine remnants by the Schmidt Hammer (SH) test. SH measurements were undertaken in the valley system of the Veľká Studená dolina Valley and the Malá Studená dolina Valley where several moraine assemblages belonging to different stadials (marked as A-D, *sensu* Lukniš 1973) of the last glaciation and one remnant of moraine presumed to have origin in oldest glaciation (Mindelian) were recognized by Lukniš (1973).

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

Mean R-values of individual moraines range between 36.03 and 58.85. The lowest value was found on degraded surface of moraine at the joint mouth of both of the valleys, correlated by Lukniš (1973) with the oldest glaciation. Contrarily the highest value was found on boulder accumulation in cirque of the Malá Studená dolina Valley described by Lukniš (1973) as the ablation moraine of early Holocene origin. Significant differences (according to the ANOVA tests) were detected between particular types of moraine assemblages. However, SH test was unable mutually distinguish the moraines of older stadials (A, B, C, *sensu* Lukniš 1973) of the last glaciation which can be explained by decreasing resolution of the SH method with increasing age of the tested surface. On the other hand, results of this paper may point to inaccuracy in Lukniš's (1973) findings and propose new insight about the Pleistocene glaciations of the High Tatras.

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Key words: moraines, relative dating, stratigraphy, Schmidt hammer test, the High Tatras

GEOMORPHIC LIMITATIONS AND RAILWAY MAIN LINE IMPROVEMENT AND MANAGEMENT. A CASE STUDY ON THE ROMANIAN MAINLINE 100

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Since the EU admission of Romania (January 2007), railway improvement works intensified mainly along the IVth European Corridor relying Dresden with Constanta (to the Black Sea). Despite these projects, focused in mainlines 300 and 900, other main railways on the Romanian Railways Network faces a high degree of infrastructure and rail traffic degradation.

Our analysis focuses on a critical area along the mainline 100 (Bucharest – Timisoara), important for the regional, national and international traffic. The sector between Balota and Erghevița railway stations (6 km) is remarkable by the technical solution when it was built. A complicated railway track configuration with eight curvature sectors (radius between 170 – 250 m) was built on a level difference of about 150 m, with local gradients of 25 – 27 ‰. The single track mainline was electrified since 1971 and an intensive passenger and cargo traffic reached its apogee to the end of the 1980s and the beginning of 1990s (the second transcarpathian railroad related to the traffic volume).

The railway had permanent technical problems along the years like speed limitations (20 – 30 km.h⁻¹), frequent derailments in some critical points, but the latest event of a sudden landslide (21.02.2010, early morning) cut the lines and the overhead together with the traffic for 3 – 4 months. The latest engineering works along this sector were built during the 1970s after the electrification while an efficient management of these developments dates since the end of 1980s.

The paper focuses on the specific conditions of the mainline sector from two perspectives: a detailed geomorphic mapping and a statistical approach.

The first issue is based on the geomorphotechnical mapping of the study area (Dobre et al. 2011), which provides in a specific formula, at a high scale of 1:5 000, the key morphodynamic features together with the slope engineering works and the transport infrastructures. On a background of an orthophoto seven active and dormant landslides were mapped along the railway track, and critical points for special engineering works were identified. Mapping was done in a multitemporal system, providing the landslide bodies' configuration in two moments (1997 and 2005). The map offer a synthetic view over the technical solutions provided by geotechnical engineers within the study area, together with the critical points (derailment points, landslide scarps, humid areas and intensive upstream erosion areas) and the technical railway infrastructure features (signals, speed limits, gradient marks, supplementary rail track sectors etc.).

Another approach is the statistical one. Based on multiple regression analysis the paper tries to find the correlation between morphodynamic features (process spatial occurrence and magnitude), engineering works (spatial relationship with railway infrastructure) and traffic features (degradation or improvement of specific traffic parameters like speed, load, train types, size and destination). The interpretation and the validation of the resulting graphs (linear, polynomial and exponential regression) made us to conclude about the efficiency of the existing railway infrastructure and engineering works within a high susceptibility sector for slope processes and mainly to landslides. The data was spatially interpolated on a map and compared with the landslide susceptibility map, which was based on a probabilistic/deterministic approach because of the less complete spatial data (Mihai et al. 2010).

Key words: geomorphic limitations, railway management, Balota, geomorphotechnical mapping

THE AGE AND EVOLUTION OF THE KARST RELIEF IN THE DINARIC MOUNTAINS - SOME EXAMPLES FROM SLOVENIA

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The evolution of karst in W Slovenia started after the Eocene, when the area emerged from the sea. In the present karst relief, both in the Alps and the Dinaric Mountains exist a variety of relief features among which many are now relict, because they are no longer controlled or shaped by the processes that formed them. We know the conditions in which specific relief feature form. If these conditions change, feature becomes relict and is just slightly changed by general karst denudation after. The relief features that best define the past changes are those connected with karst ground water level. These are levelled surfaces, blind valleys, dry valleys, some types of cave passages with sediments.

The important changes, those connected with regional ground water level were mostly connected with tectonic evolution, which is characterized by late Tertiary northward motion and since 6 Ma also by anticlockwise rotation of the Adria micro plate. That caused two sets of tectonic deformations.

Datation of karst fillings from different surfaces and caves with paleontological and paleomagnetic methods gave age to some relief features and enable the calibration of stages in relief evolution. The oldest cave sediments were dated in the Snežna jama Alpine cave (6 Ma) and caves on plateau Kras: the Račiška pečina (3.2 Ma) and unroofed cave in Črnotiče quarry (4–5 Ma) where remains of aquatic cave animal *Marifugia cavatica* were found.

If we compare the tectonic evolution frame, ages from sediments and relict and active relief features, we can distinguish two distinct phases of relief evolution. First phase is characterised by tectonic stability and evolution of relief in low position close to ground water level. Morphological expressions preserved in relict features of this long period are extensive levelled surfaces with some residual higher relief and large epiphreatic caves often filled with contemporary sediments.

Tectonic phase that followed broke the lowland surfaces and displaced them high above local or regional karst water level. Levelled surfaces are now transformed into several karst plateaus or intramontane lowlands dissected by dolines. Only the lowest parts, which are still in a level of the karst water table, are poljes.

The largest rivers only were able to follow the uplift with epigenetic entrenchment forming deep valleys that are in limestone preserved as canyons. Some rivers were redirected, leaving large dry valleys like the Čepovanski dol, the Mali dol and the Doberdovski dol. Smaller rivers flowing to karst from noncarbonate rocks start to sink and formed series of blind valleys in the Pivka Basin, Rovte, at Kočevje and Matarsko podolje. They are controlled by conditions in karst system, mostly karst ground water table

Measurements show that at present karst denudation is lowering surface of karst with rate between 20 – 50 m/Ma. If we consider that, most of the surface karst features cannot be older than about 10 Ma. The oldest elements in karst are probably the caves that formed deep below the surface and are now exposed by denudation as unroofed caves.

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Key words: karst geomorphology, relict forms, age, Alpine karst, Dinaric karst, Slovenia

EXTREME MANIFESTATIONS OF DEBRIS FLOW-WESTERN SLOPE OF THE PIATRA CRAIULUI MOUNTAINS (ROMANIAN CARPATHIANS). CASE STUDIES, JULY 2009 AND JUNE 2012

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The western slope of the Piatra Craiului Mts. shows features that are favourable to the occurrence of extreme events in all seasons. These mountains consist predominantly of limestone and represent a syncline flank, where deepened river formed a network with high relief energy. A debris flow phenomenon occurs in summer, in certain local conditions (geomorphologic and precipitations). In July 2009 and June 2012 there were rains that caused rivers triggering these rocks in an area where hydrographical network has a temporal character. Thus, in many valleys, situated in the north-west part of the massif (the Vladusca, the Padina lui Calinet), registered the presence of these phenomena. This study shows local morphological characteristics of these valleys, trigger causes (through local weather data recorded at the stations from the surrounding), how debris-flow occurred, the route taken and the local consequences. This study will complete data displaying the mountain summer risk events that occur in the area of the Romanian Carpathians.

Keywords: debris flow, the Piatra Craiului Massif North Western Slope (Southern Romanian Carpathians), local conditions, extreme events

PREDICTABILITY OF EROSION GULLY-DEVELOPMENT BASED ON RELIEF, GEOMORPHOLOGY AND LAND USE DATA

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Gully development is one of the most relevant surface forming process on the Tokaj Big-Hill, influencing the road and other infrastructure constructions, settlement development, agricultural activity. On the geographically quite isolated area of the Tokaj Big-Hill (21.08 km²) totally 162 larger erosional gully could be mapped based on topographical maps, remote sensed data and field surveys. Their summarized length could be given in 48.9 km. It means an average gully-density of 2.32 km km⁻² for the Big-Hill.

To describe temporal changes of surface land cover and cartographic analysis of geomorphologic conditions topographical map (1:10 000), aerial photos (from 1957, 1981 and 2000) and GIS software as Quantum GIS 1.7, Arcview 3.2, and Erdas Imagine 8.5 were used.

The development of erosional gullies is significantly affected by land use, slope steepness, relative relief and by the thickness of suitable loess material. Shallow situated volcanic rock layers block the further incision of gullies, as well the abandonment of agricultural areas, succession of vegetation and reforestation of surrounding areas delay the development of gullies as well.

Based on elevation data of topography map a relative relief map (elevation differences in m·ha⁻¹) and slope category (%) map was compiled. By aerial photographs and maps a land use was evaluated. All of larger erosional gullies were mapped and their area compared with relative relief map, slope categories, and land use.

The longest sections (more than 59 % of total length) of gullies are situated on areas with relative small relative relief (between 10 – 30 m ha⁻¹). More than 56 % of total length of gullies appears on slope sections between 12 – 35 %. We found that all of former active gullies which head were transformed into quarry, and therefore they are deprived from the catchment area, are actually deactivated and overgrown by dense shrub or wood vegetation. Gullies are surrounded in 41 % by forests, meanwhile the Hill is only 21 % covered by woods. Vineyards are present in 31 % in the surroundings of gullies, which is the same ratio, vineyards share from the whole area of the Hill.

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Key words: gully erosion, loess surface development, predictability of gully development, geomorphologic hazards, Tokaj

QUANTIFYING ANTHROPOGEOMORPHOLOGICAL TRANSFORMATION BY USING THE CONCEPT OF HEMEROMORPHY' – A CASE STUDY FROM HUNGARY, THE TOKAJ BIG-HILL

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Effectivity of anthropogenic and natural geomorphological processes could be expressed by volume or mass of dislocated material per area and time unit, and on this base the ratio of anthropogeomorphological transformation (R_{ag}) can be calculated as it follows:

$$R_{ag} = V_a / V_n$$

where V_a is amount of dislocated material by human activities; V_n is amount of dislocated material by natural processes (both in tons, or $m^3 \text{ ha}^{-1} \text{ yr}^{-1}$). This approach allows quantifying the degree of anthropogeomorphological transformation in spatial units. However, it fulfil the requirement to be independent from the volume, quality and intensity of the natural and anthropogenic surface shaping processes, and allows to compare landscapes with completely different conditions. Lower R_{ag} values characterize landscapes of very moderate anthropogeomorphological transformation, while high values indicate the totally artificial surfaces, where amount of anthropogenic dislocated material is much higher than that of natural transportation.

On the analogy of 'hemeroby' concept, which expresses the degree of the human influence on ecosystems, this approach could be denominated with the term of 'hemeromorphy' which is suitable to express the degree of human influence on geomorphosystems (complexes of surface forming processes) independently from their geomorphic process combinations, relief and climate. Smallest landscape units, which are homogenous according their hemeromorphy, could be referred as hemeromorphotops

$\eta\mu\epsilon\rho\omicron\varsigma$ = domesticated, educated,

$\mu\omicron\rho\rho\eta$ = form,

$\tau\omicron\pi\omicron\varsigma$ = place, locality.

The concept itself and an application after estimating natural and anthropogenic material fluxes in case of Hungarian landscapes will be presented, where R_{ag} values ranged from $R_{ag} < 10$, in case of agricultural, hilly areas, to $R_{ag} > 10\ 000$ in case of quarries.

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Key words: hemeromorphy concept, quantifying anthropogeomorphological processes, Tokaj

DATING OF LOESS COVERS ON THE TERRACE LEVELS ALONG THE DANUBE RIVER

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The traditional Hungarian terrace chronology for the Danube River is mainly based on the relative heights of the terraces, on sedimentology, paleontology and paleomagnetic data, which only provides relative chronology. Direct age constraints for the terrace formation can be given by dating of the material of the different terrace levels using luminescence or cosmogenic isotope dating (Ruszkiczay-Rüdiger et al. in this issue). However, indirect age constraints for the abandonment of the different terrace levels can be given by dating of the covering sediments, like loess and wind-blown sand. Luminescence dating is an effective tool to determine the burial ages of wind blown materials, therefore it was applied in each study sites. Independent age control – like U-series dating and amino acid racemization (AAR) measurement – is available to make a correlation with the luminescence ages. Three loess profiles, accumulated on different terrace levels, are investigated and dated using infrared stimulated luminescence (IRSL) dating.

The loess-palaeosol record in Süttő, on the right bank of the Danube River, has a thickness of 20 m and covers the Süttő travertine complex, which is formed on the VIth terrace level of the Danube River. The loess is intercalated by two greyish stratified horizons, three brownish steppe-like soils and a pedocomplex, including a reddish-brown palaeosol covered by a chernozem-like palaeosol. Detailed IRSL dating with fading correction was carried out, revealing more or less continuous sedimentation from Marine Isotope Stage (MIS) 6 to MIS 2. Uranium-series ($^{230}\text{Th}/^{234}\text{U}$) ages correlate the travertine with MIS 7-8 from below the loess (Sierralta et al., 2009). The same situation can be observed at Verőce, on the left bank of the Danube River, 50 km far from Süttő. Similarly to Süttő, the 10 m thick loess record is intercalated by three brownish steppe-like soils and a reddish and dark-brown chernozem-like pedocomplex. The luminescence ages indicate similar burial ages for this loess-paleosol sequence, like in case of the Süttő loess record. These loess records showed significantly younger ages compared to the ages of the terrace levels, which suggests huge and significant erosion between the terrace abandonment and the travertine and/or loess accumulation.

On the other hand, at Basaharc, on the right bank of the Danube River, situated on the terrace level II/b, a 20 m thick loess-paleosol profile is investigated. The luminescence dating of the loess section at Basaharc yielded much older ages than traditional terrace ages. This contradiction points out the necessity for new, revised terrace chronology, based on absolute dating methods.

Acknowledgements: Our research was supported by the OTKA 100315.

Key words: loess, luminescence dating, the Danube River terraces

CHANNEL BAR DYNAMICS AND VARIABILITY (THE VÁH RIVER, SLOVAKIA CASE STUDY)

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Channel bars are depositional features that are related to the morphology, flow and sediment dynamics of the river. As summarized by Hooke and Yorke (2011) they are very useful as indicators of characteristics and variations of whole fluvial system. Bars are also very important as habitats and formation and succession of vegetation on bars can themselves have feedback effects on the morphology and ecology of the channel (Hooke and Yorke 2011).

The aim of this contribution is to study dynamics and spatial variability of gravel bars in two different reaches of the Váh River (Púchov – Trenčín and Piešťany – Sereď) the longest river of Slovakia. The river is exemplar case of human modification (straightening, damming, by-passing, etc.) and as such ideal object to study the changes of fluvial system. Statistical analysis of the number, position, size and type of bars has been applied on the data obtained from the aerial photos and orthophotomaps from different time horizons (1949, 1985 and 2003).

Reference:

Hooke, J. M., Yorke, L. (2011). Channel bar dynamics on multi-decadal timescales in an active meandering river. *Earth Surface Processes and Landforms*, 36, 1910 – 1928.

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Key words: channel bars, by-passed river, aerial photos, fluvial geomorphology, the Váh River, Slovakia

MONITORING SLOPE INSTABILITY IN BELGRADE SUBURBAN AREA BY ANALYSING SATELLITE AND AERIAL IMAGES

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Purpose of this study is to prepare slope instability map by using a spatial criteria in a landslide-prone area of Belgrade suburban area. Landslide locations were detected from interpretation of aerial images. Several factors were used for interpretation of landslide conditioning factors. These factors are: slope, lithology, human impact, distance from rivers and streams, tectonic assembly, NDVI (Normalized Difference Vegetation Index) calculated from Landsat 7 satellite images. During last 35 years, in Belgrade urban and suburban area, more than 2000 landslides were registered. Research area includes unstable slopes in the area of the gully, the total surface area of 1.4 km². Research area is located near Sava, 20 km SW from Belgrade City centre, and it is very close to biggest, deepest and the most investigated landslide in Belgrade area, named Umka. According to Basic Geological Map (Filipović and Rodin 1976), whole area is built from marly and carbonic clay, coal, diatomaceous earth and sand. Conformably over the Pannonian sediments lie gray, yellowish and bluish marl clay. Average slope value of research area is 7.42°. Three groups of faults are noted. Regional faults are NW-SE oriented. This group of faults is responsible for gullies forming. Second detected group of faults is perpendicular to the first group. Some of this ruptures are responsible for the occurrence of couple of landslides in this area. Third group includes NNE-SSW oriented faults. Relation between the occurrences of slope instability to this group of faults was not established. The biggest part of area of 0.8 km² that was detected by analysing of areal images is considered as a potential landslide, which means that it is not active landslide, but there is big possibility, considering lithology, position and terrain slope, that could be initiated with greater rainfall or other triggers. There are 10 active smaller landslides. Biggest of them includes area of 0.3 km². Two landslides that once were active, but not now, are detected. They are in close vicinity of active landslides. Since the research area belongs to suburban area, interpreted landslides do not make any threats to people or households.

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Key words: slope instability, remote sensing, GIS, Belgrade

CIRCULAR FEATURES OF ARMENIA

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During the morphometric analysis of a three-dimensional Digital Elevation Model (DEM) of Armenia in 1:200000 scale, circular forms of the relief had been found by the authors of this article. Some of them have specific characteristics of morphological structures. Exposure in relief, features of geological and tectonic structure, connection with ore bodies and possible genesis of several circular features had been discussed.

For identifying and mapping the circular features (CF) maps of morphometric parameters are used - shaded relief, slope, aspect and horizontal curvature of the relief. Circular forms of relief are found on all species of the maps, but usually they are well identified on the color map of aspect. Such maps are useful for solving this problem, because the color or intensity of the color indicates the gradual change of the horizontal orientation of the slope, the whole term on the circular form of relief.

In the territory of RA more than 50 CF-s are quite clearly seen, the diameter of which varies from 3 to 45 km. They are located both in the Northern and Southern fault-block mountain regions, and on the volcanic plateau.

In the Northern and Southern fault-block mountain regions CF-s are located in six basic nodes and are called by the geographic location: Gugark-Virk, Pambak-Tsakhkunyats, Vayk, North Zangezur, South Zangezur, Qashatagh, two single CF-s – Shirak-Pambak and Middle Aghstev are also identified.

CF genesis is much more defined in the volcanic plateau. Almost all of them are of volcanic origin and are cones, calderas, lava eruption centers, etc, which is clearly seen on the horizontal curvature map. Ishkhanasar and Aragats arrays are the largest volcanic CF.

Many researchers point out the spatial relationship of mineral deposits with CF. Spatial proximity of mineralization to the CF is also detected in the territory of Armenia. Alaverdi ore node deposit is dedicated to Gugark-Virk CF. To Pambak-Tsakhkunyats CF node tends to Ankavan (Cu, Mo), Gyuladara (Fe), Perevalnoe (Au), Tuch-Manuk (Au, Ag), Tezhsar (Al) deposits. Martiros (Mn), Kaputsar (Au), Kakavasar (Au, Ag), Karmrashen (Mn), Gazma (Au), Azatek (Au, Ag) deposits are confined to Vayk node. The gold - polymetallic deposits of Marjan (Au, Ag) and Mazmazak (Pb, Zn, Au, Ag) are associated with Zangezur CF node. And with Meghri-Bargushat CF – Kajaran (Cu, Mo), Phrut, (Au, Ag, Pb, Zn) Ankasar (Mo, Cu) deposits.

Key words: circular features, morphometric analysis, mineral deposits, Armenia

HUMAN MODIFICATIONS OF MEANDERING VÁH RIVER AT THE LEOPOLDOV FORTRESS (SLOVAKIA) IN THE 18TH CENTURY

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The Váh River is the longest (403 km) and even historically the most important Slovak river. Its channel had been radically altered by regulation and construction of dam cascade during the 20th century. In this paper we elucidate the development of 8 km long model reach of the lower Váh at the towns Leopoldov and Hlohovec, as it has been reconstructed based on the 17th–19th century historic maps. In contrast to present, the Váh River at Leopoldov was a typical meandering river in the first half of 18th century, with more or less single-thread channel and relatively high flow energy. Due to intense lateral activity it threatened nearby riverside settlements and strategically important military fortress in Leopoldov (built by Emperor Leopold I. in 1665–1669), as well. According to historical maps, anthropic interventions into the channel took place as early as in the 18th century; maps also allow to examine the river response to them. Three meander cutoffs at Leopoldov in 1753 are among the first important regulation works ever documented in major Slovak rivers (cf. Danube cutoff at Bodíky, 1732). These channel improvements were primarily aimed to control bank erosion by the small town Hlohovec, nearby village of Svätý Peter and the very military fortress in Leopoldov, respectively. Additional river control works occurred two decades later, when a large Váh meander upstream of Leopoldov (at Červeník village) was cut off after 1775. Even after these improvements the river channel remained laterally unstable and the Váh River displayed distinct meandering tendencies along the study reach, which were most probably conditioned by neotectonics. Last regulation works prior to systematic channelization of the Váh River resulted in abandonment of the newly developing meander at Svätý Peter sometime after 1840. Map-based reconstruction of lower the Váh River development also provides absolute dating of some floodplain segments and remnant river forms, such as abandoned meanders, which survived to present days. Some point bars of former meander loops had been used for gravel extraction; today these are sites of secondary waterbodies, used for fishing and recreation, e. g. gravel pit Štrkovka by Leopoldov.

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Key words: fluvial geomorphology, meander, cartographic evidence, the Váh River, Leopoldov fortress, Slovakia

ASSESSING THE SNOW AVALANCHE FREQUENCY IN THE EASTERN PART OF THE PIATRA CRAIULUI MOUNTAINS (ROMANIAN SOUTHERN CARPATHIANS) BY DENDROGEOMORPHOLOGICAL METHODS

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Snow avalanches affect various mountain regions in the world and represent one of the rapid debris transfer mechanism in such environments. It repeatedly damages inhabited areas, infrastructure or forests and cause fatalities. The lack of historical data regarding occurrence of avalanches in these areas could be successfully completed with information provided by tree-ring analysis. Snow avalanches affect large forested area in the Piatra Craiului massif (Romanian Southern Carpathians), presenting a great potential for dendrogeomorphological investigations. In an attempt to improve the knowledge of snow-avalanche frequency, a first dendrogeomorphological reconstruction of past avalanche events was conducted in the eastern part of this massif. The dendrogeomorphological study was performed with 171 *Picea abies* (L.) Karst. sampled trees randomly distributed along four avalanche paths and showing visible disturbances related to the past avalanche activity. Another 25, non-affected *P. abies* trees were sampled in order to obtain undisturbed reference tree growth at the site and to compare it with growth anomalies (i.e. residuals) in affected trees. Tree-rings showing growth anomalies (e.g. compression wood, tangential rows of traumatic resin ducts, callus tissue, growth suppression and growth release) were used to reconstruct a minimum frequency of avalanche activity for each of the four avalanche paths. The results show that the affected trees reacted severely during or following years with snow avalanche events. The 920 growth anomalies found in cores and discs sampled obtained allows determination of a 76 avalanche events occurred during 1936–2011 period along the four avalanche paths. Differences between avalanche frequencies within the four paths investigated were observed. Data shows that by applying a high sampling strategy, determination of avalanche frequency by dendrogeomorphological analysis within the avalanche paths can be significantly improved.

Keywords: snow-avalanche, dendrogeomorphology, frequency, *Picea abies* (L.) Karst., the Piatra Craiului Massif (Southern Romanian Carpathians)

INVESTIGATION OF BED SEDIMENT HOUSEHOLD ON THE LOWLAND SECTION OF THE MAROS RIVER, ROMANIA — HUNGARY

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A key factor in fluvial dynamics and river morphology is the quality and quantity of bed load. In the meantime, the sediment household of European rivers is greatly affected by direct and indirect human impacts, such as sediment extraction, dredging or construction of reservoirs, being the most obvious and apparent interventions.

The aim of our study was to determine the annual changes of sediment budget at four sites on the gravel and sand bedded, 170 km long lowland section of the Maros River, which is affected by intensive sediment extraction. Further goals were to quantify the development of emerging sand bars, and to compare the selected study areas in terms of channel dynamics.

Four survey sites, with similar length (2 river km) and morphology were selected for the analysis. Sites were representing sections with different degree of human impact in relation with sediment extraction. The first was located upstream of the main mining activity, while the others were lying downstream at an increasing distance. Four survey campaigns were made at different hydrological conditions over a two year period.

Data collection was made along cross and longitudinal sections, the same tracks were followed during each measurement to ensure the comparability of data. Measurement error was also determined by short term consecutive surveys. Measurements were made by a hydroacoustic system (ADCP) in general, however at low water emerging bar surfaces were surveyed by total station. In both cases a GNSS RTK GPS system was used for navigation and positioning.

During the evaluation DTMs were generated from which net and absolute changes in sediment volume were derived. The lowest river bed development was measured upstream of the mining activity. Concerning the bed sediment household at consecutive measurements, an 18 000 m³.km⁻¹ change was observed, referring to a moderate influx of bed load towards lowland reaches. At two of the sites downstream of the mining activity a 25 000–30 000 m³.km⁻¹ absolute change was detected, caused by increasing erosive activity and sediment production due to mining. The greatest changes, 70 000 m³.km⁻¹ in average, however, were detected far downstream of the main extraction zone. The suspected reason is that by reaching here the river recovers its quasi natural bed load volume. Nevertheless, a longer term (10 year) comparative analysis shows, that net bed load volume is decreasing at this site as well, referring to sediment loss and gradual incision.

Key words: hydromorphology, sediment extraction, bed load household, digital terrain modelling

GEOMORPHOLOGICAL ASPECTS OF SNOW AVALANCHES ACTIVITY IN THE POLISH TATRAS

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Snow avalanches are one of the most important factors of present-day transformation of the high mountains denudation system. This regularity apply also to the area of the Tatra Mts. Avalanche tracks occur there regardless of slope exposure, and are diverse in terms of type and spatial occurrence. Activity of snow avalanches caused changes in landscape structure in alpine, subalpine and forest zones. There is relation between slope features and frequency and character of avalanches. Only the so-called dirty avalanches influence landform.

The attempt of evaluation of relation between landform and avalanches is made in the Polish Tatras. Role of geomorphological conditions in snow avalanche activity and geomorphic role of dirty avalanches in relief transformation is considered. Map of avalanches catchments in the Polish Tatras is elaborated. It is based on maps of avalanches occurred in the recent past, digital terrain model and the aerial photos. Each avalanche catchment is divided in to three main zones. Starting zones located at the top of the hills, transfer (path) zones and accumulation zone. For each type of designated zones the morphometric analysis was made. Three thematic layers were correlated with slope map, maps of exposure and the digital terrain model. This kind of analysis was made for each catchment in which the avalanche activity was detected since 1938.

Detailed studies of morphogenetic role of avalanches are conducted in four chosen avalanche chutes located in Polish part of the Western Tatras and the High Tatras. Measuring points for erosion, transport and accumulation have been installed in different parts of the chutes in the autumn 2012. It will be checked two times a year, in late spring and in autumn.

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Key words: avalanches, relief conditions, morphogenetic activity of avalanches, GIS, the Polish Tatra

**LANDSLIDE SUSCEPTIBILITY ASSESSMENT USING
BIVARIATE STATISTICAL ANALYSIS. CASE STUDY: THE
SMALL NIRAJ RIVER BASIN (TRANSYLVANIA DEPRESSION,
ROMANIA)**

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The studied area, situated in the Transylvania Depression, Romania, has recorded in the last two year economical and environmental losses: 67 persons, 45 houses, 115 hectares of land and a country road were affected by landslide. The main goal of this research is to build a landslide susceptibility map using bivariate statistical analysis, by estimating the importance of each class of preparatory factor depending of the characteristic/local conditions. In order to reduce the subjectivity and to obtain an accurate analysis, a high number of parameters were used: slope angle, slope aspect, plan curvature, profile curvature, altitude, drainage depth, drainage density, stream power index, lithology, land cover, soil, distance to road, distance to settlements and distance to river. The most significant triggering factor of landslide occurrence on the Transylvania Depression is the high rainfalls. In order to identify the temporal probability to landslide, the return period of rainfall was determined. The landslide inventory was based on SPOT imagery, Topographical Maps and field inventory. The obtained map was divided in five categories (very low, low, moderate, high and very high) to identify the areas with high exposure to landslide (which requires increasing the awareness of local communities and slope stabilization measures) and the relative stable areas.

Key words: landslide susceptibility, bivariate statistical analysis (BSA), GIS analysis, the Niraj River

CHRONOLOGY OF THE DANUBE RIVER INCISION INFERRED BY COSMOGENIC ^{10}Be AND LUMINESCENCE AGES

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The Hungarian section of the Danube River has formed an antecedent valley cutting through the uplifting Hungarian Mountain Range and thus connecting two lowland areas, the Danube Basin and the Great Hungarian Plain. In the antecedent valley several terraces have developed due to the interplay of vertical tectonic movements and Quaternary climate oscillations. The existing terrace chronology in the Hungarian Danube valley is based on geomorphological, sedimentological and palaeontological observations. Only few absolute ages are available. To provide more absolute age constrains, in situ cosmogenic ^{10}Be measurements were performed from depth profile samples together with post-Infrared Infrared Stimulated Luminescence (post-IR IRSL) measurements carried out on K-feldspar samples, comparing the post-IR IRSL 290 and post-IR IRSL 225 signals. Besides, quartz from younger samples was also measured using Optically Stimulated Luminescence (OSL). Based on preliminary results, luminescence data show older ages than ^{10}Be exposure ages for the terrace surfaces. This may be due to the fact that the dated processes are different. Luminescence ages reveal the time of deposition of the sediment, while ^{10}Be ages show the time since the actual terrace surface has been exposed to cosmic irradiation. The effect of considerable surface erosion also has to be taken into account. The possible effect of post-depositional sediment mixing could be excluded by field observation of the original bedding of the alluvial material. This is confirmed by the exponential decrease of ^{10}Be concentration with depth along all depth profiles.

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Key words: River terraces, cosmogenic ^{10}Be , IRSL, OSL, Quaternary

BASIC CONCEPT OF THE PERENNIAL SNOW PATCHES RESEARCH IN THE HIGH TATRAS, CASE STUDY AREA: THE ČIERNA JAVOROVÁ DOLINA VALLEY

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The perennial snow fields research in the High Tatras is based on the classification that defines snow, firn and ice fields. Snow field persists less than one season, firn field continues more than one year season. Ice field is created when occurring of air channels in the firn will translate to the closed bubble. Polish authors document various fields in the northern part of the Tatras but still a comprehensive study of the phenomenon within the territory of the High Tatras lacks. The fields at the end of the Čierna Javorová dolina Valley are tracked by November 2011. Their characteristic feature is that they are formed by ice and in many places covered with debris.

The proposed concept is based on the identification of snow fields on aerial photographs from different time periods, their verification in the field, using GPS and subsequent analysis mentioned above topographic and other variables. Several morphometric parameters were obtained by detailed analysis of digital elevation model (DEM). Solar radiation is the factor, which plays an important role in the formation and duration of firn and ice fields. In determining potential radiation we assume topoclimatic characteristics (air and soil temperature, relative air humidity). The next step is to analyze the avalanche paths and their accumulation zones. In the perennial snow fields is it an important factor for accumulation and spatial distribution of snow masses.

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Key words: perennial snow patches, GIS, morphometric parameters, solar radiation, avalanche, the High Tatra Mts.

LUMINESCENCE DATING OF SAND WEDGES AND THE TIMING OF LATE PLEISTOCENE PERMAFROST IN THE GÖDÖLLŐ HILLS, HUNGARY

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Optically Stimulated Luminescence (OSL) is a powerful dating technique in a wide variety of sedimentary environments. It is suitable for determining the time of deposition, or in other words the last occasion the sediment was exposed to sunlight. As a matter of the above, OSL dating in environments where bleaching might not be adequate, such as fluvial, glacial or periglacial settings, evaluation and proper interpretation of results can be complicated.

The Pannonian Basin (Hungary) was subjected to a cryogenic environment that produced a variety of periglacial features during Pleistocene glacial stages. Hungary's geomorphological setting in the Pannonian Basin, surrounded by the Carpathians, created an almost closed climatic system that resulted in a particularly cold environment during these glacials. During the investigation our primary aim was to test the suitability of the OSL method for dating Late Pleistocene sand wedge sediments at a key site in the Pannonian Basin, and to determine the time and interval of related periglacial processes.

The selected section is situated in the northern parts of the Gödöllő Hills at Mogyoród, 15 km northeast of Budapest. The Mogyoród section is comprised of several sand wedges with an average vertical dimension of 1.5–2.0 m and with a width of 30–60 cm. Wedges are located in a red paleosol and filled by fine to medium-grained sand.

In all 12 samples were collected from the section. After laboratory treatment detailed tests were performed in order to check the suitability of samples for dating. Preheat plateau, thermal transfer and dose recovery tests indicated that the luminescence properties of samples are adequate for the analysis. Measurements were performed on small aliquots in order to investigate dose distributions and the possibility of improper bleaching during sedimentation. In certain cases dose distributions were significantly skewed, therefore a minimum age model was applied to determine the true dose absorbed since burial.

The received OSL ages fell between 22.2 and 15.7 ka, indicating that extensive periglacial processes could affect the area in this period. New age data are in harmony with values at similar sites in Europe, though push the possible termination of permafrost to younger ages concerning the region.

Key words: OSL, permafrost, sand wedge, Pannonian Basin

LOW-COST AERIAL GEOMORPHOLOGICAL MAPPING USING MICRO UAVS

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Micro UAVs (Unmanned Aerial Vehicles) are flying platforms or models of aircrafts or helicopters up to 5 kg in weight remotely controlled from the ground which can be equipped with a wide range of sensors (cameras, spectral cameras, LIDAR, different physical sensors or gas analyzers). Micro UAV technologies are flexible mobile mapping units able to collect spatial data with high accuracy and density information. Compared with conventional resources (such as satellites, aircrafts etc.) the micro UAVs can be an interesting alternative for large scale mapping. Currently, there are a number of variations and modifications of these devices. Among the biggest advantages of micro UAV technology is the ability of data acquisition. These machines can operate in locations where conventional flying aircrafts (airplanes, helicopters, airships, etc.) can not fly and operate (at low altitudes above the surface, in built-up areas, etc.). Their compact dimensions are suitable for the carriage to the place they operate from. These technologies are often used to obtain basic spatial data. Application in geomorphological mapping allows to capture landscape changes, whether capturing geomorphological processes themselves which transforms the landscape (e.g. flood event), or time and space changes (e.g. volume changes, spatial changes in vegetation during the seasons creating a chronology of images). Also important application in geomorphology is UAV photogrammetry. Except landscape photography from a few tens of meters, the micro UAVs allow to create orthophotos, high resolution digital terrain models (DTM), 3D visualization and reconstruction of different objects using the photogrammetric techniques. The micro UAVs can be used for mapping and data analysis of:

- gravitational processes and landforms (mapping and monitoring of destructive slope movements (e. g. landform and volume changes)
- water-gravitational processes (expand and change the volume of mud flows during and after flash floods)
- water erosion processes (research and mapping of gully erosion, quantification and calculation of volume changes)
- fluvial processes and landforms (landform mapping and changes in ground-plan of streams, bank erosion analysis, dynamics of fluvial landforms)
- karst processes and forms (mapping of surface karst, calculation of volume)
- snow, glacial and glaci/fluvial processes and landforms (destruction of soil by snow processes, mapping of avalanche accumulations, glaciers volume changes)
- eolic processes and landforms (research and monitoring of dunes)
- anthropogenic forms (visualization and capacity calculations of quarries, mining pits, subsidence, etc.).
- land cover changes in small areas (creating an image sequences of the same area from the same definition of coordinates, altitude, azimuth and angle shooting or by orthophoto created at different times)
- Another application of micro UAV can be found in the surveillance and monitoring of morphodynamic processes and natural hazards.

In other partial disciplines of physical geography, such as hydrology, these technologies will find application in the research of flood events, mapping their spatial range, as well as in terms of threat, respectively risks at the local level.

Compared to the purchase or hire of conventional flying vehicles, the great advantage of micro UAVs is their affordability. Micro UAV technology cost hundreds or several thousands of Euros depending on composition and capability of micro UAV.

Key words: micro UAV, photogrammetry, digital terrain model, geomorphological mapping

LATE HOLOCENE SLOPE AND FLUVIAL PROCESSES RECORDED IN SEDIMENTARY ARCHIVES IN THE OUTER WESTERN CARPATHIANS (CZECH REPUBLIC)

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Environmental changes can be reflected in sedimentary archives and may be traced through geochronological, sedimentary and pollen evidence. Relatively small and shallow depressions (tens to hundreds m² in area, several m in depth), related to landslides (landslide-dammed flood-plain impoundments, intercolluvial and near-scarp depressions and double ridges) often hold sediments of various genesis (organic, lacustrine, fluvial, colluvial, etc.). In regions with otherwise poor Holocene records such as the Carpathians, landslide-related sediments can therefore provide excellent palaeoenvironmental records. Using standard sedimentological analyses combined with absolute dating, we studied tens of sedimentary cores and outcrops in the study area. Dated changes in the character of sedimentation enabled us to trace periodic activations of the landslide bodies. Obtained chronology of the landslide recurrence correlates both with global and Central European phases of climate deterioration connected in the studied region mainly with long-lasting and/or high intensity rainfall. Taking into account the mapped morphological evidence and recent catastrophic failures with preceding Holocene activity we assume, that majority of slope deformations in the study area are of a recurrent character. As on an average 10 % of the study area was previously believed to be fossil slope deformations, today we can consider them as potentially active, which is important for evaluation of landslide hazards in the study area. High-energy flood deposits within ancient and recent sedimentary pulses in the silted landslide-dammed lakes are supporting a crucial role of extreme hydrometeorological events in the formation of mountainous alluvial plains in humid late-Holocene phases. Very important agent of acceleration of the erosional processes on slopes was the local onset and character of human activity in the study area. We dated minerogenic peat bog deposits revealing accelerated sedimentation, starting in c. the 16–17th centuries and connected with the Wallachian colonization, one of the latest European colonization of nearly pristine mountainous landscape.

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Key words: landslides, sedimentary records, climate changes, human activity, Late Holocene, Outer Western Carpathians, Czech Republic

RIFFLE-POOL SEQUENCES FORMATION IN SEMINATURAL GRAVEL-BED RIVER ON THE EXAMPLE OF THE WISŁOKA RIVER IN THE BESKID NISKI MTS. (POLAND)

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Riffle-pool sequences are an important element of mountain gravel-bed river channels. They reflect diversity of channel morphology and allow to maintain dynamic equilibrium within channel system. The aim of the study was to determine the regularities in the appearance of riffle-pool sequences in the bed of the upper Wisłoka River. The study was executed on 24 km long reach between Rozstajne and Kąty. The selected reach is characterized by following sections of gorges and enlargements in the bottom of the valley. The location of all riffles in the studied area was measured using the GPS receiver, which also allowed to calculate the length of each sequence. Geomorphological mapping was carried out to investigate the structure of the channel including every form placement and properties. Maps and aerial photographs were analysed to calculate main parameters, such as migration zone width, channel width and sinuosity. In selected sections geodetic measurements were done with particular reference to thalweg profile and residual water depths. By combining data on the location and length of the riffle-pool sequences with other parameters of channel system, including floodplain width, sinuosity, gravel bars surface, cut banks surface, granulometry of channel material, it was possible to identify the factors that affect modelling of these sequences. The longest sequences of riffles and pools are associated with the occurrence of HSD (Hillslope Sediment Delivery) zones, landslides reaching riverbed and long erosional undercuts of the terraces, which are often connected with local increase of sinuosity and wider channel migration zone. Large Woody Debris accumulation zones enforce riffles formation in local scale and elongate pools upstream. Local scale influence of fords and few river training structures, especially near bridges, is noticeable as well.

Key words: riffle-pool sequences, gravel-bed channels, the Wisłoka River, the Beskid Niski Mts., the Carpathians, Poland

EVOLUTION OF THE BEČVA RIVER FLOODPLAIN (OUTER WESTERN CARPATHIANS) AFTER THE HOLOCENE CLIMATIC OPTIMUM

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In order to reconstruct anthropogenic and natural environmental changes in the Late Holocene we studied the alluvial record from the Bečva River floodplain (Western Carpathians, Czech Republic). We used 120 core drillings and 20 geophysical profiles (three different methods) to analyze the spatio-temporal evolution of floodplain. We obtained 25 ^{14}C datings and analyzed 40 reference cores by means of lithological and geochemical. We identified five significant phases of the floodplain evolution. In the studied section 5 m high Late Atlantic-Subboreal terrace occurs, older terraces have been destroyed by lateral erosion. We found abandoned channels positioned within 5 m thick gravel layer, under the 1 m thick surface layer of overbank deposits. Dated fossil trunks in the gravels indicate two separate phases of increased fluvial activity: 3650 – 2950 BC (Phase I) and 2350 – 1950 BC (Phase II). Infill of the abandoned channels was dated to the last part of Dark Ages Cold Period (7 – 9th century – Phase III). In the distal part of the active floodplain, 2 – 3 m above the present river channel, abandoned meanders occur, with the base of infill dated to the early phase of colonization of the nearby valleys (13 – 14th century – Phase IV). Sedimentation of 1 – 2 m thick layer of silty sands started during the culmination of the Wallachian colonization of mountainous parts of the Outer Western Carpathians (1600 – 1650 AD – Phase V). The uppermost 50 – 100 cm of this layer shows an increase in magnetic susceptibility, corresponding with massive industrial pollution in the last century. Historical maps (1834, 1850 and 1877) reveal an anabranching environment with narrowing active channel; orthophoto from the 1955 shows a single laterally migrating channel with sections of artificially stabilized banks. After the catastrophic flood in 1997 ($> Q_{100}$) almost whole of the single active channel has been stabilized and is vertically cutting into the bedrock. Phases I + II correlate with phase of increased precipitation and higher lake levels in Central Europe and phase of increased landslide activity in Czech and Polish part of the Outer Western Carpathians. The phases I + III correlate with increased fluvial activity in Germany. In contrary to the data from Germany, Poland and Eastern Carpathians, we did not find any evidence of increased river activity during the Roman Period. Compared to lowland rivers in the adjacent regions (e.g. the Morava River), our data show asynchronicity in the Late Holocene floodplain development.

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Key words: fluvial geomorphology, geophysics, palaeochannel, environmental change, the Outer Western Carpathians, the Bečva River

MAIN REGULARITIES OF MOUNTAIN RELIEF EVOLUTION

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1. Higher differences in elevation decide on higher energy and faster circulation of water and mineral matter. The surplus is exported outside mountains.
2. Synchronous tectonic activity and climatic changes are responsible for polygenetic and polychronous mountain relief.
3. Continuous adaptation of inherited mountain relief to climatic changes. Especially important are transitional phases when some thresholds in evolution may be passed.
4. Scale and rate of adaptation depend first on the resistance of substratum. It decides on preservation of older forms.
5. Mountain relief is characteristic by mosaic of forms which either had not reached the stage of equilibrium, which are now in this stage or have been from that stage snatched out.
6. During deepening and maturing of mountain valleys follows the change of slope length and function of particular sectors of slopes as well as its relations to the valley floors.
7. During neotectonic activity the previous (frequently mature) mountain relief may be included in the new tectonic system as well as in new (upper) morphoclimatic vertical zone and then substantially transformed. The same may follow during cyclic climatic fluctuations.
8. The extreme events depending on their frequency may be either the main agents of existing morphoclimatic system or may initiate a new trend in the evolution of mountain relief.
9. The mountains produce the surplus of runoff and sediment load. All tectonic and climatic changes are recorded in sedimentary sequences of submontane depressions.
10. Human activity in the mountains realised by degradation of natural vegetation cover accelerate circulation of water and mineral matter and by partition (and separation) of natural catchments is blocking the circulation which may be only restored during extreme events.

MODELING OF THE NEOGENE TO THE QUATERNARY LANDSCAPE EVOLUTION OF THE TRIBEČ MTS.

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Numerical models have been developed that simulate the evolution of fluvial terrain as a consequence of different geomorphic processes. The first quantitative landscape evolution models (LEM) began to appear earlier, stimulated by the intellectual shift toward investigating the mechanics of erosion and sedimentation processes. In Slovakia, however, the progress in theory of the numerical expression of fundamental geomorphological processes was inhibited, so that models have not been yet widely used. Models of fluvial landscape evolution contain the numerical solution (partial differential equations) of statement of mass continuity, geomorphic transport functions for hillslope processes, erosion and transport by channelized flows, including initial and boundary conditions on the system (climate forcing, base level control, rock erodibility) and methods of spatial discretization.

We used Channel-Hillslope Integrated Landscape Development (CHILD) model to create a simulation of the Tribeč Mts., because CHILD overcomes many of the limitations of the previous generation of models and provides a suitable computational framework for exploring research questions related to long-time landscape evolution. On the other hand some components of the model, such as the treatment of channel erosion, use an approach similar to that of existing models.

Nowadays, model river incision into bedrock that importantly influences the morphology of simulating landscapes is the central issue of landscape evolution theory, especially in unglaciated mountainous regions. CHILD contains only generic sets of numerical equation – the “stream-power” family of river incision models that is based on the simple assumption that river incision rate depends on a power of mean bed shear stress. The rate of river erosion can be limited either by the detachment of particles (cohesive indurated substrate) or by the ability of the flow to transport particles (loose, non-cohesive sediment). This has led to the concepts of transport-limited and detachment-limited behaviour. Detachment-limited systems are probably simpler and more appropriate for long-run simulation of terrain on the scale of a mountain range like the Tribeč Mts.

In these applications, computational limitations dictate the use of a coarse spatial discretization. CHILD use an adaptive, irregular spatial discretization that allow to vary spatial resolution and to incorporate the horizontal components of processes, inter alia, in this case the computation speed is higher. Other advantages for long-term simulation compared to previous models are climate forcing via a sequence of discrete storm events, several settings of tectonic deformation and optional using of the CHILD process modules considering research questions.

However, CHILD have some limitations: number of parameters in the model is potentially quite large, the modules structure of model led to carefully selecting of process equations and configuring these with appropriate initial and boundary conditions. It requires a good theoretical knowledge of mathematical expression of geomorphological processes that model contains. There are also some problems with output files loading into geomorphologist’s commonly used GIS software. Thus, graphical presentation of simulation is possible only by Matlab scripts.

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Key words: landscape evolution model, river incision, CHILD model, erosion, fluvial terrain

LATE QUATERNARY PALEO-DRAINAGE RECONSTRUCTION OF THE MAROS RIVER ALLUVIAL FAN BASED ON DETAILED STUDY OF SUPERFICIAL PALEO-CHANNELS

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Quite different ideas exist considering the age and development of the Maros River Alluvial Fan. Therefore, the aims of the presented study were to identify and map the paleo-channel systems on the surface of the alluvial fan of the Maros River and to determine their age. Based on the results, the reconstruction of the final phase of the evolutionary history of the alluvial fan became possible. During the study the flow directions of the Maros River and the channel pattern of the different paleo-channels were determined. Based on the horizontal channel parameters of meandering section the paleo-discharge of the channels were calculated. The age of the different channel-zones were determined by OSL dating of the sandy deposits of bars.

The paleo-channel generations on the Maros River Alluvial Fan form 18 zones with well defined boundaries. In these zones meandering, misfit, anastomosing and braided channel patterns were identified. The well-identifiable paleo-channels suggest that the main process of the fan development was avulsion rather than lateral channel shift and overbank accumulation. Based on the morphometric parameters and regional discharge equations the bankfull discharges of the meandering zones varied between $2\ 655\ \text{m}^3\cdot\text{s}^{-1}$ and $27\ \text{m}^3\cdot\text{s}^{-1}$. The smallest values were measured in case of misfit paleo-channels. It means that in some periods the discharge was four times greater than the bankfull discharge of the present-day Maros River (680 $\text{m}^3\cdot\text{s}^{-1}$). Altogether 12 channels were sampled for OSL dating. The oldest channel existed ca. 18.7 ± 2.3 ka ago, whilst the youngest one is only 1.6 ± 0.3 ka old. It seems that sometimes the Maros had only one main channel, though in other periods up to three channels co-existed or the avulsions were very frequent. During the last ca. 20 thousand years the Maros River shifted to north, than it gradually turned southwards, thus the youngest paleo-channels were found south of the axis of the alluvial fan.

Key words: alluvial fan, channel pattern, paleo-drainage, OSL dating, the Maros River

GEOMORPHOLOGIC ANALYSIS OF THE DANUBE RIVER IN THE SOUTHEASTERN BÖRZSÖNY MOUNTAINS, HUNGARY

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The Visegrad Gate evolved around the Plio-Pleistocene boundary, when the Danube River reached the piedmont of the Börzsöny Mountains. Since then the river has been the base level of the streams of the Southeastern Börzsöny Mountains. When the valleys of the streams started to develop, they dissected the ancient relief and it have resulted many lag surfaces formed between the valleys. The valleys deepened gradually during the Pleistocene and they formed their fluvial terraces too. Having distinguished the ancient lag surfaces from the Pleistocene fluvial terraces, the geomorphological development of the Southeastern Börzsöny Mountains and its ancient relief before the arrival Danube can be depicted and represented on maps. During our investigation we applied three methods.

GIS analysis: The old surfaces of the Southeastern Börzsöny Mountains are at four levels. The two upper levels could be identified only by statistical methods, but the two lower levels were covered by old sediments. There are some younger surfaces on the valleysides, which orientate the recent valley bottoms.

Sediments analysis: The old surfaces of level 240 – 270 m a. s. l. was covered by Miocene limestone, the surfaces of level 290 – 310 m a. s. l. was covered by gravel sheets. As a result of the sediments analysis, we assume that those old surfaces are the pieces of a larger ancient relief.

Geomorphologic analysis: We used the partial results, the values of m a. s. l., and the parameters of landforms during geomorphological analysis. We can establish that the old lag surfaces are piedmont branches, which evolved before the Danube River arrived at the Visegrad Gate. The young surfaces are fluvial terraces, which were evolved by the streams of the Southeastern Börzsöny Mountains. To former authors mind, the old surfaces at the Visegrad Gate are fluvial terraces, which were evolved by the Danube River. Those surfaces of the Southeastern Börzsöny Mountains and the old Danube River terraces of the Visegrad Gate are at the same level. We assume that, the old surfaces of the Visegrad Gate weren't evolved by Danube River, but the lag surfaces of ancient piedmont branches. The fluvial terraces evolved during the Pleistocene.

Keywords: the Southeastern Börzsöny Mountains, the Danube River, Visegrad Gate, surface analysis, GIS

AUTOMATED LINES EXTRACTION FROM DEM TO SUPPORT GEOMORPHOLOGIC INTERPRETATION

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The main purpose of this paper is to introduce abilities of geography information systems (GIS) in the area of morphostructural analysis to geomorphologic public.

This paper concerns with the part of the morphostructural analysis based on significant lines on Earth surfaces – lineaments. To extract lineaments, GIS is commonly used as a useful tool in many papers.

This article goes further in using GIS. The automated procedure to extract significant lines on Earth surface is introduced. The advantages of automation are the ability to repeat procedures on large areas, the ability to use the same rules to extract all lines and speed of the extraction in comparison to manually extraction.

The algorithm consists of several steps. The analysis base is Digital Elevation Model (DEM). The hillshade raster derived from DEM is input to digital image processing in order to recognize the significant lines in the image. The next step consists of filtering and sorting extracted lines using knowledge about lineament behaviour.

There are main parameters controlled by user on each step. The choice of resolution of input DEM raster determines the scale of results. The using of different angles for hillshade derivation influences the variance of the line's direction. The length and distance between adjacent lines is controlled by parameters of the line extraction process. The degree of importance is measured for each line in the last step. The results can vary in range from small number of clearly defined lines to many lines less clearly defined.

The algorithm was tested on two areas in Czech and Slovak mountains. The results are ready to consult with the geomorphology experts who are able to interpret them.

In conclusion, the algorithm is used to extract significant lines from DEM in order to help to geomorphologists to interpret morphostructure of the area.

Key words: geography information systems, structured geomorphology, lineaments

DEVELOPING AND IMPLEMENTING AN INTEGRATED SYSTEM IN ORDER TO ACCOMPLISH A MACRO SKI AREA ON THE PRAHOVA VALLEY, ROMANIA

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This study represents a complex analysis of favourable and restrictive factors made in order to identify the suitable areas for a macro ski development on the Prahova Valley, Romania. Our goal is to integrate the solutions in the existent touristic infrastructure for practicing winter sports (ski, snowboard, etc.). This approach is sustained by the existence of the four neighbouring ski resorts (Predeal, Azuga, Bușteni and Sinaia), by the altitude of the terrain and by the strategic position of the Prahova Valley area in the country.

The work represents an analysis of applied geomorphology and it can be very useful for the policy makers and the local authorities in order to access funded projects. The applied geomorphology is a new discipline developed in the last century. Detailed researches have been carried out recently. Applied geomorphology studies have been focused on the relationship between man and the environment and also on the access mode of the sustainable development projects. The following studies are noticed: Reynard (2004), Beniston (2000), Panizza (2000 and 2006), Char-don (1994), Ives (1999), Rieder and Wyder (1999). In Romania, this type of studies was generally focused on mountainous areas with increased anthropic pressure. In the Prahova Valley area, important researches were carried out by: Mihai (2003), Oprea (2004) and Dobre (2009 and 2011). Relevant terrain analysis of this area was made by Grecu (1997, 2002 and 2006), Ielenicz (1981), Șandric (2001, 2004 and 2008) and Mihai (2009 and 2010) and climatic researches by: Bălțeanu et al. (2008 and 2010).

The main goal of this research is to achieve a new methodology, applied for environmental factors analysis (which has a decisive role in ski area development), using GIS techniques. The methodology is based on the analysis of landscape parameters (hypsometric, slopes, aspect, geology, land cover, soil and geomorphologic processes) and on the analysis of climatic factors (snow depth, temperature, solid rainfall, wind). Each parameter is analysed and classified according to common characteristics, reclassified into the suitability categories and plugged into a formula. The result is the suitability map for ski area development.

The strengths of implementing this project are various. Those who stand out are the attractiveness and the competitiveness of the region which satisfied a wide range of skiers, the possibility to practice several types of tourism (throughout the year, not just during the weekend or in the winter), attracting foreign tourist and the infrastructure particularity for practicing various mountain activities (mountain bike, hiking, recreation, etc).

Key words: applied geomorphology, GIS, ski area development, complex analysis, Prahova Valley Romania

GEOPHYSICAL INVESTIGATION IN THE PERIGLACIAL BELT OF THE CENTRAL AREA OF THE FĂGĂRAȘ MOUNTAINS

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Our paper presents the results of geophysical investigations in the periglacial belt of central area zone of the Făgăraș Mountains. The Făgăraș Mountains are the most massive and highest part of the Romanian Carpathians, having 8 peaks above 2 500 m and a maximum elevation of 2 544 m in the Moldoveanu Peak. The study area is situated between the Vânătoarea lui Buteanu Peak (2 507 m) in E and the Lăițel Peak (2 390 m) in W. Scientific investigations consisted of Electrical Resistivity Tomography (ERT), ground penetrating radar (GPR) and electrical self-potential (ESP). Our interest was focused on the following periglacial forms and structures: rock glaciers, scree slopes and deposits, solifluction lobes, ploughing blocks, fossil patterned ground, earth hummocks and composite landform like “solifluctionated earth hummocks”. In function of deposits and landforms in the ERT investigations the dipole-dipole, Wenner and Wenner-Schlumberger arrays was used, in different field electrodes design. Starting of this design we can know and interpret the structure of different deposits and, very important thing, the depth and configuration of the surface contact with bedrock, as well revealed also by GPR investigations. Especially by the inversion model profiles, we can infer a low layered and corrugated stratification tendencies in the case of solifluction lobe, and an different design of solifluction terracettes. In the case of solifluction terracettes the inversion resistivity model show a clear difference between the upper part and the bottom part, with an expressive layering and a clear contact with the bedrock. On the upper part the internal design is characterized by the presence of the alternation of rounded pockets of low resistivities – in the area of the steep herbaceous and more humid risers –, and high resistivities bands, in the area of the flat surfaces, upholstered with frost-sorted clasts. In the case of rock glaciers, the ground penetrating radar and electrical tomography investigations reveals typical structures, and, very important for permafrost scientist, the presence of ice-rich bodies, in fact permafrost. Processing of ESP data collected in the field was performed by interpolation, so that we completely could view, “natural electrical footprint” of each of the investigated landforms, one of the microlandforms associated on the ploughing blocks being very expressive.

Acknowledgments. The authors are grateful to numerous students from West University of Timișoara for their committed help in carrying and installing the heavy equipment in the field.

Key words: periglacial geomorphology, geophysical investigations, rock glaciers, solifluctional landforms, periglacial deposits, the Făgăraș Mountains, the Carpathians, Romania

AN INTERPRETATION ON GEOMORPHIC LEVELS OF THE PÉCS BASIN, HUNGARY

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The Pécs Basin is located on the southern foreland of the Mecsek Mts. that is uplifting from the Transdanubian Hills and its evolution is related to the Mecsekalja Dislocation Zone. This basin is wedged between the Mecsek Mts. and the South Baranya Hills in east-west direction.

The morphologic base-surface of the basin evolution was the voluminous the Mecsek pediment evolving in the Late Miocene in parallel with the regression of Pannonian Lake. Southern consequent glacial-fragmented watercourses were captured by subsidence of the basin and their flow direction was changed (obsequent valleys) on the southern edge of the basin. The age of the observed changing dip angle on loess and palaeosoil series and red clays covered pediment surface is not clear, thus the age of the basin is debated.

The Pécs-Postavölgy borehole, drilled at 215 m a. s. l. on the remnants of glacial at the southern part of the basin (today an interfluvial) and the definition of the geomorphic situation and the origin of the gravels of the recently discovered (2010) Late Pleistocene fauna site close to Kozármisleny can allow to clarify the age.

The geomorphic maps of the sub-basins of Pellérd and Nagyárpád, the separated, on different altitude demonstrated surfaces and surface residues on them indicate the periodical submergence of the basin.

The surface residues that divide the two northern exposed slope units correspond well. These surfaces appear on 117 – 123, 123 – 130, 130 – 145, 150 – 160, 170 – 180 and 190 – 220 m elevation. Though the Pécsi-víz flows in the basin, the origin of the surfaces (except the lower ones) is not fluvial.

The alluvial and debris fans of the northern and southern edge of the basin prove the periodical submergence and the young origin (Pleistocene and/or Holocene) of the evolution.

Another important element of the geomorphic position is significant interfluvial divided catchment areas of Pécs-víz and Karsica close to this site east to Kozármisleny. The Pécsszabolcs watercourse and the eastern capture of the Pécsi-víz are related to the submergence of the eastern part of the basin and it reflects the recent tectonic evolution.

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Key words: piedmont/pediment, basin development, geomorphic levels, gravel horizons, alluvial fan, capture evolution, tectonic development, pull-apart basin

THE ENVIRONMENTAL AND HYDROGRAPHICAL RECONSTRUCTION OF THE AREA OF ROMAN BRIGETIO (KOMÁROM, HUNGARY)

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The purpose of our research is the reconstruction of the environmental and geomorphological conditions of an important part of Limes, the Roman frontier system. *Brigetio* legio camp was located along the Danube, near the current Slovakian-Hungarian border, forming part of the town of Komárom, Hungary. The camp and the settlement were bordered by the Danube on the north and by an abandoned riverbed on the south. Using this riverbed and the valley of the Fényes stream flowing into it the Romans constructed a dam and created a large lake or swampy area, which might have had a defensive role.

We prepared the reconstructed geomorphological map and reconstructed digital topographic model of the area based on geomorphological research, field work, GIS analysis, archive maps and historical sources. We also assessed the relationship between the hydrological-geomorphological features and the anthropological landscape-shaping impacts.

The settlement structure of *Brigetio* was formed from the 1st century onwards near the Danube, on the high flood plain of the river, on its wide embankments. Its golden age was at the beginning of the 3rd century. The accumulation of the high flood plain's material can be dated to the end of the Atlanticum and first half of the Subboreal. The high flood plain was finally formed in the last third of the Subboreal phase. At this time, at the end of the Late Bronze Age, the riverbed lying south of *Brigetio*'s island was formed. This riverbed became abandoned at the end of the Subboreal phase, in the Early Iron Age. The swamp resulting from the Roman dam construction was present up until 1747, when S. Mikoviny dismantled the flood-gates and drained the area. The history of the lake/swamp can be clearly followed on archive maps. We will present several depictions, such as Priorato 1672, yet unpublished in scientific literature

Key words: geomorphology, environmental history, GIS, *Brigetio*, Komárom, Hungary, Danube, roman time

GEOMORPHOLOGICAL CONSEQUENCES OF MOUNTAIN RESERVOIR OPERATION (THE KLIMKÓWKA RESERVOIR, POLISH CARPATHIANS)

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The construction and operation of reservoirs lead to visible changes in the morphology of valleys and river channels. The Klimkówka Reservoir on the Ropa River (in the Low Beskids) is one of about a dozen reservoirs operating in the Polish Carpathians. The reservoir was constructed in 1994, and its main functions include protection from floods, elimination of low water flows, and small production of electricity.

The geomorphological changes caused by the Klimkówka Reservoir on the slopes and at the bottom of the valley of the Ropa River are noticeable at the place where the reservoir is located. Modifications to the morphology of the valley slopes take place within the shore zone of the Klimkówka Reservoir as a result of both the hydrodynamic activity of the reservoir and mass movement. The basic morphological forms observed within the shore zone of the reservoir include continually developing cliffs (which are up to approximately 3 meters high) and seasonally formed microterraces (the smaller the size of the material that comprises the slopes and the steeper the slopes, the greater the number of microterraces and decreased their dimensions). The material from the washed away slopes (mainly built from loam and rubble material), of which the shore zone of the Klimkówka Reservoir is lined, is sorted while the transport to the deeper parts of the reservoir (the size of the material becomes smaller on its way from the cliffs to the reservoir). The size of the abrasion, according to the initial estimates, amounts to around 57 000 m³, which equals 0.13 % of the overall capacity (43.5 mln m³) of the reservoir.

The delta of the river, which was formed in the backwater area of the reservoir as a result of the blocked transport of clastic material during high water states, is a new fluvial form in the valley of the Ropa River. The main fractions found in the deposits of the Ropa River's delta include silt (81 % of total mineral composition), sand (11 %), clay (7 %), and gravel (0.3 %). The organic material constitutes approximately 1–2 % of the overall deposits found in the Ropa's delta. Suspended sediment predominates among the materials accumulated in the reservoir. As much as 99% of the suspended sediment transported by the river during floods remains in the reservoir. The bigger fractions accumulate in the river channel approximately 1 km above the reservoir where the gravel and cobble bar was formed. In the deepest parts of the reservoir, the increase of the layer of bottom deposits is small. The filling and degradation of the old river channel and its tributaries are mainly observed.

With regard to its life span, the Klimkówka Reservoir, after almost 20 years of existence, is a young hydrotechnical facility that is still adjusting to the valley of the Ropa River and its natural environment. The degree and range of geomorphological changes caused by its operation will increase.

Keywords: the Klimkówka Reservoir, the Ropa River, Polish Carpathians, geomorphological changes

TRANSFORMATIONS OF TORRENTIAL FANS DURING EXTREME RAINFALL EVENTS, ON THE EXAMPLE OF THE WESTERN TATRA MTS.

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The fieldwork was carried out during several trips which took place between June and August over the period 2007 – 2012. It involved geomorphological mapping of the effects of the catastrophic rainfall using a topographical map at a scale of 1:5 000. The fieldwork also included a study of the material in the accumulation fans in incision and in deposition zones. Samples were also taken from spruce roots for dendro-geomorphological testing. All samples of tree roots were taken at the base of the fan located in the mouth of valleys.

The fieldwork revealed large scale transformation of the valley floors and accumulation fans in the Kościeliska dolina Valley. The direct cause of that transformation was the catastrophic rainfall on 5 June 2007 that totalled 104.2 mm of water.

The sediments studied in the profiles represented proluvial-torrential covers incised by an episodic stream during the extreme rainfall event studied. Judging from their high Mz values the gravel and rocky layers developed in high-energy sedimentation environments. Their generally poor sorting and low kurtosis would confirm the slope origin of these layers.

The analysis of the material deposited on top of the fans and inside the excavations made in erosional incisions indicates that these landforms have a complex structure. The material contains alternating interbedding of fine silty-loamy material and sand-gravel-rocky material with a maximum size of 15 to 56 cm. This would suggest that the fans were built up during events with both medium and high geomorphological potential. Medium energy events would result in the accumulation of loamy and sandy material, while gravels and rocks would accumulate during high power events. For this reason the fans have a complex proluvial-torrential structure.

Various anatomical changes were recorded in the roots, including scars (SC) in all of them, traumatic resin ducts (TRDs) in earlywood (EW), latewood (LW) and in transition zones between EW and LW. There are also early wood changes (EWCh) and late wood changes (LWCh). The earliest changes in the root anatomy were found in 1934, followed by 1958 – 1960, 1970 – 1973, 1983 – 1984, 1987 – 1990, 1997 – 1998, 2001 – 2002 and in 2007 – 2008.

The presence of scars and traumatic resin ducts suggests high-energy events every 11 – 15 years, during which the fan would be incised and the clastic material could damage the bark and vascular cambium during transport. Microscopic analysis has shown that high energy events were separated by periods when the exposed roots are gradually covered with fine material.

The development of fans in areas of this type is irregular, which makes it difficult to identify any patterns. Indeed, depending on the energy of the event, a fan may either be expanded or both expanded and eroded. The maximum size of material measured on the surface and deeper inside the fans is similar, which suggests that extreme events are not exceptional in the history of geomorphological development in medium-altitude mountains.

Key words: torrential fan, the Tatra Mts., extreme events, sediment analysis, dendrogeomorphology

SEDIMENT PRODUCTION IN FLYSCH BADLANDS IN SW SLOVENIA

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The Dragonja River basin in SW Slovenia has been for more than a decade a test site for various studies of hydro-geomorphic processes, among which was also the research of sediment production in flysch badlands. Within these studies, several methods have been used, e.g., sediment production modelling, terrestrial photogrammetry measurements, and direct measurements using erosion plots. We present the latter, i.e. the results of direct measurements of sediment production from steep flysch wall (in three granulation classes) on four half-open erosion plots, as well as rockwall retreat. The barriers for capturing eroded flysch were installed on scree below the 6 to 15 m high flysch wall in one of many badlands in the upper course of the Dragonja River. Presented are results of five-year measurements (2008 – 2013) along with a parametric model which enabled us to assess the influence of each of the selected meteorological factors on sediment production. In this five-year period approximately 50 kg of flysch debris was eroded annually from m². The rockwall retreat totalled up to 2–4 cm per year.

Key words: geomorphology, erosion processes, sediment production, badlands, the Dragonja River, Slovene Istria, Mediterranean

EXTREME WIND EROSION FROM AGRICULTURAL LAND IN THE VIPAVA VALLEY (SW SLOVENIA) IN FEBRUARY 2012

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In Slovenia as in other parts of the world wind erosion occurs mostly on agricultural land; its effects are influenced by soil type, climate and human activity. It is present especially in SW Slovenia (Mediterranean part of Slovenia) where on certain weather condition (strong anticyclone over the Balkans and cyclone over the Mediterranean Sea) strong “bora” wind (over 55 m.s^{-1}) blows. With regard to wind erosion the winter months are the most problematic as fields are without vegetation cover. From historical sources it is known that bora can blow constantly up to two weeks, but usually it blows a couple of days. In the last decades it blew rarely for two weeks together, but in the first half of February 2012 there were such conditions. Beside strong wind that had velocity up to 10.1 m.s^{-1} (data from official meteorological station; or more than 50 m.s^{-1} on stations more exposed to wind but not belonging to official meteorological network) (daily average for the period between December 28 to February 14 was 2.7 m.s^{-1}) there were also other climatic factors that influenced the erodibility of the flysch soil in the Vipava Valley, e.g. the coolest February since temperature measurement records exist (long-term average mean daily temperature in the period from year 1971 to 2000 for February is $4.1 \text{ }^{\circ}\text{C}$; average daily temperature in February 2012 was $1.4 \text{ }^{\circ}\text{C}$), and a long dry period. Last precipitation event with more than 0.2 mm of rainfall was between the 3rd and the 4th of January 2012 (42.9 mm), but dry period lasted from at least September 2011 as only 440 mm of rain fell from September 2011 till February 2012 (57 % of long time average).

For wind erosion in the Vipava Valley anthropogenic factors are also important. In the early eighties of the 20th century big hydro-melioration and commassation works were conducted in the valley as the socialist government at that time wanted to transform the Vipava Valley into the “granary” of W Slovenia. While doing these works they were aware of the wind erosion problem, so they planned vegetation shelterbelts to prevent wind erosion. Unfortunately shelterbelts were not planted in all planned locations and in the last thirty year farmers also removed many of these belts to gain more agricultural land although the land with shelterbelts was not their property. Important factor was also that the farmers ploughed the fields too early during the winter.

All these factors contributed that in February 2012 app. 1 200 ha of agricultural land was affected by wind erosion. It is estimated that fields lost from 3 to 10 cm of topsoil resulting in the overall loss of soil of app. 600.000 t or app. 560 t.ha^{-1} .

Key words: wind erosion, bora, flysch, the Vipava Valley, Slovenia