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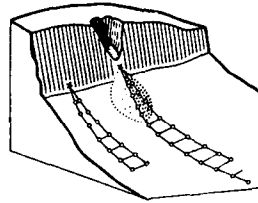
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TIME, FREQUENCY AND DATING IN GEOMORPHOLOGY

CZECHO-SLOVAKIA
TATRANSKÁ LOMNICA - STARÁ LESNÁ
June 16-21, 1992

Bratislava 1992



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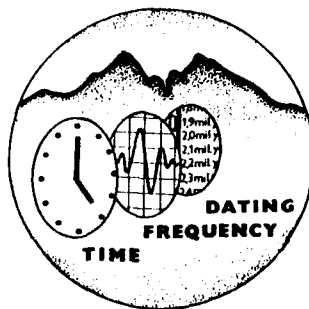
ABSTRACTS OF PAPERS

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INTERNATIONAL SYMPOSIUM
TIME, FREQUENCY AND DATING IN GEOMORPHOLOGY
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TATRANSKÁ LOMNICA-STARÁ LESNÁ, CZECHO-SLOVAKIA
JUNE 16-21, 1992

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CONTRIBUTION TO THE STAGE AND RATE OF BIOGENIC CALCRETE FORMATION
USING ^{14}C MEASUREMENTS BY LIQUID SCINTILLATION COUNTING METHOD

AMIT, R.

Calcrete bearing soils and paleosols are being used as a tool for paleoenvironmental and paleoclimatic reconstruction. They are found to be very important in subdividing and correlating Quaternary deposits. The accuracy of paleoenvironmental reconstructions and correlations requires an understanding of the rates and processes of formation of calcic horizons. Two types of calcrete formation have been identified, biogenic and physico-chemical. Most studies of rates and formation of calcrete horizons focus on the physico-chemical type. Rates and processes of biogenic calcrete formation are poorly understood.

Several biogenic calcrete horizons, developed on a Miocene limestone parent material, under Mediterranean climatic conditions, in Tarragona, Spain, were dated. The analyses also included micromorphology and stable isotopes. Age dating was done by the liquid scintillation counting method for carbon.

Results indicate that it is possible to separate two major stages in the formation of the biogenic calcrete horizons. The first stage is a passive accumulation of calcium carbonate in specific sites, for example in the roots and root hairs cell walls and in the mucilage which the roots secrete. The passive accumulation is accompanied by an active deposition of calcium carbonate crystals by fungi and bacteria inside and outside their filaments. This stage can last more than 7 800 years without indurating the calcrete horizon. The second stage is characterized by physico-chemical precipitation of calcium carbonate in micropores while the fungi and bacteria continue to contribute to the final cementation of the calcrete horizon. At this stage the passive accretion of calcium in the organic compounds continue but it is not the main mechanism of calcium carbonate accumulation. The overall induration of a biogenic calcrete horizon can take between 10 000 to 16 000 years and even more.

With time the accumulation of calcium carbonate by the biogenic activity in the rhizosphere causes a decrease in the permeability and change in moisture conditions of the soil profile. The modified micro-environmental conditions become less suitable for the rhizosphere activity and a process of physico-chemical deposition of calcium carbonate becomes dominant. The physical cementation process cause complete plugging of the calcic horizon and converts it to a hardpan. This second stage predominates by a destructing of the less resistance biogenic features which exist in the calcrete horizon, for example, plant tissues or the needle fibre calcite. The more resistant biogenic products, like the mucilage, remain, even in a mature and very indurated horizon. The occurrence of mucilage may be used in distinguishing biogenic calcrete horizons of stage two from purely physico-chemical calcrete horizons.

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CORRELATION OF THE RESULTS OF DATING EXAMPLIFIED BY THE CEROVÁ
BASALTIC FORMATION

BALOGH, K.⁽¹⁾, ELEČKO, M.⁽²⁾, KONEČNÝ, V.⁽²⁾, LAČIKA, J.⁽³⁾,
ORLICKÝ, O.⁽⁴⁾, PRISTAŠ, J.⁽²⁾, VASS, D.⁽²⁾

In the article we attempt to objectivize the dating of geological and geomorphological phenomena and forms by means of mutual confrontations of various methods realized on identical unit and identical area. The Cerová Basaltic Formation is very suitable for this aim, because it underwent numerous measurements and it was geomorphologically researched in details.

The investigated formation participates in the volcanosedimentary geological structure of the Cerová Vrchovina Mts in southern Slovakia. It is of Plio-Pleistocene age. It consists of basalts, basanitoides and their volcanoclastic rocks. They build only a smaller part of the mountains, but they are of a great importance for the forming of local positive morphostructure. The basaltic volcanism accompanied and earlier period of the rise of dome-horst morphostructure. Its products were incorporated into the geological structure monotonous until that time and this fact was a condition for and inversion of landforms development as to the initial prevolcanic shape. The uplifting of the morphostructure initiated an exogene destruction of original volcanic landforms mainly by periglacial processes in the cold periods of the Pleistocene.

The Cerová Basaltic Formation underwent several dating measurements. By mutual correlations of the results of the individual measurements confronted with the results of the geomorphological research we achieved in most cases a statement that they coincide within an admissible temporal span. We distinguished 6 basic periods of the volcanic activity within 0,4 to 6,1 m. a. interval by means of K/Ar method and paleomagnetically, biostratigraphically and geomorphologically. Only the results of measurement obtained by means of the fission track method does not correspond to the other results of the dating. According to them the age of the basalts in the Cerová Vrchovina Mts may be interpreted for more than 7,5 m. a.

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**EFFECT OF TIME ON THE EVOLUTION OF TWO GEOMORPHIC SYSTEMS:
PROXIMAL BRAIDED RIVER IN THE POLISH CARPATHIANS AND TORRENTIAL
FAN IN THE TRYN BASIN OF BULGARIA**

BAUMGART-KOTARBA, M.

Time's effects in geomorphology are controlled by climatic and neotectonic factors and also by lithology and time of recurrence. In the case of the fluvial environment the role of discharge as function of catchment size pulls out ahead. The aim of the paper is to illustrate the rate of geomorphological activity in two different fluvial environments.

The example of braided proximal environment of the Bialka River ($A=232 \text{ km}^2$, min. discharge $5 \text{ m}^3/\text{sec}$, effective floods $200-400 \text{ m}^3/\text{sec}$) with source area within the northern slope of the Tatra Mts illustrate postglacially reworked fluvioglacial deposits. The large floods with recurrence of 6-7 years produce a new flood channels with alternate scouring and accumulation on 100-200 m long reaches. During 2-3 day flood related to daily precipitation of 100 mm scouring or accumulation of the order of 1-1,5 m in the channel was established. During 50-100 years braid-plain is totally reworked (width of 100-500 m). During 1000 years the 1 m deepening of whole alluvial plain against the young terrace has taken place. The rate of deepening 1 mm/year could be comparable with the rate of Holocene dissection of Late Glacial terrace of 8-10 m high.

The example of torrential fan (radius of 1,5 km) from the Tryn Basin in the marginal zone of the Rui Mts demonstrate Holocene activity. This fan is modelled by episodic stream. The intensive rainfall 70-100 mm per day were recorded only a few times during this century. Structure of fan up to 3,5 m is tripartite. The lower part (1,2 m) consists of loam with gravel. The middle part, 0,8 m thick represents period of more organic deposition. Age of organic layer in its central part was evidenced by ^{14}C data (6000-4000 BP for residuum and for humin acid). This horizon was fossilized by 1,5 m clayey-silt layer. In the lower part of overbank organic muds of the Erma River the older ^{14}C data (10 000 and 6 000 BP) were established. This 1,1 m thick muds are covered by 0,7 m of laminated silt. The rate of mid-fan accumulation for the last 4 000 years is 0,4 mm/year. The rate of earlier more organic accumulation is 0,13-0,4 mm/year. If the lower part with coarse material represents more active pre-Holocene formation the organic part could be related to Boreal and Atlanticum with rate 0,13 mm/year.

Institute of Geography and Spatial Organization, Polish Academy of Sciences, Krakow, Poland

**SOME NEW ASPECTS OF DENUDATION CHRONOLOGY OF THE WEST
CARPATHIANS**

BIZUBOVÁ, M., MINÁR, J.

In the contribution, the Neogene denudation chronology of West Carpathians traditionally used in Slovakia (Mazur 1963) is critically revalued from the point of view of latest geological chronostratigraphy of central Paratethys. The mentioned chronometric scale approaches some of the Neogene epochs and ages in a new way and it changes the time determination of individual Neogene orogenic phases. The insufficient sizing up the transformation relation between earlier and latest chronostratigraphy on the one hand, and the denudation chronology on the other hand, causes the heterogeneous approach to the West Carpathians genetic forms dating of Slovak geomorphologists, too. This dissonances are emphasized by schematicity and static approach of traditional denudation chronology of West Carpathians that did not take sufficiently into account spatial differentiation of tectonic movements during orogenic phases.

The suggestion of modified West Carpathians denudation chronology, that considered this new facts, is presented in the paper. It modifies individual West Carpathians geomorphologic cycles dating and defines the cycle, up to this time not considered, that is showed up by the planation surface named in advance as "underintramontane level". Its existence is documented by several examples.

At the end of the paper, possible ways of the dating of beginning and finishing West Carpathians planation surfaces forming are showed (by study of weathering crust, by the age of geological bearer of planation surface, by loaded and subsequent geomorphic forms, and the like). There are showed the problems and possibilities of identification of multigenetic planation surfaces that resulted mainly from considerable differential tectonic movements.

The paper, as a whole, is formulated problemly. It outlines several relevant questions and shows some way of solution.

DATING MARINE AND EOLIAN SEQUENCES IN THE RABAT REGION, MOROCCO

BRÜCKNER, H.⁽¹⁾, LAOUINA, A.⁽²⁾, HALFAR, R.⁽³⁾, HAMBACH, U.⁽⁴⁾

The Atlantic coast of Morocco displays one of the most complete sequences for the marine Pliocene and Quaternary of Africa. Due to the interference of the continuous uplift of the Moroccan meseta with the sea-level fluctuations since the Pliocene, a series of beach-ridge complexes has been deposited. Each one consists of littoral gravels and sands plus the fossilized former dunes. These sequences exist both laterally and vertically. Paleosols and erosional disconformities separate the different sedimentary cycles.

The cycles were stratigraphically analyzed by paleosol and mineralogical studies. Different dating techniques (C-14, Th-230/U-234, thermoluminescence /TL/, electron spin resonance /ESR/, paleomagnetism) were used to establish a chronostratigraphy.

TL dating of dunes and eolianites rendered reliable results up to c. 100,000 years B.P. Supported by the investigation of intercalated paleosols and paleosol sediments, a differentiated chronology of the geomorphodynamic events during the last glacial epoch is established.

Deposits of the last interglacial are well exposed at various sites. However, a discrimination with the absolute dating techniques is not possible due to their gross resolution. It is from geomorphological aspects that the last interglacial trans- and regressions can be deciphered.

Since the majority of the beach ridges is older than the dating range of the Th/U dating technique (up to c. 350 ka) and since recrystallization made an ESR dating practically impossible, the focus was on the paleomagnetic investigation of the older beach ridges. The paper presents the paleomagnetic stratigraphy of the region which has for the first time been studied under this aspect.

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LICHENOMETRY: SOME DIFFICULTIES IN THE ESTABLISHMENT OF RELIABLE
LICHEN GROWTH CURVES

CHUECA, J., JULIAN, A.

In this work, the results obtained through the elaboration of a *Rhizocarpon geographicum* (s.l.) growth curve carried out for a sector of the southern Central Pyrenees are shown. The study area comprises the upper part of the Esera river basin, in the Benasque valley, and is situated in the axial section of this mountainous range, characterized by the presence of crystalline lithologies (granites, granodiorites) and recently glaciated landforms. The choice of this zone was motivated by the abundance of historical ruins (churches, hermitages, graveyards, etc.) - well documented and dating from the end of the XVIII century up to now - built in those materials and showing a plentiful lichen covering.

In this process of constructing the lichen growth curve we attempt to accomplish a methodological approximation, trying to compare the validity and degree of similarity of different techniques usually mentioned: 1) measurements of the largest diameters; 2) percentage cover measurements, and 3) determination of size frequency distributions. All of them were used in the same sample points and allowed us to build up three independent growth curves. The statistical calculation of the similarity level existent among them have let us infer some conclusions that affirm the relative reliability of chronologies obtained through the utilization of a single method. The comparison with the present-day growth-rates of several samples of *R. geographicum* with different ages measured by photogrammetrical techniques during the last two years in the same study area, has indicated the existence of a notable degree of general adjustment for only the last two options, while the first approximation seems to be unacceptable.

**APPLICATION OPPORTUNITIES FOR COSMOGENIC DATING METHODS IN THE
STUDY OF DIAMICTON DEPOSITS, CENTRAL APPALACHIAN MOUNTAINS, U.S.A.**

CLARK, G. M.

Large areas in the Piedmont, Blue Ridge, Ridge and Valley, and Appalachian Plateaus physiographic provinces of the Appalachian Highlands major geomorphic division are blanketed by diamicton deposits of unknown ages. These sediments include colluvium, alluvium on high terrace levels, and - in the vicinity of the glacial borders - glacial sediments of pre-Wisconsinan (pre-Würm) ages. Many of these sediments lack suitable materials that could be dated by established numerical age dating techniques.

Cosmogenically-produced isotopes of ^{10}Be , ^{14}C , ^{26}Al and ^{36}Cl can be measured accurately with small sample sizes by Accelerator Mass Spectrometry (AMS). The analytical results can provide exposure ages and estimates of erosion rates over suitable intervals of geomorphic time, if suitable sample localities can be found. Field research results indicate that the tops of tors composed of orthoquartzite and metaquartzite bedrock offer the best opportunity for sample points. Large tors project several meters above the surrounding forest floor and offer protection from effects of spallogenic (thick rind type) weathering related to fire events. The presence of Opferkessel on exposed tor tops is strong evidence that these surfaces have been exposed for cosmogenic bombardment for at least the time duration required for these solutional features to form in high-purity quartzite bedrock. Tor exposure and weathering history can then be related to the surrounding regolith through both soil-stratigraphic and geophysical research methods.

These new data will be used: to test multiple working hypotheses on landform and material origin and evolution, and to construct a numerically-dated Quaternary terrestrial history. This research will advance knowledge by providing quantitative data on rates of erosion and landform evolution, and on the influence of climatic change on landscape development. Appalachian Laurentide terrestrial glacial border and palaeoperiglacial records will then be correlated with the North Atlantic marine record. This combined record will then be related to research results elsewhere, and used in evaluation of pole-to-pole global change models.

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**BRUNHES-MATUYAMA BOUNDARY AND GEOMORPHOLOGICAL DEVELOPMENT OF
THE MIDDLE-MORAVIAN CARPATHIANS**

CZUDEK, T.

The Middle-Moravian Carpathians are formed of hilly and upland relief on strongly folded Paleogene claystones, sandstones, sands and conglomerates of the flysh zone and Neogene deposits (clays and sands). The highest unit of the Middle-Moravian Carpathians is represented by the Chřiby Upland (max. absolute height 587 m). It is a strongly dissected region with narrow, often rocky watershed ridges and isolated elevations as well as deeply incised valleys (as many as 120 m) with steep gradient of slopes. The major water courses follow the general inclination of the territory flowing from the Chřiby Upland southeastwards. In the lower land area on the margin of the Kyjovská Pahorkatina Hilly Land and especially in the Dolnomoravský Úval Graben, they form extensive, even 30 m thick alluvial fans.

In one of the alluvial cones, i.e. southeast of the village Boršice near Buchlovice, the Brunhes-Matuyama boundary was determined in a depth of about 9 m (Czudek, Havlíček, Kovanda 1985). The material of the alluvial cone of the Dlouhá Řeka Brook above and below the boundary differs considerably. The sedimentation below the Brunhes/Matuyama boundary was fast, chaotic. The material is rather coarse-grained and badly sorted with less rounded pebbles. The sedimentation above the B-M boundary appears to be calmer. The material is visibly more sorted, the gravel becomes finer and more rounded. No successive refinement of the gravel upwards is to be observed in the sequence of the Quaternary strata. The Brunhes-Matuyama boundary represents here a quite expressive lithological (sedimentological) limit. Accordingly it can be concluded, that the intensity of tectonic uplifts in the Chřiby Upland and probably in the entire Middle-Moravian Carpathians was higher in Early Pleistocene than in the Middle and evidently even Upper Pleistocene.

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DEVELOPMENT OF THE SLOVAK WESTERN CARPATHIAN RELIEF IN SPACE AND TIME

ČINČURA, J.

The Western Carpathians formed as a result of a collision of the NW projection of the Apulian microcontinent with the margin of the European platform. This collision took place during several stages (megacycles) which can be distinguished in the sedimentary record as well as in the erosional history.

Traces after the oldest reliefs of the Alpine period are not present in the present-day relief. However, they can be reconstructed from the sedimentary record. Lower Triassic quartzites reflect one of the oldest Carpathian reliefs. They are interpreted as sediments of ephemeral streams deposited in a Piedmont lowland in semiarid climate. Gutenstein limestones and dolomites of Middle Triassic age represent sediments of sebkha environment. Pseudomorphs after anhydrite and gypsum crystals indicate aridity of the environment. On the boundary Triassic/Jurassic there are known the up to now oldest karst phenomena of the Alpine period. Breccia limestones of Lower Lias age penetrate deep into the underlying limestones in the form of filling of widened fissures or surfacial depressions. In the Jurassic period there are not known any terrestrial sediments or traces of subaeric relief.

As a result of the collision development, an important continental period started during the Cretaceous in the Central and Inner Western Carpathians. Subaeric conditions progressed gradually from the south to the north. A wide scale of typical karst forms and sediments originated in monsoon or subequatorial climate conditions on carbonate rocks; among them also karst bauxites. This important karst period started generally during the Middle Cretaceous.

The progressing Paleogene sea interrupted the period of subaeric development. The mainland was gradually flooded and Paleogene sediments buried the pre-transgressive relief.

The collision development during the Neogene caused not only horizontal and vertical movements, but also rotation of blocks. The buried pre-transgressive relief was gradually exhumed and partially eroded. The maxima of sedimentation rate in molasse basins migrated not only in time, but also in space from W to E, similarly as volcanic activity. Therefore the formation of extensive synchroneal levelled surface in source areas of the frontal deep, intramontane basins as well as of the backdeep (i.e. the outer, inner and back molasse) appears to be in contradiction to the conception of dynamic evolution in the Western Carpathians.

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DATING OF THE LONGEST PALEOKARST PERIOD IN THE WESTERN CARPATHIANS

ČINČURA, J., KÖHLER, E.

The considerable areal extent and great thicknesses of carbonate complexes - especially limestones and dolomites of Middle and Upper Triassic age - in the Inner and Central Western Carpathians led in the periods of subaeric development to the formation of paleokarst. In accordance with the model of collision development of the Western Carpathians during the Alpine period it can be stated that the most important paleokarst development periods were initialized by the Early Kimmerian, Middle Cretaceous (Austrian) and Savic-Styrian phases.

In spite of the fact that Cretaceous transgression went in global scale the largest inundations, the Middle Cretaceous (Austrian) collision caused, especially in the Central Carpathian space, a diametrically opposed development. The duration of the longest paleokarst period in the Western Carpathians can be chronostratigraphically defined by its lower and upper boundary. The onset of this paleokarst period was different in the Western Carpathians. The southernmost units emerged already at the end of Upper Jurassic. The youngest sea sediments of Hronicum (southern parts) are of Barremian age, in Fatricum (more central parts) they are Late Albian to Cenomanian, the sediments of the lowermost Turonian are locally known in Tatricum (northernmost zones).

Among products of the longest paleokarst periods are typical karst bauxites forming the filling of karst cavities, ferrous weathering crusts, red clays, collapse breccias with speleothems, freshwater limestones or polymict conglomerates. Surficial forms of this period are large depressions of polje character, hums or extensive paleokarst plateaus.

The longest paleokarst period in the Western Carpathians was on a great part of the territory ended by transgression of Paleogene sea which flooded the northern part of the Malé Karpaty Mts, Myjavská Pahorkatina, Váh valley, Orava and Pieniny already in the Paleocene. The most marked progress of the sea can be observed in the Middle and Upper Eocene, when progressing from NW to SE, the sea flooded a considerable part of the paleokarst relief. The progress of the sea continued until the end of the Eocene, the youngest basal beds of the uppermost Eocene are known from the region Štrba-Lučivná. In the Middle and Upper Eocene a shallow epicontinental sea reached from the south to the Western Carpathians, to the region of Upper Nitra. Some parts of the Western Carpathians continued to be unflooded during the Paleogene transgression. Up to now there is no evidence of Paleogene sediments in the Spišsko-Gemerské Rudohorie Mts and in the Nizke Tatry Mts.

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SOME COMMENTS ON THE POTENTIAL FOR USING CAESIUM RADIONUCLIDES
TO INVESTIGATE OVERBANK SEDIMENTATION IN CARPATHIAN RIVERS

FROEHLICH, W.,⁽¹⁾, WALLING, D. E. ⁽²⁾

The caesium-137 technique has been used widely for dating recent horizons in lake sediment cores. The use of caesium radionuclides to investigate rates of floodplain deposition may be viewed as a logical development of its application. The floodplain surface will receive inputs of radiocaesium both directly from atmospheric fallout and in association with deposited sediment eroded from the upstream drainage basin. Overbank deposition on floodplains is likely to represent the major transmission loss and a preliminary attempt has been made to use caesium-134 measurements to document recent rates of deposition on the floodplain bordering the lower reaches of the Homerka Stream and the main tributaries of the Dunajec River. The presence of ^{134}Cs reflects only inputs of Chernobyl derived fallout. Most of the ^{134}Cs activity occurs, as expected, near the surface. Some downward diffusion or migration has obviously occurred (probably along macropores), but the profile shape closely reflects fallout inputs to the surface. At the time of Chernobyl fallout in mid 1986, the level which is now 14 cm below the surface would have been exposed at the surface and would have received fallout of caesium-134. Subsequent deposition of caesium-134 bearing sediment eroded from the upstream drainage basin has buried the surface exposed in 1986 and the deposited sediment has increased the total caesium-134 inventory. Since cores were collected in Homerka 1989, annual deposition rates of ca. 4 cm year^{-1} may be estimated. Similar rates of deposition have been estimated for other floodplain locations within the Dunajec River system, indicating that floodplain accretion is widespread and that even in these high energy mountain environments, significant transmission losses may occur in association with floodplain deposition. Further work is, however, required to quantify the magnitude of the transmission losses involved.

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GLACIAL STRATIGRAPHY AND DATING OF THE QUATERNARY ACCUMULATION
FORMS AND DEPOSITS ON THE FORELAND OF THE TATRA MTS

HALOUZKA, R.

Brief survey of complex morpho- and lithostratigraphical analysis of the Quaternary glaciogenic and glacifluvial accumulation forms and sediments at the southern foreland of the High Tatra and West Tatra Mts (i.e. in the Poprad and Liptov Basins). Local mutual parallelization of the Quaternary stratigraphical successions inside the foreland. Scheme of their connection with the fluvial stratigraphical system of terrace deposits in adjacent or near areas of the Carpathian depressions (in continuity or correlation relations). Conclusion (interregional): general correlation of glacial stratigraphy of the Tatra's area with both glacial climatic-stratigraphical scales of Europe (i.e. the Alpine and Nordic scales) and so also with their competent time scales (it is so called indirect dating of forms and sediments).

DATING REPORT ABOUT QUATERNARY LATEST VOLCANIC ACTIVITY IN
CZECHO-SLOVAKIA (BAZALTS NEAR NOVÁ BAŇA-BREHY)

HALOUZKA, R., ŠIMON, L.

Latest activity of final basalt volcanism (Štiavnica stratovolcanoe of central Slovakia). It is a lava flow of nepheline basalts near Nová Baňa (between Tekovská Breznica and Brehy, effusion from the area of the present-day Pútikov Vršok Hill). The stratigraphy of basalts is mainly determined by their geologic-morphological position (on gravelous accumulation of the lowermost Hron River terrace). Radiometric dating by K-Ar method and analysis of paleomagnetism. Quaternary stratiography in the valley, paleogeographical development.

MORPHOGENESIS OF GRAVITATION SLOPE DEFORMATIONS IN THE VIHORLAT
MTS (BASED ON PALYNOLOGICAL DATING)

HARČÁR, J.(1), KRIPPEL, E.(2)*

The Vihorlat Mts is a component of the East Carpathians. It is built of Neogene volcanites with prevalence of andesites and their pyroclastics. Morphologically it represents a typical volcanic mountain range with landforms already prevailingly destroyed to a considerable degree to the present. Typologically it is gebirgsland with absolute altitudes over 1 000 m. Typical are, especially for northern marginal parts of the mountain range, mightly gravitation slope deformations of various types. In this way the valleys were dammed and so they gave the rise of small lakes, morasses and depressions. A typical example of this fact are the small lakes Ďurová Mláka, Malé Morské Oko and Kotlík as well as the peat bogs Hypkaňa and Postávka. All this area belongs from the geomorphological and genetical view to one and the same group of forms arisen in the Postglacial. The beginning of the rise of peat bogs is ordered by us into the initial phases of the Holocene. The pollen analysis points out to the beginning of the rise of basal sites of the peat bog Hypkaňa in the Preboreal Period, when in Central Europe it came to the definite warming of the climate as to the Postglacial Period. A definite contraction of pine/birch stands and an onset of mixed ones begin.

From the above mentioned it results that the processes proper, leading to the rise of slope deformations, occurred in a period before the Holocene, namely in the period of the Late Glacial. In the Pleistocene and Early Holocene very intensive weathering and erosional processes occurred in the territory, connected with being incised as to the valleys, with the movement of weathered masses along the slopes and with their transportation into the valleys.

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THE SIGNIFICANCE OF INTERDUNAL DEPOSITS IN THE NIZZANA SANDS,
SOUTHERN NEGEV, ISRAEL

HARRISON, J. B. J., YAIR, A.

Fine textured layers (primarily silt and clay) have been observed in the interdunal areas of continental sand dunes in arid areas. The origin of the fine textured deposits is important in that they are found associated with sediments that consist predominantly of sand size particles. The fine textured layers have been attributed to three main processes: a) high watertables or springs which produce swamps in the interdunal areas, and result in fine textured sediments, b) runoff from the dunes washes eolian fines into the interdunal depressions and c) overbank deposition from ephemeral streams which flood the depressions. Each of these processes is a results of an iuncreased input of water into an arid environemnt.

The interdunal area between longitudinal dunes in Nizzana, in the Negev Desert, Israel, contains deposits of sand and isolated areas of fine grained (playa) deposits. A series of trenches across the interdunal area exposed stacked sequences of up to four buried, localised, playa surfaces. The former playa surfaces consist of couplets of more silty and more clay rich layers and these couplets are separated by horizontally layered sandy deposits. Some of the couplets exceeded 1 m in thickness.

Morphological and sedimentary data suggest that the fine textured layers in Nizzana are the result of overbank deposition from the Nahal Nizzana and not high water tables or sediment runoff from the dune slopes. The fine textured layers are probably reworked loess from the Negev highlands (the headwaters of the Nahal Nizzana) the deposition of which occurred in the Middle to Late Pleistocene. TL dates of different clay layers at Nizzana range from 40 000 yrs BP to 6000 yrs BP suggesting that the loess was still being reworked during the Holocene. The presence of these layers suggests the occurrence of large magnitude flood events in this area in the late Pleistocene and Holocene. The possible climatic significance of such floods is under investigation.

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**THE EFFECTS OF TIME ON THE EVOLUTION OF GEOMORPHOLOGICAL CYCLES
IN THE NAMIB DESERT, NAMIBIA**

HEINE, K.

The influence of orbital parameters on climatic changes is documented by climate-sensitive facies of marine and terrestrial origin. However, the longterm evolution of Namib landforms appears not to reflect this climatic history with the obvious frequency cycles. Rather, the landforms of the Namib point 1st to phases during which adjustment occur to the different cycles (e.g. the past 700-900 ka with 100 000-year cycles) and 2nd to phases during which the climatic setting is represented by the landforms (characteristic desert forms). The resulting patterns of landscape development include relief persistence, stagnacy of development, transient forms etc. In the Namib the cycles of landform evolution rather seem to be a matter of physical models than of climatic change.

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EVOLUTION AND RECOVERY TIME OF VOLCANIC LANDFORMS

INBAR, M.

There is a clear starting time of geomorphic development of monogenetic volcanic landforms, and the rate of development depends on climatic and physiographic factors. Most of the observations and studies of erosional processes after volcanic eruptions are short term and follow the first period after the eruption. Erosion rates are high, about three to four orders of magnitude above the normal erosion rates for non affected areas. Several years after eruption, initial rates decrease with stripping of the fine ash layer in pyroclastic eruptions, vegetation cover and development of a steady drainage system.

A comparative study was conducted in several volcanoes of Mexico, South America and Antarctica in order: (1) to examine erosion and sedimentation processes in pyroclastic cones and adjacent lava fields; (2) to identify revegetation processes and soil development, and (3) to determine the changes in the drainage system and rates of integration after eruption. In Mexico, the Jorullo cineritic cone (1759) is covered by a dense vegetation and its lava flow is in an early stage of vegetation cover and soil development. In the Paricutin cone (1943-1952), after the removal of the initial fine ash layer, there is no noticed erosion. Following processes were observed: a) Revegetation started to promote soil development; b) In the lava fields the rate of erosion is very low, the drainage is internal and most of the flows have a fresh appearance; vegetation is developing in crevasses and low places; c) Floodplains-"Llanos"-developed at the outlet of the dammed rivers by the lava flows, and accumulation of sediments is still notorious; only one of them integrated in the external drainage system; d) Erosion rates for the fluvial drained area are about 50 % higher than adjacent similar areas in the region; deceleration was rapid in the first 5 years after eruption.

Lava flows of the last eruption (1870) in the Ceboruco stratovolcan have little vegetation cover and soil development. In the humid and subtropical forest area, pyroclastic flows and ashfalls from the recent eruption of the Chichon volcano (1982) are already covered by a dense vegetation in large affected areas by the eruption.

In cold environments of the Southern Andes mountains (Lat. 40 S), the Escorial flow (400 yr. BP) shows a partial cover of forest. The recently erupted Navidad cineritic cone (1988) is at an early stage of development and wind erosion is the main process. In Deception Island (Antarctica), there is a rapid morphological evolution of cinder cones erupted in 1968-1970.

In all the studied areas most of the declining trend of erosion rates is of several orders of magnitude during the first years after the eruption. Vegetation cover, soil development and integration of drainage systems are slower processes which may last hundreds or thousands of years.

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GULLY EROSION AND ITS ROLE IN ENVIRONMENTAL DEGRADATION
(A CASE STUDY)

JHA, V. C.

In this paper an attempt has been made to find out the stages in break-up of the initial surfaces accelerating gully erosion in the Lateritic Terrains of the Birbhum District, West Bengal, India, and the role of gully erosion in environmental degradation. The gully erosion is observed as dominant mechanism in creating environmental degradation in the study area and considered as serious geomorphological hazards. Three gully erosion sites have been selected for the proposed investigation where the gully development have been taken place at the large scale. The length, width, depth, cross section, plan and profile including special features have been mapped with the help of field instruments. The rate of gully erosion has also been studied in two different rainy times. A few of developed gullies are anthropogenic in origin producing ecological imbalance in the study area. A landscape ecology map of the Mohammad Bazar P. S. has been prepared based on considerations of the natural and anthropological aspects as well as the needs and processes of gully development.

FREQUENCY IN EROSIONAL PROCESSES AND ENVIRONMENTAL INFORMATION

KASHIWAYA, K.⁽¹⁾, OKIMURA, T.⁽²⁾

There have been several severe landslides and debris flows by heavy rainfall, which caused natural hazards in the Rokko Mountains of Kobe District. Most of the mountains are composed of weathered granite which is fragile. Analysis of pond sediments, mainly composed of clay, during the past 40 years in the mountains shows that coarser grains flowed into the ponds in the severe landslide year, which is identified by using ^{137}Cs .

Temporal change in heavy rainfall during the past 100 years (excess rainfall; annual summation of heavy rainfall over 100 mm/day) in Kobe District has some dominant periods of conspicuous 24-30, 10-13, and 5-7 years. The period of 24-30 years in this area corresponds to that of occurrence of the severe landslides and debris flows by heavy rainfall; years of the maximum rainfall correspond to years when there have been severe landslides and debris flows in the area.

Changes in tree ring width in the same area during the past 80-120 years indicate that most of the sequences have a dominant period of about 24-30 years. Coherencies between the rainfall and the ring width at 24-30 years are very high, though there remain some problems on causal relationship between them. These suggest that the excess rainfall may provide a first approximation for external force which have developed erosional features and that tree ring width may be used as a proxy data for the force.

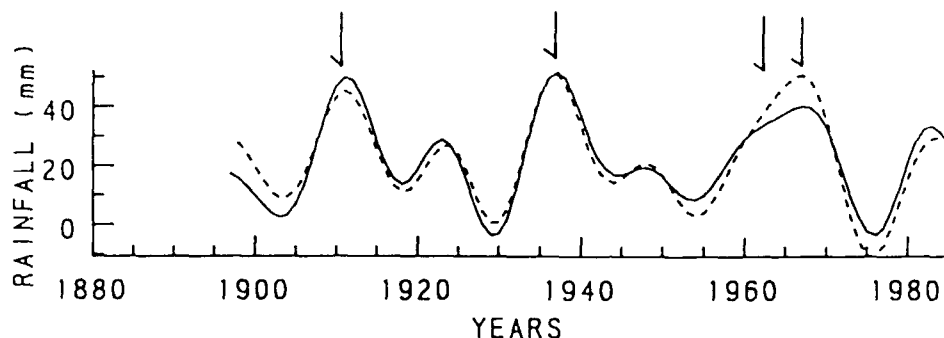


Figure 1. Time sequence in excess rainfall in Kobe District. Arrows indicate severe landslide years by heavy rainfall.

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DEVELOPMENT OF THE MORAVA RIVER BED NEAR STRÁŽNICE (SOUTH MORAVIA)

KIRCHNER, K., NOVÁČEK, V.

Floodplains are ones of the most dynamically developed natural types of relief affected and remodelled by human activities (e.g. canalization, dam building, etc.) at the same time. Recently the wide floodplains with natural modelling processes (meandering) are rare from both ecological and scientific viewpoint in the Czech Republic. The floodplain of the Morava River near Strážnice with natural river bed (meandering) belongs to valuable territories. In this region canalization of the river have not carried out yet. Hence we attempted to determine a dynamics of the river bed development in the mentioned area. Maps from different time levels were used and compared with the present conditions. We employed historical maps from 2nd military mapping (1836-40), maps from 3rd military mapping (1876-77) and topographic maps (1960). Contemporary situation was investigated with the help of detailed geomorphological mapping and remote sensing data. In the last century the expressive meanders were not developed in the area investigated. In the second half of the 20th century the outstanding meanders were originated within the framework of meander belt and their development was extremely accelerated. In the last thirty years this meanders have been cutted off by continuing erosion and moved. In this period undercut slopes have shifted downstream approximately about 100-120 m, slip-off slopes about 70-100 m. Owing to lateral erosion the lateral moving of meanders did apprimately 40-60 m.

Historical maps provide valuable informations about development of river bed and for dating of young alluvial deposits. Research area enables to link historical data to next investigations of river bed and floodplain landforms. It is necessary to establish nature and to forestall a river canalization.

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LATE-HOLOCENE SLOPE DENUDATION IN THE POLISH TATRA MOUNTAINS
SEEN IN THE LIGHT OF LACUSTRINE SEDIMENT STUDIES

KOTARBA, A.

Overdeepened mountain valleys filled with lakes are natural traps collecting sediments that were washed down from granodiorite debris slopes during the Holocene. Lacustrine sediment cores were recovered from the Czarny Staw Lake (1621 m a.s.l) and Zielony Staw Lake (1672 m a.s.l) in the Gasienicowa Valley, High Tatra. Both lakes are adjacent to debris flow affected talus slopes. Gyttja type sediments (content of organic matter 20-25%) are interbedded with minerogenic layers (content of organic matter 1-5%). X-ray radiography of the sediment cores from the lakes was utilized to reveal the vertical bulk density variation and the structure of the sediment layers. Grain size changes in the cores are interpreted as sedimentation variation during quiet periods separated by periods with extreme events on the surrounding debris slopes. The layers of sandy and sandy-silty layers produced by turbidity currents, recognized within gyttja are directly related to debris flow single events or periods of events.

The mean rate of deposition during the Holocene (0,15-0,2 mm/yr) gives only a general idea about sedimentation rate. Real values are changing in successive time spans. It was evidently found that substantial debris flows occurred in the Tatra Mountains during the Little Ice Age. Sedimentation rate for the period from about 1300 A.D. to 1860 A.D. is as high as 0,36 mm/yr. Coarser sediment pulses at that period suggest that at least six extreme events or periods of debris flow activity occurred in the High Tatra Mountains. The most important event was the last one (ca 1840-50), and is correlated with the largest and relict morphological features (debris flow levees, tongues, gullies) dated by lichenometry on the surrounding slopes.

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YOUNG LANDFORM DATING BY USING OF CAESIUM-137

LEHOTSKÝ, M.

Agriculturally utilized landscape is one of the most dynamic semi-natural system. As to the dynamic and experimental geomorphology the study of young landforms and processes are very interesting in this type of landscape utilization. Researches concerning arable land development and management are actual not only from the scientific point of view but these studies have great importance in the practice too. In the last decades for this purpose so called caesium-137 method has been begun to utilize. This procedure serves for the determination of the rate of erosion-accumulation processes during last 35-40 years as well as for the dating of very young landforms which can be identified only due to very detailed geomorphic mapping. Utilizing this method it is possible to distinguish as to the shape very similar but as to the genesis very different landforms too. Examples of a colluvial fan (Luborča study area), moderate undulated toe-slope part (Bzince study area), bottom of dell and very young slope microbasin (Voderady study area) and dell bottom subsurface undulation (Pata study area) are presented.

TIME, MAGNITUDE AND FREQUENCY IN CONTEMPORARY GEOMORPHOLOGY
(SOME THEORETICAL ISSUES)

LI, Y. Q., JU. X. M.

Much of our current understanding of the magnitude-frequency characteristics of geomorphological events derives from the work undertaken by Wolman and Miller (1960), who contended that most sediment transport is achieved by intermediate events of high frequency, though the semiarid environment could well present as an exception, where extreme events tend to be far more important. Event timing and landscape recovery were later added by Wolman and Gerson (1978) into the consideration, both factors thought to be also significant controls on the geomorphological effectiveness of an erosive event. Time, magnitude and frequency are three main concepts central to the tenets of contemporary process geomorphology, though their true significance in landform development still remains to be fully defined. Much existing controversy over catastrophism, uniformitarianism and equilibrium attests to the present deficiency of our knowledge about the forces-over-time problem and, until some thorough understanding is reached, present process studies as providing a key to long-term landform development will remain as an unfulfilled promise in the earth sciences (Douglas 1982).

Applicable landform evolution models are difficult to develop, if no detailed field evidence is available to test them. This is probably true of the prepositions Thornes and Brunson (1979) prescribed for geomorphology, and indeed also of Brunson's (1991) latest ten commandments of geomorphology. Based on a wide range of field observations from many parts of the world, this study sets out to provide a critical review of some of the theoretical issues concerning time, magnitude and frequency in geomorphology. Emphasis is placed on several widely-held views and future directions for further research are outlined.

TIME IN THE EVOLUTION OF SEMI-ARID CATCHMENTS
(THE LOESS PLATEAU MODEL)

Li, Y. Q., Ju, X. M.

Based of field observations in Wyoming, USA, Schumm and Hadley (1958) put forward a model of semi-arid erosion cycle which arranged three distinctive catchment landforms types, namely: catchments being deeply entrenched at the outlet, catchments having actively eroding source tributaries, and catchments experiencing aggradation in the lower reaches, in a sequential order to generalize how the catchments have evolved in time. Erosion is thought to begin from the outlet and with time, the belt of maximum erosion migrates upstream, more channels created in the process. Active lowering of the source areas and gradual aggradation in the lower reaches finally lead to a relatively uniform catchment relief, which completes an erosion cycle. It follows that the Schumm and Hadley model is particularly applicable to places of relative tectonic stability where deposition also occurs in great quantity in the lowland areas. Modification to the model is necessary if either of these two conditions does not hold.

The vast Loess Plateau in NW China is a semi-arid region that has underwent periodical tectonic uplift throughout the Quaternary, further, the sediment delivery ratio in the area generally approaches to unity (see Walling 1983), due to an efficient gully conveyance system, the fine loessial particles of a low settling velocity and the flashyness of extreme floods. The loess catchment development is shown to follow a unique sequence of evolutionary stages.

STABILITY - THE FUNCTION OF TIME

LIKHACHEVA, E. A.

Stability is a property of relief to preserve its diverse state character for significant periods of time during environment changes. This period of time can be defined as "the time of stability".

"The time of stability" during natural development of relief t_1 depends on a number of factors: age of landforms (A), form's dimensions (D_1), lithology of rocks (L), tectonic conditions (T), climate of the area (C), stability of the adjacent landforms (S_1). All these factors can be presented in the following form:

$$t_1 = f (A, D_1, L, T, C, S_1)$$

"The time of stability" of relief having undergone anthropogenic influence is determined first of all by the stability of natural relief (its time of stability) and then by correlation of dimensions of landforms, and the degree of influence ($D = D_1/D_2$), time of influence (t_1), intensity of influence (i). The latter is defined by the degree of lithological, climatic, tectonic changes, and also changes of the adjacent landforms (S_2).

"The time of stability" of the anthropogenic relief can be presented in the following form:

$$t_2 = f (t, D, t_1, i, S_2),$$

where t_2 can be equal to t_1 , or more or less than t_1 , that is determined by the level of management - activities on rational management of agriculture, techniques, and their interactions with relief. Hence, plans should be worked out to regulate "the time of stability", activizing or lowering natural geomorphological processes.

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FIRST-ORDER ^{14}C DATING OF THE COASTAL RANGE, EASTERN TAIWAN

LIN, J. CH.

The purpose of this study is to produce a chronology of the neotectonic landforms of the Coastal Range using absolute dating techniques in order to (a) test the assumptions of the tectonic movement model; (b) determine the absolute ages of the raised beaches and thereby ascertain the degree of coastal deformation to be incorporated in the model.

The First-Order ^{14}C dating method has been adopted to obtain these chronological data. It involves sampling, pretreatment, extraction of ^{14}C and determination of the rate of ^{14}C decay. The samples used are mainly from coral and shells as their original environment of deposition is known. The intertidal zone where these samples originally inhabited is readily recognised and therefore provide a good indicator of the effect of the neotectonic regime on coastal landforms.

From the results of ^{14}C dating, it has been shown that the coastal area has a differential uplift rate ranging from 0,4 to 4,4 mm/yr in a non-linear relationship. The difference between each different sampling section, and the clear evidence of fault control demonstrated by reference to the structure of the area. The Coastal Ranges is not being uniformly uplifted.

GEOMORPHIC PROCESSES IN THE LIGHT OF QUATERNARY BIOSTRATIGRAPHY

LOŽEK, V.

The development of biocoenoses is affected by relief changes in time and space. Biostratigraphic analyses of depositional sequences thus may throw light on geomorphic processes which controlled their formation. They provide information on the following aspects of particular processes and events: /1/ geological age, /2/ rates of deposition or erosion, /3/ reconstruction of environments, /4/ estimate of accumulated or eroded soil volume. Most favourable conditions occur in karst regions or lime-rich areas where fossiliferous series are developed in a wide variety of facies and position. Within the time span Pliocene-Pleistocene particularly large-scale processes and events can be traced, e.g. the process of valley formation on the basis of terrace sequences which enable erosional, depositional as well as standstill phases to be distinguished, or the process of karstification reflected by the cave fills of various age. Sedimentary fills in cave entrances and rock-shelters are strongly affected by sheet erosion and slope retreat. Valley floor sediments date the last phase of downcutting and reflect in detail the Postglacial climatic development. Tufa deposits with soil or scree intercalations record the history of scree accumulation phases alternating with precipitation of pure CaCO_3 corresponding to standstill intervals. During the last 7 millenia anthropogenic impacts can be documented by the correlation of archaeological findings with biostratigraphically treated sequences. Our data demonstrate a reasonable relationship between the relief changes and biostratigraphic data whose correlation may considerably contribute to the knowledge of landscape development.

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**VOLCANITES-SCULPTURAL LANDFORMS INTERFERENCES IN THE ROMANIAN
VOLCANIC MOUNTAINS (PREMISES FOR DATINGS IN GEOMORPHOLOGY)**

MAC, I., IRIMUS, I.

There are numerous interferences between volcanites and sculptural landforms both on the interior of volcanic mountains and on their border with The Transylvanian Basin.

The overlapping and interference of volcanic products with polycyclic levelled surfaces from Mount Metaliferi permit the establishment of their age.

Similarly, the interferences which appear at the level of accumulation fluvial forms in valleys of the Aries, Ampoi, Olt and Mures River are evaluated and chronologically differentiated, stating in this way the morphogenesis periods. Taking into consideration the fact the manifestation of magmatic-volcanic processes took place successively from the Badenian to the Pleistocene, the temporal scale of the datings has a very wide gauge.

In this way dating could have been extended for other regions too, regions which were not affected by volcanism but their evolution took place in the same time and in the same manner as the interference regions of volcanism with exogenic landforms.

**RATE AND DYNAMICS OF CONTEMPORANEOUS EROSIVE PROCESSES INDUCED BY
THE SURFACE RUNOFF IN HIGH MOUNTAINS OF THE WEST CARPATHIANS**

MIDRIAK, R.

Research was carried out by the deluometric method, e.i. direct measurements of the surface runoff, its turbidity and an amount of the soil loss.

Results of studies are very different according to a kind of ground surface and/or a vegetation cover. Minimum of surface runoff is in the spruce- and dwarf-pine stands where from 87,4 to 189,1 m³ of water is outflowing per hectare per annum. During that runoff (with the turbidity of 0,13 g load per litre) 39 to 152 kg.ha⁻¹.yr⁻¹ of soil is lossed.

There is 210,8 m³.ha⁻¹.yr⁻¹ of surface runoff, an average 0,14 g.l⁻¹ of turbidity and 169 kg.ha⁻¹.yr⁻¹ of the erosive soil losses on the both bare places in forest stands and uprooted tree places. From the surface of the grass-covered subalpine and alpine belt an amount of the surface runoff is 222,1 m³ and the soil loss is only 59 kg.ha⁻¹.yr⁻¹. A great deal of soil is removed by the surface runoff from the ground with a thin vegetation cover within the forest and the subalpine belts (e.g. ski routes). The runoff on that ground is 327 m³ and soil loss 3 437 kg.ha⁻¹.yr⁻¹. Maximum of the runoff (632 m³.ha⁻¹.yr⁻¹) with the turbidity of 0,41 - 0,61 g.l⁻¹ is on the disturbed soil mantle above the timberline. There are soil losses as much as 4 556 kg.ha⁻¹.yr⁻¹ there.

Time distribution of soil losses by seasons in the forest and dwarf-pine stands: spring 20 to 36 %, summer 26 to 42 %, autumn 22 to 36 %, winter 11 to 22 %. On the bare and destructed surfaces above the timberline a great deal of erosive soil loss is displaced during summer (52 % on the average). Frequency of severe soil losses occurrence in the area above the timberline is once for 2 to 15 years in the Tatra Mts or once for 25 to 30 years in other high mountains of the West Carpathians, respectively. The frequency is mostly identical with the occurrence of heavy rains of rate 100 mm per 24 hours and more.

MAIN STAGES OF THE WEST CARPATHIANS GEOMORPHOLOGICAL EVOLUTION AND THEIR DATING

ONDRÁŠIK, R.

The West Carpathians are characterized by mountain ranges and basin topography. The last comprehensive concept of their geomorphological evolution had been set up thirty years ago by Lukniš and Mazúr. Their interpretation was based on the ideas of the alpine and the following germanotype tectogenesis. Later discoveries have not proved the validity of their interpretation in all aspects. Among such discoveries belong e.g. the differential uplift of granitoid bodies occurring since the Carboniferous-Permian period in the Inner West Carpathians and since the Neogene period in the outer parts of the Inner West Carpathians, the depth and shape of the Moho-discontinuity, the south-east dipping of textural planes in the lithosphere of the Inner West Carpathians, differential kinematics of the Neogene subduction of basins based on chronostratigraphy of filling sediments, the role of gravitational tectonics in the geomorphological evolution of various areas and its correlation with the distribution and development of slope deformation, etc.

A more convenient framework for the interpretation of the above-mentioned discoveries and their correlation with the geomorphological evolution of the West Carpathians represents the principles of the new global tectonics. The adapted interpretation of the West Carpathians geomorphological evolution with the definition of the main stages and their dating, is to be presented for discussion.

ARCHAEOLOGICAL DATING, GEOMORPHOLOGICAL RECONSTRUCTIONS AND
PALAEOCLIMATIC CORRELATIONS IN NORTHERN SPAIN

PEÑA, J. L., CHUECA, J., JULIAN, A.

The datings carried out by geoarcheological techniques in slopes and infilled-valley deposits located in northern Spain, have allowed us to establish several evolutive sequences resulting from the alternance of fill and downcutting stages. Such sequences are due to environmental changes mainly generated by climatic variations during the oldest phases (Upper Pleistocene-Holocene), or by the combination climate-anthropic activity along the Upper Holocene. In this area the best chronological and palaeoclimatic information is given by slope deposits, linked to the clear individualization of different stages provided by the existence of intermediate downcuttings. Besides, processes that originate slope-regularizations are more easily related that infilled-valley ones to particular thermopluviometric and environmental conditions.

Following these geoarchaeological criteria, we identified in study area several evolutive sequences developed along the Upper Pleistocene and Holocene that permit the outlining of a first chronological approximation to the palaeoclimatic characteristics of a broad area placed in the northern Spain (Ebro river basin). This data, basically obtained in the lowlands, has been related to the climatic phases previously established - through the use of absolute dating methods, palynology, lichenometry, etc. - for the two neighbouring and marginal mountainous ranges (Pyrenes, Iberian Chain), and confirm the existence of a high degree of simultaneity among palaeoenvironmental events developed in both areas.

**CONTEMPORARY TRENDS OF THE RIVER CHANNEL BEDS
(CASE STUDY FROM ROMANIA)**

RADOANE, M., ICHIM, I.

Our study occurs to discuss the contemporary trends of the riverbed dynamics of almost the whole area of the Eastern Carpathians. The quantitative data represent the measurements of the maximum river depth in over 70 cross sections from 42 streams over periods between 11-30 years. The data were elaborated graphically to facilitate the study of the phenomenon behavior in time, to apply some techniques of the time series statistical analysis and, finally, to favour the comparison of the trends. We also viewed the analysis of the discharge regime to establish the main causes that favour some trends of the riverbed dynamics. Also, we analysed the channel deposit's variability related to the long profile form.

The linear tendency of the vertical riverbed dynamics was evaluated by means of a time function: $y = a + b \cdot x$, where y = riverbed elevation in centimeters and x = time in months. We considered that the degradation tendency is expressed by the negative values of the regression coefficient, the aggradation by positive values and a certain stability by the values of the coefficient close to zero. We used the regression coefficient value (b) as index of the vertical riverbed mobility in the considered area. By means of these values we evaluated the dominant riverbed process (degradation, aggradation) and stability in the 73 cross section. The same coefficient value (b) enabled us - through the repartition frequency - to notice that: degradation is most frequent of the riverbed processes in the Eastern Carpathians.

The polynomial trend in the vertical riverbed dynamics was determined by means of the polynomial functions of the 2nd, 3rd, 4th order. They indicate an existence of aggradation - degradation cycles, which are superposed on the general trends (uplifting and sinking) of river channels.

The periodical components of the series referring to the riverbed elevation were determined by means of the spectral analysis.

Final conclusions of the paper are related with areal distribution of the riverbed mobility and with main controlling factors.

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ELECTRON SPIN RESONANCE (ESR) DATING IN GEOMORPHOLOGY

RADTKE, U.

ESR dating has been systematically applied in earth sciences and archaeology since 1975 when IKEYA dated a stalactite from Japan. In the meantime this relatively new technique has been successfully applied to the dating of material such as speleothems, mollusc shells, corals, tooth enamel and quartz. The major emphasis of this "state of the art" paper lies on the outline of the application of ESR dating in geomorphology. Besides these general topics special emphasis lies on the presentation of ESR dating results from coral reef tracts as a tool in timing and reconstruction of the Quaternary sea-level curve. Examples and unpublished data from Papua New Guinea, the islands Kikai-Jima and Hateruma (Japan), Sumba (Indonesia), Barbados and the atolls Rakahanga and Pukapuka (Cook Islands) are presented. ESR dating of corals covers at least the whole Middle and Lower Pleistocene and the Holocene. The precision of the technique allows to distinguish between isotopes stages 5a, 5c, and 5e. For samples from stages 5 to 9 the precision of repeated analyses were in the range of 10 %. Samples from stages 11 to 17 display an increasing age scattering. ESR dating of corals extends the dating range of the U-series dating methods up to at least 600 000 yrs B.P.

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TIME AND FREQUENCY OF SLOPE EROSION EVENTS IN NORTHERN MOUNTAINS

RAPP, A.

Based on field studies in Scandinavian Mountains and Spitsbergen in the 1950's and later the dating and frequency of geomorphic events will be discussed in this paper. Two altitudinal zones of debris slopes will be high-lighted: 1) blockfields (felsenmeer) on high plateaus and 2) talus slopes on valley sides. It is argued that in north Scandinavian Mountains the felsenmeer of altitudes above ca 1200 m a.s.l. and an annual mean air temperature of below -4 C are a zone of very slow glacial and periglacial geomorphic development, due to conserving permafrost and cold-based glaciers. The middle-alpine altitude belt of ca 600-1200 m is a zone of more rapid geomorphic development, as shown by case studies in the Abisko area, north Sweden.

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MAGNITUDE, FREQUENCY AND DATING OF FLOODS - SOME QUESTIONS AND INITIAL ANSWERS FROM A STUDY IN THE NEGEV DESERT, ISRAEL

SCHICK, A. P., GREENBAUM, N.

Several extraordinary floods, often but not always with a marked geomorphic effect, have been identified and studied in several parts of the world's arid zone. Among these, several had occurred in the veritably dry ("hyperarid") belt of the Middle East and were studied in some detail: the 1966 Ma'an Flood (Southern Israel & Southern Jordan), the 1971 Mikeimin Flood (Southern Sinai Peninsula), and the 1975 El-Arish Flood (Sinai and Negev Deserts).

While estimates of the magnitude of these and other similar floods in deserts elsewhere vary considerably according to scientific, technical and logistical constraints, the problem of the frequency of these events presents even greater difficulties. One method, recently developed by the Arizona school of geomorphology and adopted since by several other groups, uses sedimentation relics of historic and even prehistoric floods for radiometric dating in conjunction with the reconstructed peak flow channel cross section and hydraulic characteristics. The relics, called paleo-stage indicators (PSI), are mostly in the form of slackwater deposits (SWD), which offer relatively abundant and reliable chronostratigraphic evidence to enable an adequate statistical analysis of frequencies.

In a study currently in progress in the Central Negev Desert, a flood in the 1400 sq km catchment of Nahal Zin, which exceeded the highest flow observed during the instrumental period of the last 40 years by a factor of more than 2, has been dated at 885 y BP. Although questions of temporal stability - both of channel geometry and of climate - do present themselves, the continuation of the study is bound to shed new light on the magnitude-frequency relationship of desert floods and, through these, on the basic controversy of the magnitude-frequency balance in geomorphic processes.

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MAN'S ACTION AND SLOPE EROSION. THE CATASTROPHE IN AROSA (1981)

de SERPA MARQUES, B., de SOUSA PEDROSA, A.

When a catastrophic landslide occurred in a small river basin on the left bank of the Tamega Valley, in the Northeast of Portugal, which involved the sudden sliding of several tons of arable land and rocks and caused the destruction of a house and the death of some twenty people in 1981, the authors decided to carry out a careful investigation of this geomorphological phenomenon.

After having formulated a number of hypotheses, they did a lot of fieldwork in the area and carried out measurements to determine, as accurately as possible, both the real extension and the causes of the occurrence of such a phenomenon in that particular place and at that particular time of the year.

A series of studies enabled the authors to come to the conclusion that both natural and human-induced causes had been responsible for the disaster.

Among the conclusions they reached, they would like to emphasize the following:

- 1 - the sharp angle of the slope;
- 2 - a long period of heavy rainfall;
- 3 - the long-term use of the valley for agricultural purposes which interrupted the talweg as the bed of the small temporary brook had long been used to produce corn and vegetables;
- 4 - the destruction of the natural system of drainage of rainwater, specially important in years of unusually heavy rainfall;
- 5 - the recent deviation of the runoffs to avoid the formation of rills in a newly-rebuilt road leading to the local farms; this deviation favoured the flowing of the runoff to the primitive valley axis, now turned into cultivated land, as it has already been said above;
- 6 - the construction of a building right at the bottom of the mentioned valley, so breaking off completely the natural flow of the water.

Disasters like this don't unfortunately constitute isolated incidents. Therefore, the authors think it is very important to study the local geomorphology carefully before any local authority begins planning or allows the building of houses or the setting up of any human activity within the territory it is responsible for.

UTILIZATION OF THE PEDO-GEOMORPHIC APPROACH IN A STUDY OF VALLEY
NETWORK CHANGES (ON THE EXAMPLE OF THE GIDRA CATCHMENT IN
THE DANUBE LOWLAND)

STANKOVIANSKY, M., LEHOTSKÝ, M.

This contribution is devoted to changes of spatial distribution of valley network in the lowland part of the Gidra catchment in one of the loess islands of the Danube Lowland.

The Gidra River is predominately a lowland flow. It issues in the Malé Karpaty Mts, which is a positive horstlike morphostructure. The length of the flow in the mountains is 10 km. Leaving the mountains down to tectonically dropping negative morphostructure - the Danube Lowland - the flow runs in a length of 28 km across the Trnavská Pahorkatina Hilly Land, which is one of islands representing an upper step of the lowland. The Gidra River is cut into its proluvial fan below the foot of the Malé Karpaty Mts and downwards (to Cifer) crosses the hilly step built of the Neogene sediments, covered by loess loams. Below Cifer the Gidra River flows across the region of the Trnavská Tabuľa Table, built of the Neogene sediments covered on average by a 16 m thick layer of loess. It flows into the Dudváh at Malá Mača. In its lowest part, the Gidra River is situated in a tectonically conditioned longitudinal depression prolonged in the direction of the flow (NW - SE), the width of which is 3-4 km.

There has been elaborated a hypothesis of the repeated changes of river network in this region on the basis of results of the detailed geomorphic investigations connected with a mapping to the scale 1 : 10 000 and an analysis of the valley network pattern of the Gidra catchment in the above mentioned tectonic depression as well. The hypothesis has been based on an assumption of stagelike migration of the Gidra River valley from SW margin of the depression towards NE. Evidence for such a hypothesis is the presence of soils with a mollic diagnostic horizon (fluvi-haplic phaeosol) in abandoned flowless valleys.

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**FLOOD FREQUENCY DURING THE HOLOCENE IN THE UPPER VISTULA BASIN
(BASED ON SEDIMENTS, FORMS AND ABSOLUTE DATINGS)**

STARKEL, L.

The detail examination of sediments and forms and determination of their age make possible only rarely to distinguish the beds deposited during single floods and much more often to constate the long-term tendencies of changes in the flood frequency. The best sequence of big floods may be investigated in the near-channel zone of levees or slack-water deposits. On the contrary the registration of long-term changes is much better in facial variations on the flood plain and in the creation of cuts and fills combined with avulsions and changes in the channel sizes. The radiocarbon method help to approximate the age of events (up to one century). The black oaks correlated by the dendrochronological method make possible to distinguish even separate floods.

In the upper Vistula basin a more detail picture of flood frequency may be reconstructed for last 2 centuries as well as for the transition between The Boreal and Atlantic periods. Facial and channel pattern changes as well as frequency of black oak deposition help to identify phases of the higher flood frequency: end of The Younger Dryas, 8700-7700 BP, 6600-6000, 5200-4900 4550-4350, 3300-2850, 2350-1650 BP, V-VIc AD, X-XIc AD and from XVIc. New records slightly changed a previous author's picture from 1983. The flood phases correlate well with other records on glaciers, lakes, vegetation etc. The evaluation of the role of the human intervention in the flood frequency is still open.

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DATING AND FREQUENCY ANALYSIS OF GEOMORPHOLOGICAL PROCESSES USING
DENDROGEOMORPHOLOGICAL METHODS

STRUNK, H.

For the past three years, we have evolved and re-examined several dendrogeomorphological methods for frequency analysis of debris flows. For this purpose we analysed about 200 buried and 260 undisturbed spruces (*Picea abies*) from five study areas in the Alps. Additionally, we have excavated 40 buried spruces down to the original root systems and found that all these trees react even to a slight accumulation of debris by suppression, which is a pronounced decrease in growth. Consequently, several burial events cause several phases of suppression. Thus, for each event the time of burial can be dated by determining the first narrowing of annual rings in the trunk with a precision of ± 0 to ± 3 years.

Since growth-ring sequences may vary from normal to reduced or widened tree-ring diameters even in undisturbed trees, due to climatic variations, it is indispensable to establish a standardized curve of normal growth conditions in each study area, representing the arithmetic average of the tree-ring width in every single year as obtained from about 40 dominant undisturbed trees. This curve helps to distinguish climatic variations in the widths of growth-rings from those due to burying by debris.

With the help of phase-diagrams of suppression from 140 buried spruces on a debris flow cone we can reconstruct the spatial distribution of each of 12 debris flow events having happened since 1830. The medium recurrence interval of debris flows on this cone is about nine years between 1884 and 1989, with the length of intervals ranging between six and 13 years.

Though among all dating methods the dating of so-called scars, injuries of the cortex of trees caused by the collision with boulders during debris flows shows a very high precision of ± 0 to ± 1 year, similar injuries may be caused by avalanches and timber transport. The most reliable among several current dating methods proved to be the determination of the year of sprouting of the oldest root in each horizon of adventitious roots and of the start of suppression in tree-ring sequences of buried trees. Both methods work with a precision of ± 0 to ± 3 years.

CYCLICITY AND FREQUENCY OF LANDSLIDES IN ROMANIA

SURDEANU, V., ZEMIANCHI, S.

Landslides represent one of the major erosional phenomena in Romania. There were several researchers who have made only ascertain approaches, as far as their frequency and spatial development is concerned.

They rely on historical documents, pollen dating and C₁₄ dating. They also underlined the role of the Riss-Wurm interglacial for the Holocene evolution in order to state the age and importance of landslides on hillslopes.

On the basis of an over 150 years of climatic records and by stating the periods of maximum humidity, they came to the conclusion that there existed at least three periods of maximum development of the process: 1912-1914; 1940-1942; 1970-1972. During the last period the process had a great extension in Transylvanian Tableland, Moldavian Tableland, Oriental Carpathians and Subcarpathians. It was predicted that at the end of the millenium there will be another cycle of intense activity of landslides.

On the background of this major cycles there were other smaller cycles of about 3,7 and 13 years which reactivated old landslides.

Finally, the topometric and inclinometric measurements show very clearly the existence of seasonal cycles of this dynamic process.

After examining the spatial distribution it comes out as a fact that high frequency of the process appears on regions in which lithology is very rich on clay components.

A NEW APPROACH IN UNDERSTANDING OF GEOMORPHOLOGICAL TIME

TIMOFEEV, D. A.

In geomorphology the problem of time is not only associated with the age dating of relief according to the scale of absolute time. On the assumption of scientific views of Vernadsky, time along with space is regarded as structural discrete - continuous categories. There can be distinguished a) the time of individual being - the time of development of separate form of relief, or its elements; b) the time of species - the duration of geomorphological landscape development, or types of relief; c) the time of evolution - the periods of time corresponding to paragenetic complexes of types of relief and embracing periods of geomorphological cycles. Every elementary morphological unit of the surface, every form of relief, a geomorphological landscape have been existing in their own spacial time. Every spatial - genetic and morphodynamic category of relief reflects the whole complex of events; daily, seasonal, of many years, secular, stages and cycles. These events can be of slow, continuous, evolutionary character, yet they can be changed by catastrophic periods of active life, separating periods of relief or absolute stability, when the time for a particular object (a form or process) disappears. The geomorphological time is able to compress or widen, to accelerate or slow down in the dependence on the force and the number of events.

For ecological geomorphology it is very important to estimate the intensity and the recurrence of geomorphological events and the prognosis of possible consequence of these events. The absolute (geological) time can be regarded as an instrument of geomorphological events, changes of processes, forms and sets of forms of relief. The study of discrete geomorphological time as one of the factors of morphogenesis - is the key to understanding of morphodynamic mechanism.

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AGE AND TIME OF RELIEF: RESULTS OF THE IRKUTSK CONFERENCE 1991

TIMOFEEV, D. A.⁽¹⁾, UFIMTSEV, G. F.⁽²⁾

The conference of the Soviet geomorphologist "Age and Time of Relief" was held in Irkutsk (East Siberia) in September 1991. There were discussed diverse aspects on the problems of time in geomorphology: theoretical, methodological, regional. In the field of theory and methodology the discussion was focused on the two main problems: 1) the notion "geomorphological time" and its association with philosophical interpretation of time; 2) principles and methods of geomorphological chronology and the age dating of relief. There was presented a concept of discrete - continuous aspect of geomorphological time, associated with discreteness of geomorphological space, discussed the role of events in the history of morphogenesis. There was proposed to distinguish periods of active life of geomorphological systems of any range and periods of their passive state or rest. The importance of the recurrence of geomorphological events and absolute age dating was emphasized. Hence, the theory of geomorphological cycles was assessed from the new point of view. In accordance with it there were expressed traditional ideas about the continuity of absolute (astronomic, geological) age, the continuity of relief-forming processes development. The new results of regional studies of some areas history development of European and Asian parts of the country, particularly Siberia, were also reported. The new data, including absolute age datings of river valleys and terraces of the Enisey Basin and the Baikal Depression were presented.

All in all the conference outlined the actuality and insufficient elaboration of the problem "time in geomorphology", revealed the existing difference of opinion in the theory and methods of investigation.

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HISTORICAL APPROACHES TO GEOMORPHOLOGICAL DATING

TRIMBLE, S. W.⁽¹⁾, COOKE, R. U.⁽²⁾

Many questions of time in geomorphological processes can be illuminated by examining the historical record of the past century or so. The recent past sets the stage for contemporary processes, which may not be fully intelligible without an appreciation of the past. Extrapolations of process rates and predictions of future changes may require records that are of sufficient duration and accuracy to allow the segregation of short-term and secular trends. The causes and consequences of historical environmental changes are often fundamentally different from paleoenvironmental events because of the unique and often unpredictable role of human activity.

Many landforms adjust to changing environmental conditions over decades. Such adjustments are often very difficult to study from field evidence alone. Historical sources are therefore potentially invaluable not only for calibrating the nature, rates, and locations of medium-term changes, but also for exploring the dynamics of geomorphological systems and their relaxation and reaction times, thresholds, and equilibria. More than that, historical sources may provide the only evidence of the causes and management contexts of change that are fundamental to understanding present landforms and developing the theory and practice of environmental management.

This paper provides a brief introduction to the enormous range of potentially useful dating sources. We recognize 11 broad types of information: travel and exploration accounts; newspapers and journals; instrumented land surveys; topographical surveys; geological, soil, and soil erosion surveys; aerial photographs; ground-based landscape photography; land-use data; drainage and irrigation records; climatological data; and stream and sediment discharge records. Examples from each category are given and discussed.

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GEOLOGICAL AND OWN TIME OF RELIEF

UFIMTSEV, G. F.

Geomorphology uses, commonly, the geological time, which, in this case, has attributes of the Newton's absolute time. It has well elaborated metric and is used under reconstructions of morphogenesis of the past or under study of the modern geomorphological processes where the following calculations use the ideas of classical mechanics. The formula is used "... relief in space and time ...".

The recognition of unity of space-time of relief demands of creation the theory of relational (own) time of relief which is built on the base of properties and relations of its forms being both spatial and temporal. The own time of relief has two varieties: (1) evolutional or genetic rows of the relief's forms which example by the geographical cycle (this is the Davis's time, according to the analogy with the Newton's time or the Leibniz's time); (2) the morphological sequence which is the part of the common spatial-temporal structure of relief and is analogous to the stratigraphical sequence of geological structure.

The geological and the own time of relief have different functional purpose in geomorphological investigations. The geological time of relief - is its period of existence. The morphological sequence and the Davis's time - is the structural time of relief.

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LUMINESCENCE DATING OF SEDIMENTS - LIMITATIONS AND PERSPECTIVES

ZÖLLER, L.

During the past decade, TL dating of eolian sediments has developed to a reliable method. This is based on the fact that long bleaching by sunlight is able to reset the "clock" to a level close to zero, which can be reproduced in the laboratory. If the illumination during transport and deposition of a mineral grain was not sufficiently long and intensive ("partial bleach"), TL ages be overestimated. This is often the case for several fluvial and lacustrine sediments. Special "partial bleach" methods have been suggested to date those sediments, but the results still remain questionable in some cases, e.g. the Holocene flood-loams from smaller rivers. Sediments transported by solifluction, mud-flows, turbidity currents and similar spontaneous mass movements cannot be dated by TL.

Great experience exists in some TL laboratories for dating of loess and dune sand, but also raised beaches have been dated successfully. Meanwhile eolian sediments can be dated reliably within their typical error bars of 10-15% in the range between a few and about 100 ka. Thus, the TL method is able to date the entire last glacial-interglacial cycle. The upper limit is still under discussion. It depends on the material, the grain size and mineral fractions, and the laboratory technique. TL ages from the fine-grain (4-11 μm) fraction of loess, older than the last interglacial, are more or less underestimated, if compared to ages derived from the tuned oxygene isotope chronology. Those TL ages have to be regarded as minimum ages. According to our experiences from numerous loess sections in Middle and Eastern Europe it seems possible, however, to establish a relative loess chronology as far back as the penultimate interglacial.

The upper limit of TL dating of eolian sand has not yet been established unambiguously, but reliable ages as old as some 500 ka seem possible under certain circumstances, especially from sediments with very low natural radioactivity.

Consequently, cycles of geomorphological activity reflected by deposition of eolian sediments can be reliably dated as far back as 100 ka, in some cases even further back. The time resolution can normally not be much better than about 10% of the age. Examples from the European loess belt and the subtropical desert belt will be presented.

The newly emerging optical dating techniques (Optically Stimulated Luminescence, OSL) look more promising for reliable dating of partially bleached sediments. Error bars and upper age limits are in the same order of magnitude as for TL dating, but especially for young (e.g. Late Glacial-Holocene) sediments systematical errors due to partial bleaching are supposed to be much smaller.

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