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3

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CONTENTS

LANDSCAPE OF PSAMMOSTEPPES OF THE IRTEK RIVER VALLEY IN SOUTHERN RUSSIA

Alexander A. Chibilyov[*], Tadeusz Szczypek[**], Stanisław Wika[***], Olga G. Kalmykova[*], Zhanna T. Sivokhip[*], Pavel V. Velmovskiy[*]

Introduction

Psammosteppes in the valley of the river Irtek (a tributary of the river Ural – Fig. 1A) are one of a few regions of aeolian sands spreading in the southern part of Orenburg region, Russia, which are contemporarily overgrown with specific herbaceous psammophilic vegetation. These psammosteppes occur both in the zone of typical *fescue-feather grass steppes* (*Festuca* sp. – *Stipa* sp.) and southern *absinthium-grassy steppes* (*Artemisia* sp.), which are situated more southwards. To the north of them, a belt of *grassy-feather grass steppes* has developed (Fig. 1B; Geograficheskiy atlas…, 1999; Enciklopediya..., 2000; Chibilyov 2003). Psammosteppes described in this paper have developed in the overflood terrace of the right part of the lower section of the Irtek valley (Fig. 1C), where they cover the area of about 15–16 sq km.

The research area is characterized by a dry continental climate. Total yearly precipitation there falls between 350–400 mm, with the thickness of the snow cover being small – not exceeding 30 cm, and ground being frozen to the depth of 140 cm in winter. The average yearly air temperature is +4.1°C, but thermal contrasts between summer and winter are distinct there: the average temperature in June amounts to +22.0°C (maximum 42.0°C), while in January – -14.5°C (minimum -44.0°C). Hence, the maximum yearly temperature amplitude amounts to 86.0°C. The research area of the Irtek valley is characterized by diverse anemological regime: north-westerly winds prevail in summer (dry southerly winds, reaching the velocity of up to 20 m/s, also occur in that period), whereas easterly winds in winter. Winter and early spring winds generally show highest velocities (10–15 m/s on average; Geograficheskiy atlas…, 1999; Enciklopediya..., 2000; Chibilyov 2003).

The area of the overflood plain in the lower Irtek is composed of gray-yellow sandy and sandy-dusty deposits. At the Pleistocene-Holocene interface, the upper part of these sediments was subject to intensive aeolian proc-

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esses. That resulted in creation of various accumulative and deflational landforms. As recently as the early part of the 20th century, when the population of cattle, goats and sheep (1936) was about 30 thousand, the area was still largely stabilized by herbaceous vegetation. Rapid growth of cattle, goat and sheep breeding 1970s and 1980s (their population there reached about 150 thousand in mid-1980s) resulted in destruction of the plant cover and aeolian processes were started again in most of the discussed area: sandy material was intensely moved by wind. As the result of the economic crisis, the stock of bred animals has decreased significantly since the beginning of 1990s (the population of cattle, goats and sheep was still as much as 110 thousand in 1990, and only slightly over 60 thousand in 2001), which resulted in moving sands being immobilized by herbaceous vegetation and clumps of shrubs in depressions, where the groundwater table was closer to the surface.

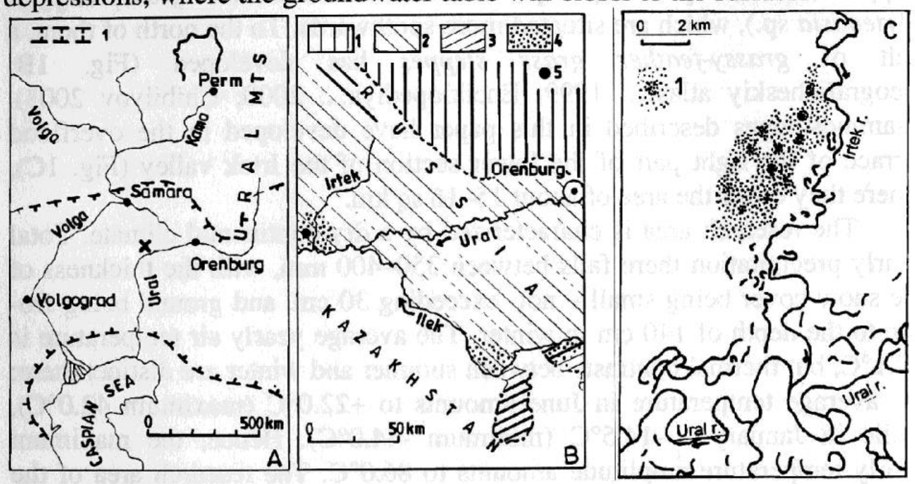

Fig. 1. A – Location of investigated area (x) against a background of limit of steppe zone (1), B – location of investigation area against a background of steppe landscapes (after: Geograficheskiy atlas..., 1999): 1 – zone of northern steppe (grassy-feather grass steppe), 2 – zone of typical steppe (fescue-feather grass steppe), 3 – zone of southern steppe (absinthium-grassy steppe), 4 – psammosteppes, 5 – area of investigation, C – location of aeolian sands (1) in the Irtek river valley (after topographical map 1:200 000)

Results

Prevailing in the contemporary landscape of psammosteppes over the river Irtek are densely distributed, relatively low (4–8 m) oval dune hummocks with softened outlines, separated with wind-blown troughs of various sizes and shapes (Photo 1). It is difficult to distinguish any distinct dune types among them, as their formation is not promoted by the aforementioned varying directions of prevailing winds. Thus, there could not be formed distinct, easily classified types of dunes; instead, dunes have formed which join one another and have complex outlines. The term „barkhan", commonly used here, relates to dunes of any shape and does not reflect real desert or semidesert dunes of specific shape or origin.

The presently forming aeolian features in psammosteppes of the Irtek valley is of typically deflational nature, because various formerly shaped dune formations are blown away (Photo 2). Examples of such deflational features are presented in geomorphological sketches in Figs. 2–4.

Photo 1. General view of psammosteppes near Irtek river valley (photo by T. Szczypek)

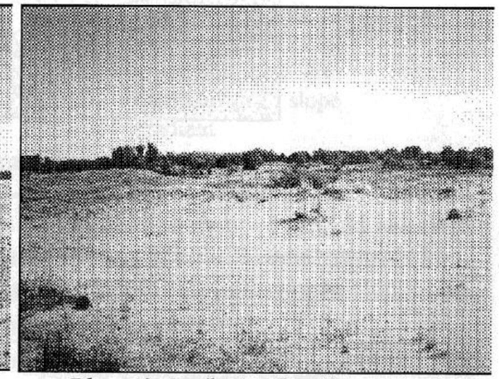

Photo 2. Deflation landforms of psammosteppes near Irtek river valley (photo by T. Szczypek)

These sketches indicate that the formations they present were mostly created as the result of winds from the southern sector. Prevailing among the elements of the surface features are more or less extensive plains, wind-blown troughs and ditches, as well as deflation remnants of various sizes and shapes. Old dunes are still represented here by remains of typical leeward slopes (windward slopes have been practically completely destroyed).

The results of aeolian accumulation are usually much less visible. The can be seen in the form of small covers of blown sands and sandy mounds (sandy shadows), which form in the shade of tufts of mainly grassy vegetation.

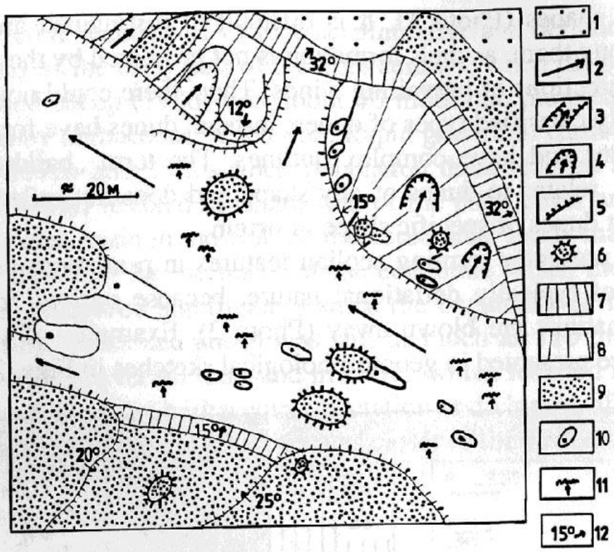

Fig. 2. Geomorphological sketch of psammosteppe fragment in site Ilmenskiy barkhan: 1 – stabilised aeolian forms, 2 – deflation plate, 3 – deflation tunnels, 4 – deflation basins, 5 – deflation edges, 6 – deflation remnants, 7 – leeward slopes, 8 – windward slopes, 9 – covers of blown sands, 10 – sand shadows of nebkha type, 11 – ripple-marks, 12 – size and direction of slope gradient

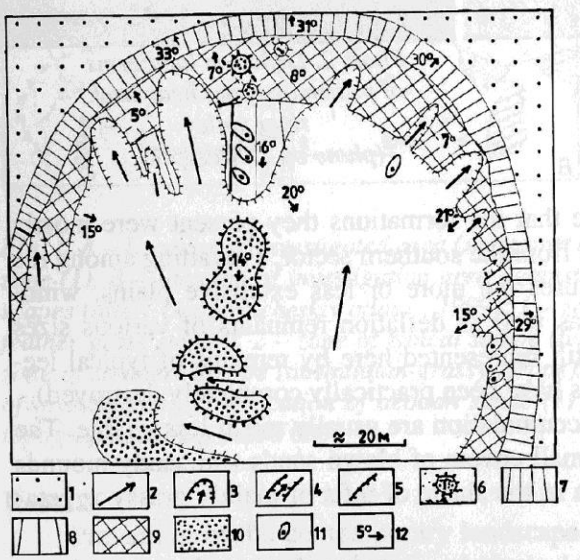

Fig. 3. Geomorphological sketch of psammosteppe fragment in site Kozhukhaevskiy barkhan: 1 – stabilised aeolian forms, 2 – deflation plate, 3 – deflation basins, 4 – deflation tunnels, 5 – deflation edges, 6 – deflation remnants, 7 – leeward slopes, 8 – windward slopes, 9 – transite slope, 10 – covers of blown sands, 11 – sand shadows of nebkha type, 12 – size and direction of slope gradient

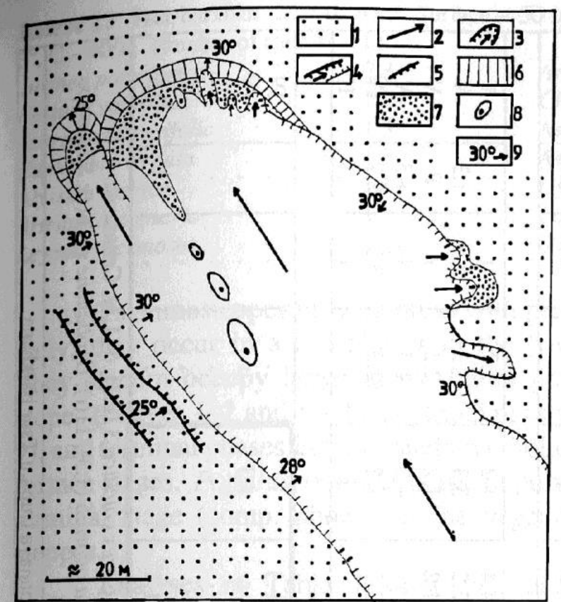

Fig. 4. Geomorphological sketch of psammosteppe fragment in site Peschanaya truba u Tsar barkhana: 1 – stabilised aeolian forms, 2 – deflation plate, 3 – deflation basins, 4 – deflation tunnels, 5 – deflation edges, 6 – leeward slopes, 7 – covers of blown sands, 8 – sand shadows of nebkha type, 9 – size and direction of slope gradient

Formations of various sizes (although mainly small), which have been and are still formed by winds of different directions, can also be observed there. These are usually short-term formations, though.

Large area of the discussed sands is occupied by three plant formations: forest-steppes with prevailing *Populus tremula*, feather grass steppes with significant part of *Stipa pennata*, and psammosteppes dominated by grasses. Only psammosteppes were the subject matter of phytosociological research carried out using the Braun-Blanquet method (1964; table 1). The characteristics are presented on the examples of 3 sites: Ilmenskiy barkhan, Kozhukhaevskiy barkhan and Peschanaya truba u Tsar barkhana.

All the analysed patches were treated as a community of *Leymus racemosus-Festuca valesiaca*. Out of 21 species of vascular plants (Table 1), only 7 serve the phytocoenogenic function. They reach V or IV class of constancy with varying coverage (from 1 to more than 30%). The said community forms loose, usually low swards, although where *Leymus racemosus* prevails their height exceeds 1 metre.

The low dune hummocks have occasionally been intentionally strengthened by man with species of willows and other shrubs, e.g. *Lonicera tatarica, Rhamnus catharticus,* or *Rosa acicularis*. The floristic composition of these phytocoenoses is visibly different from the aforementioned ones.

Table 1. Community Leymus racemosus-Festuca valesiaca

Succesive number of relevé	1	2	3	4	5	6	7	8	9	10	11	Constancy
No. of relevé	2	10	1	3	4	9	11	8	5	7	6	
Date	22.06.2003											
Locality	J.B.	P.T.		J.B.			P.T.		K.B.			
Surface of relevé in m²	60	20	50	60	100	100	20	70	50	70	70	
Exposition	S	SE	NNE	ENE	N	N	ENE	WNW	WNW	SWS	E	
Inclination in °	8	15	20	15	5	25	5	5	5	10	5	
Cover of herb layer c in %	15	10	30	35	40	40	70	50	40	40	20	
Number of species in the relevé	5	4	11	11	11	13	10	9	7	6	5	
D: Community *Leymus racemosus-Festuca valesiaca*												
Leymus recemosus	2.3	2.3	3.4	2.3	3.3	3.4	4.4	+.3	1.2	r	.	V
Festuca valesiaca	.	+.3	1.3	+.2	+.2	1.3	2.2	3.3	3.3	2.2	1.3	V
Gypsophila patrini	.	.	1.3	R	1.3	+.2	1.2	1.2	2.2	r	R	V
Euphorbia virgata	.	.	1.3	2.3	+	R	r	+.3	+.3	+	+.3	V
Allysum lenense	.	.	.	+.3	+.2	+.3	2.3	1.2	2.3	3.3	2.2	IV
Tragopogon podolicus	.	.	.	R	r	.	.	r	.	r	.	II
D: variant with *Corispermum* sp.												
Corispermum sp.	+.2	2.3	1.3	2.3	2.3	2.3	+.3	+.3	.	.	.	IV
Chondrilla brevirostris	.	.	+	1.1	1.1	.	r	.	r	.	.	IV
Astragalus macropus	r	.	r	1.3	r	.	.	.	.	.	.	II
Scorzonera ensifolia	+	.	+..	.	2.3	.	.	.	.	.	.	II
Artemisia arenaria	.	.	+	.	.	+	1.1	R	.	.	.	II

Sporadic species: *Astragalus testiculatus* 4.5 (r); *Bromus tectorum* 4 (r), 7(r); *Carex colchica* 3 (2.3), 6 (1.3); *Centaurea marchalliana* 6; *Gypsophila paniculata* 3(r), 6(r); *Jurinea polylomos* 6; *Linaria odora* 5 (1.3), 11(r); *Orobanche* sp. 6(r); *Silene* sp. 7(r), 9(r); *Stipa pinata* 8.

Sites: J.B. – Ilmenskiy barkhan; K.B. – Kozhukhaevskiy barkhan; P.T. – Peschanaya truba u Tsar barkhana

Relevé 13. Tsar barkhan. 22. 06. 2003. Surface – 50 m^2, Exposition – NNW, Inclination – 3°, C – 40%, Number of species – 14.

Jurinea polyclomos	2.3	*Artemisia austriaca*	+.3
Festuca valesiaca	2.2	*Chondrilla brevirostris*	r
Scorzonera ensifolia	1.3	*Astragalus macropus*	r
Euphorbia virgata	1.3	*Asparagus officinalis*	r
Alyssum lenense	1.1	*Gypsophila patrini*	r
Artemisia arenaria	+.3	*Linaria odora*	r
Leymus racemosus	+.3	*Silene* sp.	r

Psammosteppes grow in areas with prevailing initial soils. Most typically, they occur in a complex with the two remaining plant formations. They seldom occupy larger areas. Initial phases are formed in windward slopes (relevés 1–2 and 10–11), optimal phases in leeward slopes (relevés 3–9), and terminal phases in wind-sheltered hollows. Table 1 presents only two former stages. *Populus tremula* plays important part in the patches of the terminal stage (comp. photo 1). The vegetation succeeds towards forest-steppes.

Analyses of Table 1 show two distinct variants: one with *Corispermum* and a typical one. The former is positively distinguished by four more species, which are present in patches in relevé 13. It is possible that they may serve the same function in the variant with *Jurinea polyclomos*, which also has its own distinguishing species.

As to floristic composition and habitat conditions, the community with *Leymus racemosus-Festuca valesiaca* is related to psammosteppes between the valleys of the rivers Ilek and Malaya Khobda – tributaries of the river Ural south of Orenburg, i.e. to the community of *Artemisia arenaria-Euphorbia virgata* (Chibilyov et al., in press).

In that situation, species like *Agropyron cristatum, Anemone sylvestris, Artemisia arenaria, A. abrotanum, A. austriaca, Asparagus officinalis, Scorzonera ensifolia*, among others, occur in the herbaceous layer.

Patches with more abundant part of *Jurinea polyclomos* (relevé 13 – outside Table 1), frequently met in top parts of sandy elevations, probably represent the internal variability of the previously discussed community of *Leymus racemosus-Festuca valesiaca*.

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ANTHROPOGENIC RELIEF TRANSFORMATION IN EASTERN PART OF DĄBROWA COALFIELD IN THE 20[TH] CENTURY

Renata Dulias*

Introduction

Problem of anthropogenic relief transformation in geographical literature appeared in the latter part of the 19[th] century and saw numerous scientific elaborations done (Fischer, 1915; Scherlock, 1923; Hornig, 1955; Marsh, 1967; Zapletal, 1968; Żmuda 1973; Havrlant, 1979; Nir, 1983 and others). Presently, when in many mining and industrial areas so-called cycle of anthropogenic relief-forming is of essential importance for the natural environment evolution, the evaluation of human economic activity influence on relief is one of more important issues of geomorphology (Stankowski, 1976). But evaluation of anthropogenic mechanical denudation size is very difficult and in general only estimated. For Upper Silesian Industrial Region (U.S.I.R.), which is known to be one of the most degraded areas in Europe, such quantitative evaluation of anthropogenic relief-forming activity was undertaken by S. Żmuda (1973). He estimated that during 150 years of intensive industry development in the area of Upper Silesian conurbation such large mass of earth underwent translocation, which after disposing on the whole surface could make the layer 97 cm thick. On the other hand, according to J. Jania (1983) in eastern part of Silesian Upland in some years the index of anthropogenic denudation amounted even to 17 000 $m^3/km^2/year$. But such investigations are separated, and anthropogenic relief of Silesian Upland, although described in many scientific elaborations, still waits for the complex dynamical expression.

One of simpler methods to determine degree of relief anthropogenisation is the calculation of percentage share of anthropogenic landforms in basic fields of defined area (e.g. 1 km^2, 4 km^2), which net is marked in the area investigated. Results are presented in a form of cartogram or isarithmic

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map. In relation to Silesian Upland this method was applied among others by above-cited S. Żmuda (1973) and J. Jania (1983), R. Dulias and A.T. Jankowski (1990) as well as by A.T. Jankowski and M. Havrlant (1999). These studies present anthropogenic relief for the definite time period and although they very well reflect the degree of relief anthropogenisation, they do not allow drawing conclusions on dynamics and direction of this process. The above-mentioned studies are moreover uncomparable in respect of different pattern and size of basic fields and applying of different intensity classes. It seems that good results can be obtained making anthropogenic relief cartograms for the given area for at least two and even better 3-4 time periods. The author made such attempt for Dąbrowa Górnicza city (Dulias, 1991) and although the analysis enclosed relatively short time period (1960 - 1982), results of investigations well presented the tendency of anthropogenic relief transformation in the city area.

In the given paper the possibilities of anthropogenic relief investigations were presented on the base of cartographic material from the beginning of the 20th century. As the test area the eastern part of Dąbrowa Coalfield was selected. Till the end of the 19th century this name was given for historical-economical region, located in eastern part of Silesian Upland at the border of Silesia and Little Poland. It included many localities of industrial-agricultural character, which development was connected with black coal as well as zinc and iron ores mining, and which presently is located within the territory of Dąbrowa Górnicza, Sosnowiec, Będzin and Czeladź. This was not chance selection of area. J. Jania (1983) formulated the thesis, that natural geomorphological borders were clear barriers for anthropogenic landforms to expand and they were mainly concentrated within structural depressions. Eastern part of Dąbrowa Coalfield is located within basins – Dąbrowa to the north and Biskupi Bór to the south, as well as the elevation of Ząbkowice Hummock and Bytom Plateau (Fig. 1). This situation allows checking the J. Jania's opinion in relation to slightly different area from investigated by him.

The beginning of relief transformation in Dąbrowa Coalfield goes back the 11th and the 12th centuries, when in elevations built of Middle Triassic carbonate rocks silver and lead ores were extracted and limestone and dolomite was exploited for building purposes. But the essential relief changes were made by started at the end of the 18th century open-mined and next underground exploitation of black coal. At the beginning of the 19th century the degradation of relief surface was caused by renewal zinc metallurgy and slightly later also by iron metallurgy. In the interwar period in Dąbrowa Coalfield also functioned more than 2500 primitive surface mines,

often of tens m deep, in which the needy dug coal for their own use. Quarries, clay-pits, sandpits, round dumps around shafts - warpie, dumping sites, and railway embankments gave typical anthropogenic character for the landscape of Dąbrowa Coalfield. After the Second World War in the valleys of Czarna Przemsza and Biała Przemsza rivers the exploitation of stowing sands was started on increased scale and large in size sandpits have originated, and after filling part of them with water – large artificial water reservoirs. Further essential changes in relief were caused by building of „Katowice steelworks" in Dąbrowa Górnicza. Building of numerous housing estates and industrial objects as well as communication routes heavily influenced relief transformation.

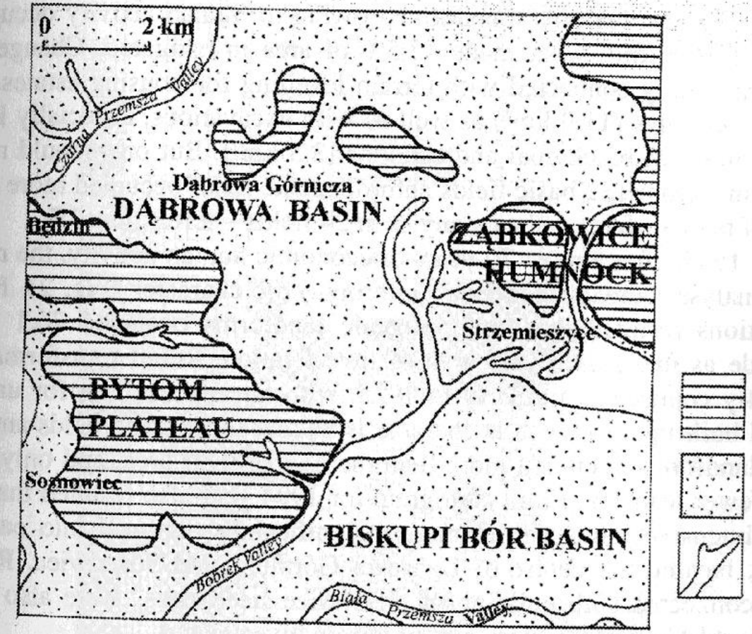

Fig. 1. Location of area investigated against a background of main geomorphological units

1 – humnocks and plateaus built of Triassic and Carboniferous rocks; 2 – bottoms of basins; 3 – bottoms of main river valleys

Results

The analysis of anthropogenic relief in the area investigated was carried out for two time periods – for 1925, on the base of Map of Dąbrowa

Coalfield from 1929 (but presenting the relief in 1925) and for 1994, on the base of actual topographic maps 1:10 000. In both maps the area investigated was divided into 132 square basic fields of 1 km² in area. In every field the area occupied by anthropogenic landforms - excavations (including filled with water), dumping sites, communication routes and levelled areas for housing estates and industrial buildings, was calculated. After analysing obtained interval of values the following classes of terrain transformation were divided: below 1%, 1 – 10%, 10,1 – 25%, 25,1 – 50%, 50,1 – 75% and 75,1 – 100%.

From the analysis of relief degradation degree in 1925 results, that the largest transformation was in the centre of Dąbrowa Górnicza and Sosnowiec, but it was also marked in Strzemieszyce Wielkie and Ostrowy Górnicze (Fig. 2). Terrains transformed owing to human activity occupied the area of 16,5 km², what made 12,5% of area investigated. Changes in relief were mainly connected with terrain levelling for housing estates and industrial buildings (11,9 km²) as well as with excavations, especially large opencast mines of black coal and sandpits (3,5 km²). But one should mark that only in 5 from 132 basic fields anthropogenic relief occupied more than the half of their surface, and as many as in 24 fields – fewer than 1%.

In 1994, after almost 70 years of economic human activity, the relief of area analysed already had clear anthropogenic character (Fig. 2). From investigations resulted that anthropogenic landforms occupied 76,1 km², what made as many as 57,7% area of investigation. Relief transformation was mostly connected, similarly to 1925, with terrain levelling for urban-industrial built-up areas. It was characteristic, that in 81 basic fields anthropogenic landforms occupied more than the half of their area, and only in 3 fields – fewer than 1%. From cartogram for 1994 year also resulted that the zone of intensive relief transformation significantly removed into eastern direction, beyond the centre of Dąbrowa Górnicza and Sosnowiec. Relief changes connected with building of „Katowice steelworks" were also very clearly marked in north-eastern part of terrain investigated.

Degree of anthropogenic relief transformation is well expressed by multiplication factor of increase in area occupied by them in years 1925-1994. This factor was calculated for every basic field separately and presented in the additional cartogram (Fig. 3). The results are very interesting, because this factor clearly exposes areas of the largest dynamics of anthropogenic relief changes during last 70 years. When in the prevailing area anthropogenic landforms increased their area not more than 10 times, then in the region of the above-mentioned "Katowice steelworks" building - some hundred times. One should emphasise that distribution of anthropogenic

landforms in area investigated does not fully confirm the J. Jania's opinion (1983) in relation to their concentration mainly within structural depressions, because many terrains transformed owing to urban-industrial building is located in the watershed zone between the Czarna Przemsza and Biała Przemsza rivers.

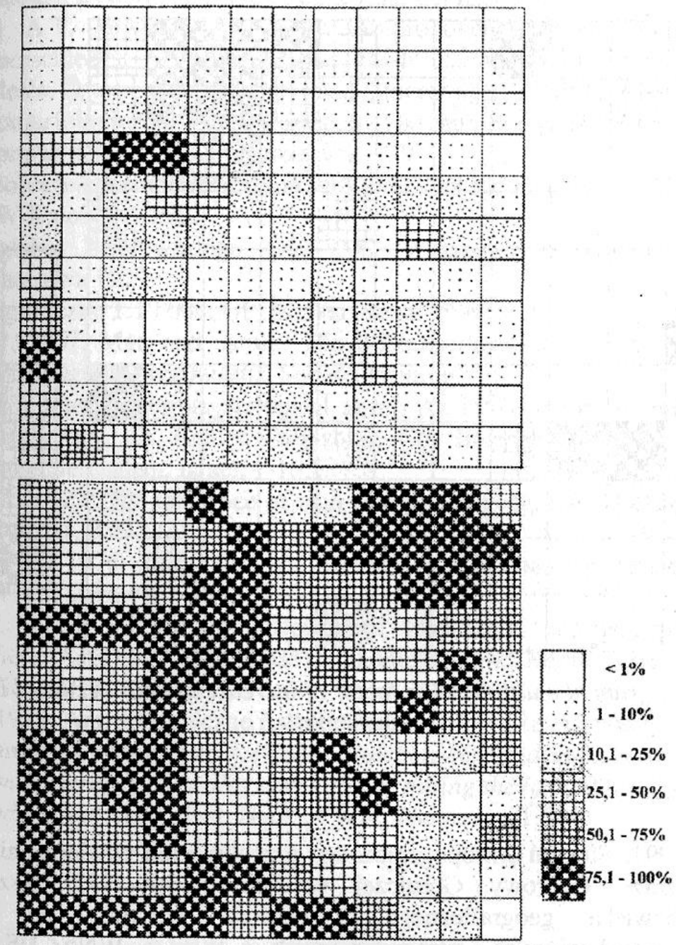

Fig. 2. Cartograms of anthropogenic relief in 1925 (A) and in 1994 (B) years

Results of investigations carried out in eastern part of Dąbrowa Coalfield indicate large possibilities to use archival and contemporary cartographic materials to evaluate the degree of relief anthropogenisation. For the central, the most degraded part of Silesian Upland, apart from present day maps, also exist old maps from the 18th, 19th and the beginning of the 20th centuries as well as thematic maps as „Geomorphological map of U.S.I.R." with special regard to anthropogenic landforms from 1959 year and „Map of transformation of earth surface of Katowice Province" from 1982 year. They make good base to carry out investigations on dynamics and directions of anthropogenic relief transformation during last 150 – 200 years.

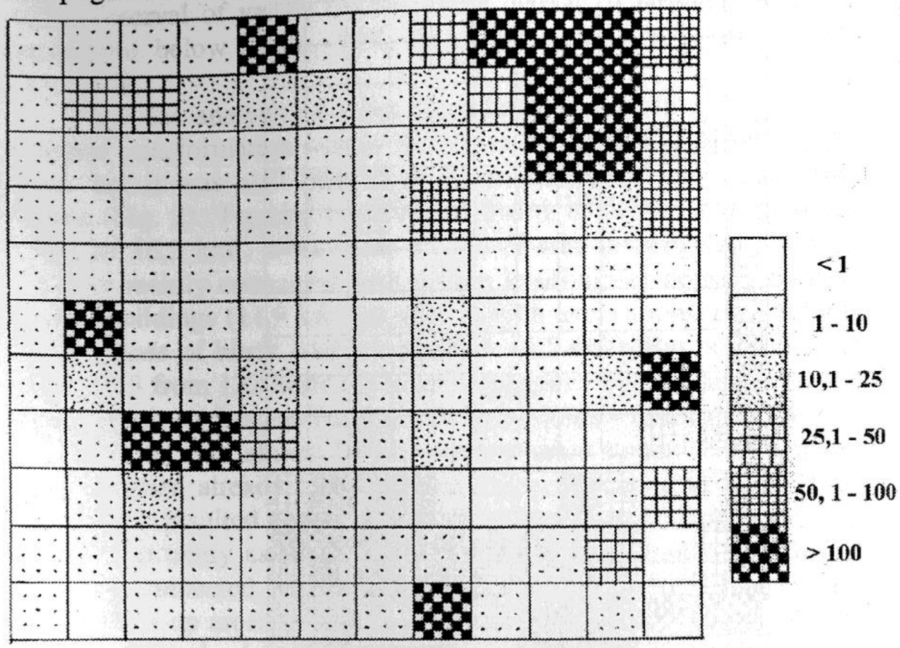

Fig. 3. Cartogram of multiplication factor of increase in area occupied by anthropogenic relief

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SELECTED SOURCES OF ENVIRONMENT DEGRADATION IN THE AREA OF LIBIĄŻ TOWN

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Introduction

Sources of environment degradation were precisely defined in the Obligatory of Minister of Environment Protection, Natural Resources and Forestry from 14 July 1998 Rozporządzenie..., (1998). It defines sources, which are especially damaging to human being and his health as well as such, which can worse the state of environment. To sources, which are especially harmful for the environment belong as follows: oil refineries, conventional power stations, nuclear power stations, plants of asbestos extraction and processing, investments serving the primary crude iron smelting and steel making and production of non-ferrous metals, chemical works, infrastructure investments, including motor highways, express roads, airports, seaports, pipelines, electrical supply lines, investments serving transmission of water resources, settlement tanks, investments connected with use and utilisation of hazardous wastes, paper-making plants, investments connected with animal farming, sewage treatment plants, mining plants, storing reservoirs, desulphurising installations, plants producing mercury.

Sources of environment degradation can occur in a form of points, delivering pollution in concentrated way, lines – giving pollutants along the line as well as surfaces – delivering pollutants in the given area. Linear sources often make the system of point sources and surface sources in many cases make the complex of dispersed point or linear sources, occurring with large intensity (Chełmicki, 2002; Maciak, 1996; Pyłka-Gutowska, 1996; Turzański, Wertez, 2000). Surface sources of degradation belong to the most harmful to the environment.

Results

The aim of this paper is to present selected sources of environment degradation in the area of Libiąż town and their influence on the environment against a background of natural and technical conditions.

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Libiąż is located in southern Poland in western part of the Province of Little Poland, in Chrzanów district and in Libiąż commune. It occupies the area of 35,88 sq. km and is inhabited by 18 thousand people. Very important influence on the town development was the discovery of black coal deposits and start-up in 1907 year mine „Janina", what caused inflow of people from different parts of Poland and the increase of investments connected with town development from the side of mine. Therefore, mine „Janina" was here the main town-shaping factor (Pawela, 1997).

In the area of Libiąż town among point sources of environment degradations were numbered: coal-fired boiler plants Ruch I and Ruch II, unauthorised municipal landfill sites and mining water discharges (Fig. 1).

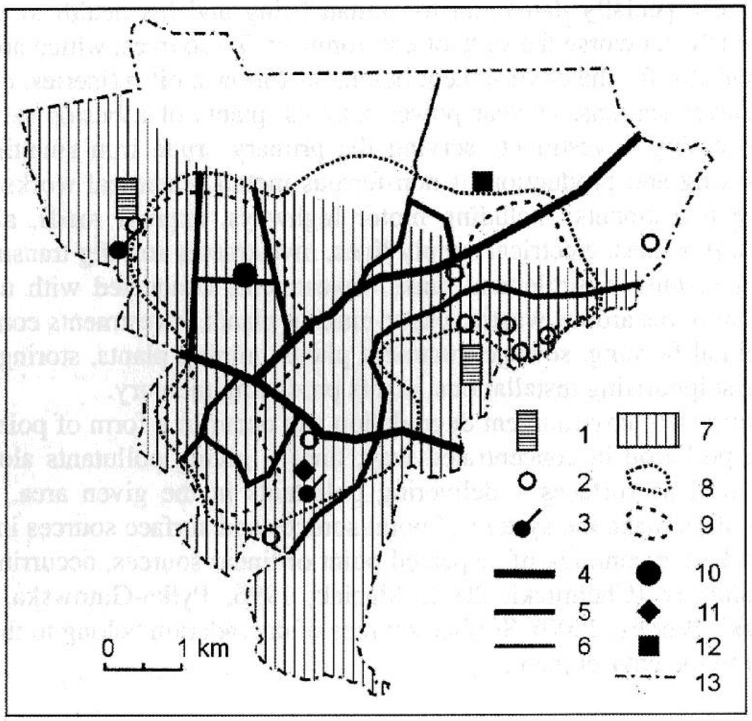

Fig. 1. Selected sources of environment degradation in the area of Libiąż: point-: 1 – chimneys without electrofilters, 2 – unauthorised municipal landfill site, 3 – mining water discharge; linear: 4 – provincial roads, 5 – district roads, 6 - communal roads; areal-: 7 – mining area, 8 – individual domestic fires, 9 – unsewered areas, 10 - municipal landfill site, 11 – industrial dumping ground, 12 – quarry; 13 – urban boundary

Boiler plant Ruch I is located in eastern part of the town in the distance of 2 km to the south of the centre. To the south it is surrounded by industrial and agricultural terrains, loose single-family and economic housing. The nearest housing estates occur in the distance of 800 m to the west and 580 m to the north of its chimney. Boiler plant Ruch II is located in western part of the town and is surrounded by forest. To the south in the distance of 3 km the town of Chełmek is located. Boiler plants produce heat for technological and heating needs of main plant of "Janina" mine and for nearing housing estates. Boiler plants are sources of increased emissions of: CO, SO_2, NO_2, B-α-P (Wronka, 2003).

In the area of the town there are numerous unauthorised ("wild") landfill sites. To the rule they are located in roadside ditches, artificial or natural terrain depressions, or at the border with forest. These are rather small but of the large waste distribution in one discontinuous layer of the length of even some hundred m. The typical feature is the lack of organic material and thus digestion processes. Among wastes prevail substances as follows: iron things, products made of plastic, glass and broken glass, ash from domestic fires, pieces of building materials, cardboards, fires, rags and earth with rubble. These sites damage the landscape aesthetics and – considering the kind of material disposed – in the majority of cases they do not make large hazard for the underground water quality (Wronka, 2003).

Mine "Janina – Ruch I" discharges saline water to mine water settlement tank Ruch I, located within dumping ground. This is earth settlement tank located above ground level. In 2001 this plant produced 18177 m^3 industrial discharges per 24 hours. After mechanical purification waters still have increased value of pH reaction (8,1) and content of dissolved substances (2150,0 mg/l). Therefore, within chlorides they do not meet standards of sewage possible to discharge into waters and ground (1250,0 mg/l). Mine „Janina – Ruch 2" discharges waters for the settlement tank situated in the distance of 250 m to the south of industrial terrains of Ruch 2. It is the settlement tank located above ground level and receiving industrial waters and surplus of drinking waters from the level of 200 m. Water from the tank meets waters from the second purity class. Multiannual polluting of surface streams, and especially carrying waters, containing a large amount mineral suspension, caused that all streams have silted channels (Wronka, 2003).

In the area of Libiąż town to linear sources of degradation belong these, which are connected with car transport, i.e. mobile sources of emission, moving by the net of communication routes with changing in time intensity and movement structure. In the area of Libiąż the largest movement intensity is noted at provincial and transfer roads, where additional ways of transport are observed, i.e. cars from beyond Libiąż town as well as in the town centre in morning and afternoon hours. It is connected with movement of local vehicles and daily access to work or school. Large intensity is also observed on Fridays, which are market days. Car transport, considering large amount of emission of toxic combustion gases, is the source of air, soil pollution as well as degradation of both plant and animal worlds. It also negatively influences human being through emission of chemical compounds and noise. In the area of Libiąż the road density amounts to 3,8 km/km^2. The total length of roads amounts to 135388 m, including provincial - 10472 m, district - 44113 m and communal - 80803 m. In the area of the town 6832 vehicles were registered, including 6769 used cars. Amount of pollutants emitted by cars depends on kind of fuel, type and degree of engine wear. Vehicles can also be the source of dust pollution, because dust is exhausted together with combustion gases through exhaust system as well as it derives from grinding of tires, brakes and road-surface.

In the area of Libiąż to surface sources of degradation belong: municipal landfill site, dumping ground, quarry of dolomite, mining area of "Janina" mine as well as domestic fires and unsewered areas.

Municipal landfill site "Jazdówka" functioned before 1999 year, now it is closed. It occupies the area of 2 ha and was originated at the slope of local elevation within inactive slope-underground quarry, in which Triassic dolomites and limestones were exploited. Site is located in the neighbourhood of private grounds, waste lands and plough lands, pastures, belonging to agricultural co-operative society in the distance of 150-200 m to the east. Municipal wastes were dumped directly at the bottom of quarry at Triassic dolomites and limestones of large permeability. Analysis of water from leachate confirmed the occurrence of pesticides (0.506 μ/dm^3-0.764 μg/dm^3). Underground waters were characterised by occurrence of suprastandard content of ammonia (2.2 mg / dm^3), manganese (0.067 –0.111 mg/ dm^3), oil-derived substances, hydrocarbons (16.899 mg/ dm^3), benzo-α-pyrene (0.384-0.424 μg/ dm^3). Landfill site was also active source of emission of fermentative gases resulting from biological decay of organic substances (maximum value – 1097 thousand m^3 in 1998), which make the direct hazard for surface waters and causes worsening of Quaternary waters. During exploitation municipal landfill site „Jazdówka" was a source of suspended and falling dusts emission, as well as a source of microbiological emission. The above-mentioned kinds of emission had not organised character and were connected with waste supply, unloading, levelling and covering with insulating material (Wronka, 2003).

Dumping ground, built of waste rock after black coal mining, is located in southern part of the town in the distance of 2 km from mine Janina" and it neighbours with housing buildings and surface waters – fish ponds as well as wastelands and forests. This dump has functioned since 1965 year; at the beginning post-mined wastes were used to level natural terrain depression. Expansion toward south caused the heaping of dump above ground level in relation to adjacent areas. Older part of the dump, heaped in the years 1965-2001 underwent land reclamation in forest and recreation-forest directions, during 36 years of dump exploitation 20100000 tons of wastes were here deposed. At dump were deposed as follows: stone from mining works, wastes from the plant of coal cleaning, including loam wastes, wastes from mechanical processing of coal. Dump makes the hazard for surface and underground waters; it is also the source of air pollution. Leachate water exceeds the standards within sulphates (459,0 mg SO_4/l) and conductivity (1460 μS/cm), whereas water from girdling ditch – within dissolved substances (1440 mg/l), electrical conductivity (1870 μS/cm), pH reaction (3,54), hardness (797,0 mg $CaCO_3$/l), contents of iron (6,35 mg Fe/l), manganese (1,81 mg Mn/l), sulphates (958,0 mg SO_4/l) and zinc (1,56 mg Zn/l) in relation to the third class of water purity. Exceeding of the following standard values is also observed in underground waters: zinc (820 mg/l), nickel (226 mg/l), cadmium (20.0 mg/l) and CHOD for the third class of underground waters. The dump is the source of not-organised emission of dust and substances from burning of fuel oil and the source of secondary dusting.

Quarry of dolomite "Dolomit" is located in north-eastern part of the town and is surrounded by forest complex and single-family housing. This opencast mine exploit 50 thousand tons of dolomite per year. This plant is the source of air dust pollution by mineral materials (alkaline) around the area of extraction, what can cause the local soil alkalisation. This plant is also the source of relief transformation (excavation) and mechanical soil and vegetation cover degradation. It is also the source of increased emission of noise (L_{AeqT}=57,8), especially for inhabitants of single-family housing (Wronka, 2003).

Mining area of „Janina" mine, which occupies 62,3 sq. km, exploits black coal by means of "roof-fall" method. It is the source of natural relief transformation in a form of continuous (subsidence depressions) and discontinuous deformations (collapse depressions and cones), which are observed in the half of mining area. 70% of them occur in the area of Libiąż town, where subsidence depressions predominate (3-5 m.). So, the consequence of mining activity is mining damage, reflecting in ground flooding (south-western part of the town) or drying (depressive cone – north-eastern part of the town), what changes water relations, and next influences soil and vegetation cover.

Individual domestic fires in the area of Libiąż are the source of air pollution, being the result of firing with black coal, which contains sulphur and ash substances. Moreover, the process of burning is accidental, at chimneys there is the lack of filters, there is a large number of domestic fires in a relatively small area, and the average height of coal-fired buildings amounts to 7m, what causes that pollutants occur near the ground (low emission) and directly influences the nearest neighbourhood (Wronka, 2003).

Unsewered areas are the sources of microbiological and foul smell emission. They can pollute underground waters by compounds of phosphorous and nitrogen and cause biological contamination of soils, surface waters (eutrophication) and indirectly influence organic world.

To summing up, all above-described sources of degradation importantly influence the environment of Libiąż town. Predominating source of degradation are surface sources. Influence of surface sources is intensified by damage caused by mining activity by "roof fall" method. Environment transformation in the area of the town results from natural conditions as well technical limits. Disadvantageous natural conditions are as follows: anemological conditions (large share of calm airs and winds of small velocity per year), which make pollutant transfer beyond the area of Libiąż difficult, local distribution of fogs, which favours the concentration of pollution, local presence or the lack of impermeable layers of the Miocene age in the area of mining activity, presence of permeable rocks of the Carboniferous, Triassic or Quaternary age in the dumping ground substratum, block tectonics, discontinuous character of impermeable layers. Technical conditions are as follows: old, over-exploited black coal-fired boilers of low heating efficiency, lack of desulphurising equipment, improper technical state and lowered efficiency of dust collectors, using of coal-dust of large sulphur amount, average height of emitters, pumping of mine waters of large mineralisation, improper location of sewage discharge, presence of large amount of motor vehicles, and the predominance of old cars.

To limit the influence of degradation sources in the area of the town many activities are undertaken, which aim is to improve the state of the environment. These activities are as follows: land reclamation of municipal

landfill site and dumping ground, sewerage of the remaining part of the town, building of acoustic screens and planting with trees, imposing an obligation to have waste containers, improving the efficiency of heat producing through the new boiler buying or liquidation hazardous boiler plants, building of girdling ditch around the subsidence depression, limitation of saline water discharge through flooding of inactive workings, closing of mining boreholes, insulating of workings by means of dams (Wronka, 2003).

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ECOLOGICAL CONDITIONS FOR VEGETATION GROWTH IN LITTORAL ZONES OF RIVERS AND LAKES ON THE EXAMPLE OF SALICACEAE

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Introduction

The life of plants and their ecological adaptation are closely related to the dynamics of their environment where they develop a strategy of growth. Exposed sediments in river channels and on lake shores are main sites of colonisation (regeneration) for riparian trees and pioneering shrubs (Braatne, Rood, Heilman, 1996). These sediments are very unfavourable and hard to occupy for plants, as they are subject to frequent environmental changes like erosion or abrasion, accumulation, both during frequent high water stages and dry spells, which are usually associated with low water periods.

Zones of frequent active river- and lakeside flooding shape the creation of various habitat and microhabitat conditions, which are formed as the result of geomorphological processes and their interactions with plants. What is particularly important for plants is time- and space-related disturbance and damage being the main effect of erosion and deposition of organic-mineral matter during periods of high flood (Hupp, Ostercamp, 1996; Richards, Brasington, Hughes, 2002). Patches of pioneering woody species, river- and lakeside vegetation – in which species of the family *Salicaceae* play essential part – are of short-term nature. They may remain for slightly longer in more stable conditions. Old flood terraces, in turn, overgrown with pioneering assemblages including softwood communities, are replaced by hardwood forest, e.g. *Acer*, *Ulmus*, *Fraxinus*, at a terminal stage of succession.

Time-related forms of disturbance in littoral zones of lakes and river channels are closely linked to climatic conditions within the catchment area, e.g. seasonal changes in precipitation, thaws, etc. Organisms that grow in such habitats have adapted to regular changes in their environment during the periods of maximum high flood in a given area. The time of high water occurrence is difficult to predict in various climatic zones. Regardless of their origin, high floods have a significant effect on the way the vegetation

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is adapted to extreme habitat conditions that are formed at that time (Karrenberg, Edwards, Kollman, 2002).

Space-related forms of disturbance are highly diversified within the area of a floodplain, both in its cross profile and along the whole river course. In the sections of a braided or anastomosing river, vegetation in the active zone of river channel occurs in the form of many scattered islands of various sizes (Johnson, 2000). In some rivers such islands may be formed after each high flood, e.g. as a result of a tree, which was previously torn out and transported downstream, set in a shoal (Gurnell et al., 2001). During high water stages, water contains large amounts of woody matter, fine organic matter and inorganic mass. The whole of the transported material forms accumulations around the left out tree in the river channel, thus creating pioneering islands. If a so created island is stable enough, it may resist further flood periods. It may also increase its size by retaining more logs, sediments of various fractions and other matter, e.g. of anthropogenic origin. That way an island may grow and join adjacent vegetation patches. Islands are frequently subject to erosion, though, especially during intensive high water periods Island are also eroded, and material coming from a damaged island is transported further downstream and may be redeposited. According to Gurnell et al. (2001), most river islands have traces of previous erosion and redeposition, which are interpreted as the result of interactions between large wood logs, vegetation, geomorphological features and hydrological regime. Generally, islands form an unstable and unpredictable habitat for vegetation and animals.

Habitat conditions in active flooding zones of rivers and lakes

Flood areas provide diverse habitat conditions as to substratum types, humidity, and nutrients for plants. The state of nutrients may be related to geological substratum and land management within the catchment. The conditions as to availability of nutrients are diverse in flood areas overgrown with vegetation (Walker, Chapin, 1986); in most situations, however, water is possibly the most important factor that limits the growth, especially germination.

Use of water by plants in such areas is limited by permeability of substratum formations resulting from the fractional composition of sediments and depth of underground water table. Large parts of flood areas in river valleys are composed of gravel sediments (Petts et al. 2000). Variability of the fractional composition of sediments is of high ecologocal importance, as it influences both the microclimate and microhydrology of exposed

littoral sediments of rivers and lakes. Finer sediments retain more water and provive better conditions for germination, particularly for some species of *Salix* and *Populus*. Also, coarser sediments may prevent fast loss of water in some conditions by preventing evaporation, which may be important for germination during hot and dry periods (Bishop, Champin, 1989; Rapp, Shainberg, Banin, 2000).

Willows (*Salicaceae*) occupy much more diversified areas than poplars. Skvortsov (1999) pointed out that willows might be divided into two large ecological groups: alluvial and non-alluvial species. Species belonging to the former group mostly include well developing high shrubs with narrow leaves. The non-alluvial ecological group of willows includes woodland, rock and marshland species of trees and shrubs, as well as trailing shrub heaths of tundra and willows of alpine habitats. Skvortsov (1999) argues that communities related to the alluvial habitat are more primitive conditions, whereas *Salicaceae* in the non-alluvial habitat are more advanced evolutionary.

Growth, vegetative propagation and expansion of Salicaceae

The seedlings of both willows and poplars are exceptionally small, but their growth rate is very fast compared to other woody species (Grime and Hunt, 1975). During the first vegetative season, seedlings of *Salicaceae* may reach 0.5-1 m in height (Stromberg, 1997; Glenn et al., 1998). They are characterized by fast and expansively growing roots which make it possible for them to remain in unstable and damp substratum. (Mahoney, Rood, 1998). Roots of poplar seedlings may grow between 4 and 13 mm per day and reach 40-60 cm in their first vegetative season (Mahoney, Rood, 1998). Research by Walker and Champin (1986) suggests that high nutrient concentration in the substratum influences the growth rate of species of the family *Salicaceae*.

Most species of the family *Salicaceae*, especially of the genus *Salix*, have highly flexible branches. They cannot be easily broken by fast water flow. Additionally, some species have brittle branch bases (e.g. *S. fragilis*). This enables branches to fall off the shrubby and woody willows, which contributes to decreasing the resistance of flowing water (Beismann et al., 2000).

The root system of *Salicaceae* is adapted to even long-term anaerobic conditions, although clear diversity in that respect can be observed between the species of that family (Blom, 1999). One of the main features of the willow species is the ability to regenerate from both sprouts and roots, which results in efficient asexual propagation and transportation of their fragments (e.g. branches, roots) by water. Each fragment of a willow, regardless of its size, is capable of regeneration. Thus flowing water, transporting various fragments of plants, serves the function of a factor that spreads the range of the plant along the river course and the cross-profile of its valley.

Ecological adaptation of species of the family Salicaceae

Species of the willow family (*Salicaceae*) in flood terraces and plains are characterized by a number of ways of adaptation that enable them to grow in the substratum of high degree of morphological transformation caused by high water stages (erosion, sedimentation). Propagation and growth of these plants are promoted by: very large production of seeds, which are quickly transported by wind, high rate of germination and growth of seedlings, fast regeneration of fragments (e.g. branches, stems) and largely developed root systems which fix the plant in little stable substratum. The thicket of root network of some willow species stops sediments of various fractions, thus seasonally stabilizing the bank and slowing down the rate of its erosion. Flowing water and waves may also uncover the root system of trees and shrubs by washing out the material that builds up the bank, which may result in knocking them over towards the water body or the axis of the river and creating a specific groin (Rzętała, 2003). Willow communities, as well as other types of vegetation of various ecological groups that overgrow the banks of watercourses, influence the intensity and range of littoral processes. In specific conditions, occurrence of these plants restricts the development of erosion and abrasion processes, making the banks morphologically stable, and determines generation of specific forms in littoral formations during stronger erosion influence (Rahmonov et al., 1998).

Apart from species of the family *Salicaceae*, some species of the genus *Alnus* also show high adaptation to growing in floodplains. Similarly to *Salicaceae*, they have high ability of seed reproduction and represent a type R life strategy. The ways of ecological adaptation and features of species may be an important factor implying their adaptation in the process of evolution. Firstly, production of a large number of anemochoric seeds may increase the gene flow rate between populations of these species. Another important feature is distribution of vegetative organs of plants without the contribution of seeds (an alternative way of propagation of these species). It is essential for individuals which produce relatively few, if any, seeds of low viability (Karrenberg, Edwards, Kollman, 2002). An example of that kind of

plant is some species of the family *Salicaceae* characterized by dynamic growth resulting from their fragments being transported to areas which are geographically exotic for these species (Shafroth et al. 1994). This results in many hydrophilic and hygrophilic species having large geographical range and accordingly wide range of ecological tolerance.

Summary

Exposed sediments of river and lake shores are not favourable substrata for growth and germination of plants. It is related to unfavourable microclimate and habitat which is poor in nutrients and changes frequently. Nevertheless, various species of *Salicaceae* successfully colonize such sediments and are adapted to growing on regularly flooded areas. Efficient distribution of seeds of willows is conditioned by abundant production of seeds in spring and early summer, which are dispersed through anemochory and hydrochory. Seeds live for a short time, but they germinate quickly in a damp substratum. A seedling will be established unless the damp surface is mechanically disturbed. This provides an opportunity to use some species of the family *Salicaceae* in reclamation and revitalization measures, especially in anthropologically deformed areas. Another argument in favor of using these plants in environmental restitution is low financial expenditure and guaranteed ecological efficiency of revalorization measures determined by spontaneity of plant succession.

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LANDFORMS OF CRYOPLANATION ORIGIN AS INDIVIDUAL LANDSCAPE VALUES OF THE SZENDRŐ-RAKACA BLOCK MOUNTAINS

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Introduction

Due to the revaluation of nature conservation and environmental protection noticeable nowadays, conservation and promotion of the unperturbed advancing of the current status of objects, phenomena and processes interpretable as natural, social and scientific values are more and more accentuated. The protection of environmental values of various types is of public interest, however can be achieved only if having an eligible overview on them. A presupposition of the value evaluation on exact bases, thus, is to recognise and survey these values.

'Individual landscape values are natural values and landscape-forming factors, created by human activity, characteristic for the given landscape that are relevant for the society from the point of view from nature, history, culture history science or aesthetics.' (MSZ 200381/1999) During my work this standard aimed to promote the recording of individual landscape values and prepared by the assignment of the Department of Environmental Protection and Regional Development during the 1990s (MSZ 200381/1999) was applied with some necessary modifications, but according to the above mentioned definition.

The Szendrő-Rakaca Block Mountains bear several objects significant from the points of view of nature conservation and environmental protection. Although, the importance of culture historical and biological values of the Block Mountains can not be called in question, in this study, the geomorphologic features and values, especially those of cryoplanation origin are intended to be discussed in details. These landforms are worth interest as in our country cryoplanation surface-forming processes are more characteristic in the higher, therefore calmer regions of the mid-mountains. Such cryoplanation features within the area of the Szendrő-Rakaca Block Mountains can be found at an unusually height of below 300 meters above sea level. As cryoplanation landforms at similar heights are not mentioned in the literature, their local occurrences seems to be an absolute curiosity.

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During the Pleistocene, the territory of Hungary was belonged the periglacial zone in the forefront of the ice-sheet intruding to the interior of the continent, thus consequences of the landscape-forming impacts of periglacial processes can be traced at every step. Primarily, the cold climate typical at that period (according to PÉCSI, M. (1962), the annual mean temperature was between -1 and -3°C), determined these processes reshaping the different Hungarian landscapes in various ways and scales due to their different characters and intensities. The determining factor in the character of periglacial processes causing significant geomorphologic alterations is frost action, or to be more exact, the fluctuation of temperature around freezing point.

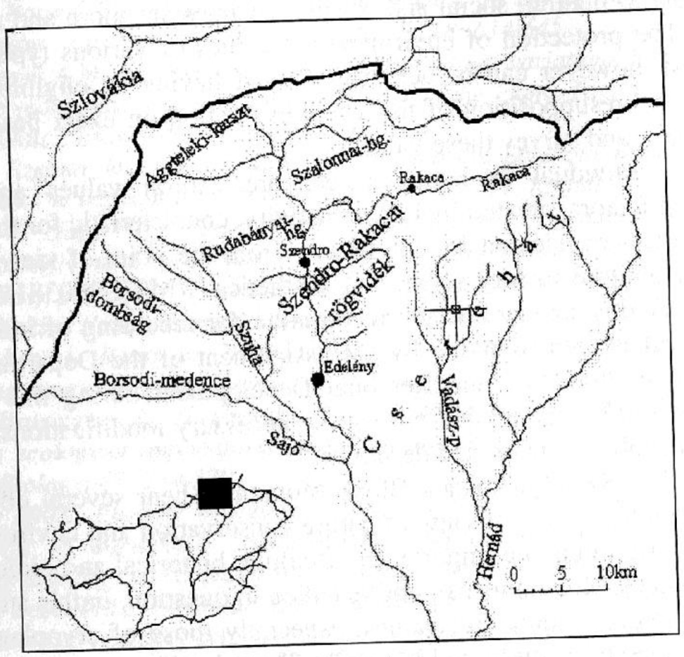

Fig. 1. Topography of the Szendrő-Rakaca Block Mountains (Szendrő – Rakacai rögvidék)

Landforms of altiplanation origin are noticeable by one in the valleys of the Szendrő-Rakaca Block Mountains, in connection to fronts of reverse faults. The complete cryoplanational sequence however can not be found at any known locations but landscape-forming by altiplanation combined with mass movements characteristic in our mid-mountains can be traced from the characters of the formations.

Various cyroplanational landforms in the Abodi Valley

Location of the Abodi (or Nagy-Csákány) Valley indicates a tectonic front of reverse faults, along which the most remarkable local remnants of the landscape forming by frost action are surface limestone cliffs showing a great variability in size. The smaller outcrops at the (0.5 meters in height) Northern side of the Abodi Valley are present near the hilltops, their size indicate a growth in the descent direction, and they make up a quasi-vertical cliff. These cryoplanation cliffs are continuous only at short sections, however some of their outcrops are present at the same contour line. They are 2.5 to 3 meters at their highest, stooping to the North-East and also to the South-West, as the typical width of these cliff-sections is 5 to 7 meters. They are scarcely with single appearance, groups of them spread in some ten meters. The most typical cryoplanation cliff can not be found here but about 1.5 kilometres to the North East. Regarding its size, cliff of the Nagy-Csákány crag is significantly higher than other such features, as its continuous cliff with 90° spreads along a 25-meter-long section, and at its height is 11 meters. Most of the cliffs are exposed to the North (Fig. 2), and as a result of this, these slopes are cooler and wetter that along by the influence of the Carpathians can accelerate frost-shattering. The nearly uniform North Western trending requires an explaination.

Paleozoic formations of the Szendrői Block Mountains are North to North Western in vergence and are imbricated in structure. Along the fronts of reverse faults in the tectonically determined valleys, bassets are often exposed. These limestone cliffs imply suitable surface to frost action. Local significance of the appearance of bassets, regarding the development of the cryoplanation features, is greatest on the disconnected cliffs in the valley of the Abodi Stream. Cryoplanation cliffs are aligned in a group of two or three at the same altitude or above each other. Although their appearances suggest a multi-lined series of towers, their basset-origin eliminates the presence of a cliff continuous at the early stages of their development and they rifted into towers during the following times.

To observe the shaping of the cryoplanation cliff, the most suitable was the Nagy-Csákány crag, because of its size.

At the base of the main cliff, minor hollows are deepened in the rock (*cryoplanation niches*) in which the temperature remains around freezing point for a longer time period. Under this micro-climate, snow melts slowly, providing continuous humidity to refreezing. The lowest third of the cliff is cut by several crackings, in which smaller pieces of debris are wedged, supporting the present process of weathering caused by the fluctuation of freezing and melting (frost shattering). At the base of the cryoplanation cliffs, a *cryoplanation steep slopes*, with an average angle of slope of about 30 to 38° are situated. They are covered by coarse rocks, dropped continuously during the process of weathering, and being further disintegrated.

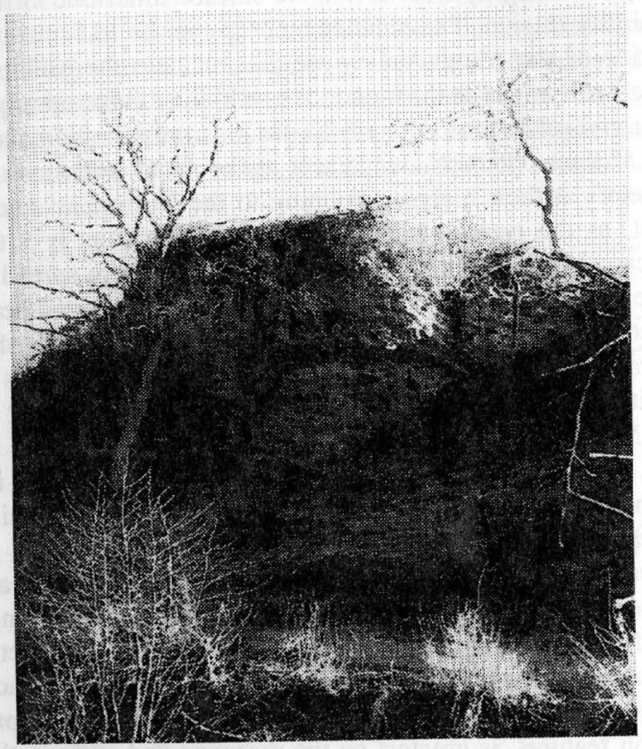

Photo 1. The grand block of the Nagy-Csákány crag

Based on what has been described above, the variety of cryoplanation landforms in the Abodi Valley is limited to only a few of such. The hilltops lack the various sized, usually stable block fields formed by local frost heaving. Cryoplanation cliffs formed by the decay of bassets can be described as small-sized, and by uniformity in structure and lithology, thus the extent of surface less resistant to frost action is not significant. Consequently, there has not been the possibility to the development of small block streams wedged to weathered out cliffs, nor block streams, said to be the most spectacular cryoplanation features, are present. Shortness of the slopes does not allow the formation of debris aprons varied with slide blocks, slowly moved by solifluction and gelisolifluction. As well as, the short distance of slopes is

an obstacle to the development of the cryoplanation terraces and the cryoplanation steps in close connection to them. Although, the angle of slope has a relatively sudden decrease of approximately 12 to 14° on the hillside of the Nagy-Csákány crag, with its own dip of 16 to 18°, it exceeds the gentle slopes of 1 to 8° of the cryoplanation terrace surface (SZÉKELY, A. 1993, in: BORSY, Z.).

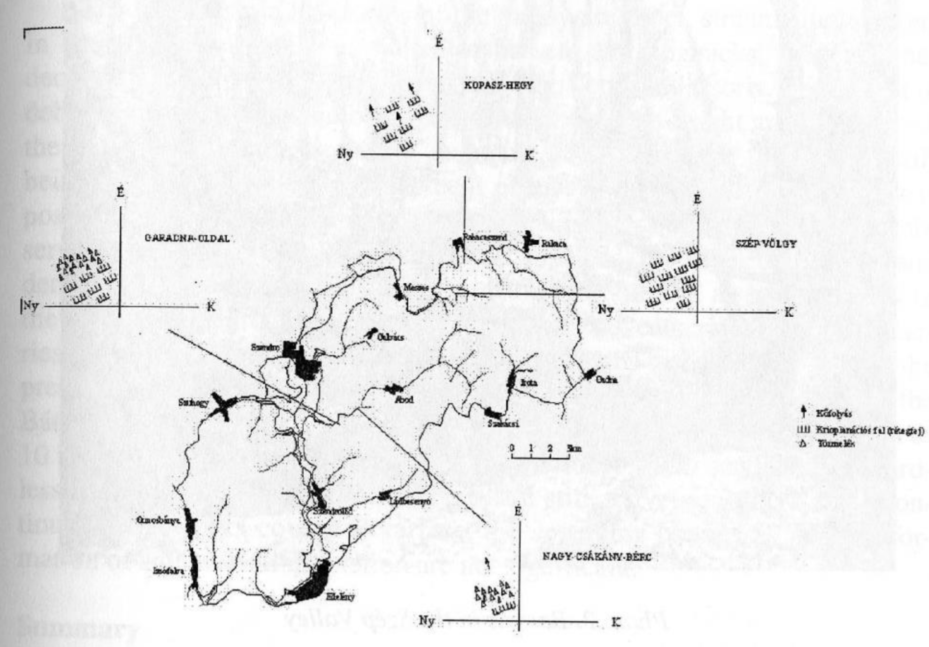

Fig. 2. Location of cryoplanation landforms in the Szendrő–Rakaca Block Mountains

Various cryoplanation landforms in the Szép Valley

Szép Valley located in the Northern part of the Block Mountains is a North to North-Eastern trending side-branch of the Éger Valley. Its slopes on the left side, North to North-Western in exposition, are made to cryoplanation in character by vast cliff outcrops present in two sections (Photo 2.). In both cases, *Stair-like*, a group of altiplanation features can be observed, differing only in their sizes. The large number of these '*stairs*' is situated one above the other, they are more or less similar in size: their height is between 70 and 100 centimetres, and their surface is 1.5 to 2 square meters. The small cliffs with an angle of slopes frequently exceeding 90° did not provide large surface to the frost action. Coarse debris formed during the altiplanation cover the surface imperfectly.

Photo 2. Bassets in the Szép Valley

The formation and exposition of the series of stairs again have geological reasons, in their formation the role of bassets is decisive. This theory is also supported by the uniform dip, the discontinuous surface appearance and exposition. Frost decayed these bassets, causing their gradual regression. The use of this past tense seems to be justifiable in the previous sentence, as by now the edges of the steps are habitats to thalli of mosses and lichens resultant from the cease or a very slow character of the frost-shattering. On the left (trending to the North) slopes of the Éger Valley, remnants of a *cryoplanation series of stairs with slope-breaks* can be observed in many locations. There are only a few occurrences of outcrops of cliffs, apparently as a consequence of the different orientation of the dip of the slopes and the beds. From the lack of cliffs and weathered debris, it can be concluded that it is a fixed, decaying landform, weathered out in the Szép Valley due to the deepening side-valley.

Cryoplanation landforms in the Rakaca Valley

A very unique feature is the so-called Kőajtó (meaning Stone Door), the only cryoplanation gate in the hills. It is difficult to access because of the vegetation. Because of its size it only can be named as door, as only one can go it through at same time.

The most visible landforms of the valley are block streams, few meters in length. Their location is linked to bassets and hogbacks, the first ones decayed and are hardly seen as hidden by the deposited debris. The length of debris flows is determined by the angle of slopes, the height and structure of the cliff providing the supply of material, in our case it is the lack of cliff being the obstacle to the development of longer landforms. On the vast exposed rock surface of the abandoned marble quarries, it is possible to observe the trend-like character of the rock material, the bedded structure and dense system of cracks. Disturbance caused by mining also contributes to the fact that these rocks are highly susceptible to weathering. Near the quarries, block streams are more frequent, their lengths can exceed those of the previous ones even by several times. Quarries of the Rakacai Marble at the Bátor Valley and the Kopasz Hill have block streams even with the length of 10 to 15 meters and 3 to 4 meters in width. These linear landforms, regardless to their size and location of origin are still active nowadays, their continuous edgy rocks cover the surface, the spreading of mosses and the formation of soil indicating fixation are not significant.

Summary

Characteristic features of the various landforms in the Szendrő-Rakaca Block Mountains, resultant from frost action can be summarized as follows.

1. In the area, at the height of 200 to 280 meters, at certain locations diversified group of landforms are present.
2. The bed rock consists of laminated, bedded limestone, crystalline limestone and phyllite, as the dip of the beds is South to South West, uniformly. Exposition of the cryoplanation cliffs is opposite in direction to the stratal dip.
3. Surface forming by cryoplanation began during the Pleistocene, some of the resultant formations have been fossilized by now, whereas others are still evolving.

4. None of the cryoplanation sequences (cliff, stair, terrace, debris cone and debris apron) is complete, at a given location different features are present, depending on the rock type.
5. Landforms shaped by frost action are much smaller in size than the similar ones described in the mid-mountains.

The landforms described above are mostly and to a greater extent characteristic at the top regions of mid-mountains in Hungary at the altitudes between 500 and 1000 meters (SZÉKELY, A. 1969, 1973). Their presence is curiosity at this orographical situation of hills which is a result of conjoint and cumulative presence of certain factors, as follows.

- The Szendrői Block Mountains is one of the calmest micro-regions in Hungary, where the mean annual temperature is 8°C.
- Slopes formed by the etchings of deep valleys provide good endowments to frost action. At the hillsides of the valleys facing to the North, because of the calmer micro-climate cooled by the influence of the Carpathians, frost-shattering is more intensive. Another important factor is the more abundant, even water-supply resultant from the slower melting of the snow.
- The largely dissected, highly folded and thin-bedded bedrock is more vulnerable to weathering.
- Bassets represented optimal surface to frost action. The steep slopes in connection to the fronts of reverse faults, and also their trending and micro-climatic conditions (see above) provided suitable conditions to the frost.

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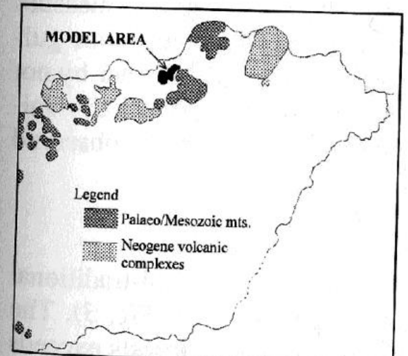
CONNECTION BETWEEN LAND-USE CHANGES AND EROSIONAL (DERASIONAL) VALLEY DEVELOPMENT DURING THE LAST 300 YEARS IN A MODEL AREA

Gábor Demeter* – Szalai, K.**

Introduction

The importance of climatic characteristics in Pleistocene surface evolution has been well-known for a long time. In Hungary, warm-wet, warm-dry, cold-wet and cold-dry phases alternated with each other during the Pleistocene (SZÉKELY 1973). Consequently, linear and areal surface forming processes prevailed by turns causing the typical landforms of hilly regions. Linear erosion was predominant in warm-wet phases, while areal denudation became general in warm-dry ones. In cold-wet and cold-dry periods however, gelisolifluction processes and gravitational talus creeps formed the surface (MARTONNÉ 2001).

It is an interesting though less examined question, how the short but intensive human activity affected the morphology of hilly regions, especially the valley forms. This article concentrates on how much the land-use and its change modified surface landforms during the last few hundred years.



The investigated area includes 13 settlements of the Heves-Borsod Hills, the Ózd-Egercsehi Basin and the Uppony Mountains. Each settlement is situated in the northern foreland of the Bükk Mountains and their administrative limits do not extend over the territory of the wooded mountains (*Fig. 1*).

Fig. 1. Geographical position of the model area

Methods

The examined human effect is the way of land-use and its temporal and territorial change. We tried to find out whether there is a relationship between land-use and valley development. The main question was how much

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human activity influenced the development processes of valleys - formed by fluvial erosion and/or mass movements. Moreover, we measured the valley densities and the changes in the length of gullies and dry valleys.

The reasons why these parameters and geomorphological elements were chosen for examination are the followings. The required amount of data relating to land-use from the 16th century provides a proper base on which the changes in time and the spatial distribution of differently used areas can be well modelled. The data originating from the times before the 1st military mapping of the country (1780s) were counted from the talliage-list of 1548. In other cases we had exact data. The archivalia (BML) proved to be rich in maps, therefore we could take an interest in not only the changes in the proportions of differently used areas but the changes in time as well. Maps prepared after the consolidation of land-strips (1850s) were especially valuable. On the one hand, these are equal-area maps, on the other, the administration limits of settlements have not been changed significantly thus a comparison could be made between earlier and presently used maps.

The examined geomorphological factor was chosen because linear forms can be detected well on most of the Hungarian maps. Thanks to the economic-social function of the maps which were prepared for the consolidation of land-strips, all the considerable gullies and valley forms were drawn on them. As a result, within given limits, it was possible to measure the changes in valley lengths during the last 150 years. Moreover, some gullies – apart from the fact that they became bigger – developed further by not only fluvial erosion but mass movements as well and changed into dry valleys. In some occasions the evolution of these features can also be observed on the maps.

Results

On the basis of the sorted data two different historical-traditional land-use types could be separated in this hilly region (*Fig. 2, Fig. 3*). The first type is the group of settlements where the proportion of forests exceeds that of arable lands, grass-lands and pastures approximating 50% (Arló, Borsodnádasd, Csernely, Bükkmogyorósd, Uppony, and Dédestapolcsány). In case of the second type the territorial ratio of forests is less than 30%, while arable lands, grass-lands and pastures cover bigger areas (Borsodszentgyörgy, Járdánháza, Borsodbóta, Csokvaomány, Lénárddaróc, Nekézseny, Sáta).

While arable lands, grass-lands and pastures became bigger during the 19th century, the spatial distribution of forests decreased at least 20%

since the 18th century. The territory of forests however, has been growing since the middle of the 20th century thanks to the fact that more and more arable lands, grass-lands and pastures have become uncultivated.

Using historical-geographical bibliography we examined whether there was significant erosion in the 18th century. The data originates from the answers for the questionnaire on the duties of serf, villeins and copy-holders in the period of Marie Therese (1770) (CSORBA-TÓTH 1991). Most of the arable lands were endangered by areal erosion at that time (*Table 1*). The intensity of land-use had a considerable influence on the speed of erosion. Unfortunately, the degree of slope denudation can not be measured though it exceeded the degree of soil forming on the hills.

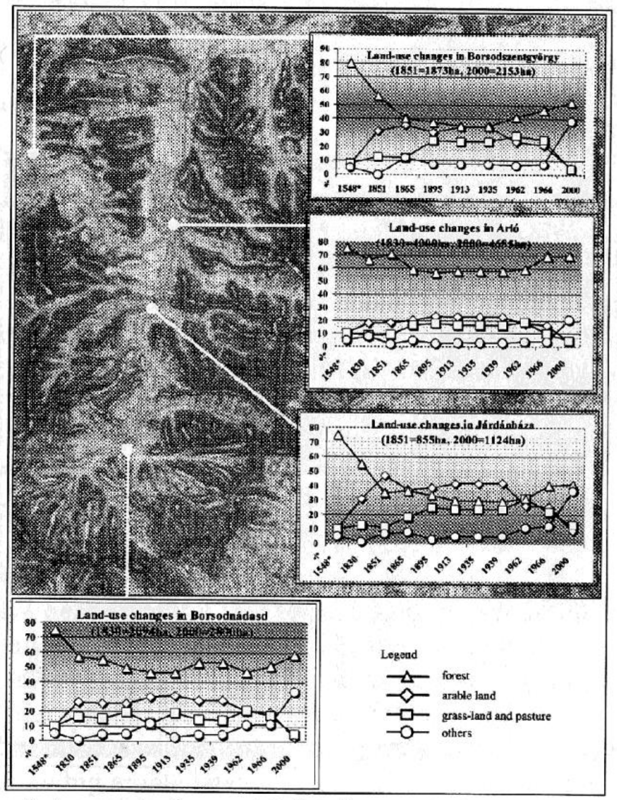

Fig. 2. Temporal changes in the spatial distribution of differently used territories in the catchment area of Hódos stream[1]

[1] Maps and diagrams were prepared using the data of the Archives of Borsod County and the Central Statistical Bureau, the pages of the first military mapping survey of Hungary

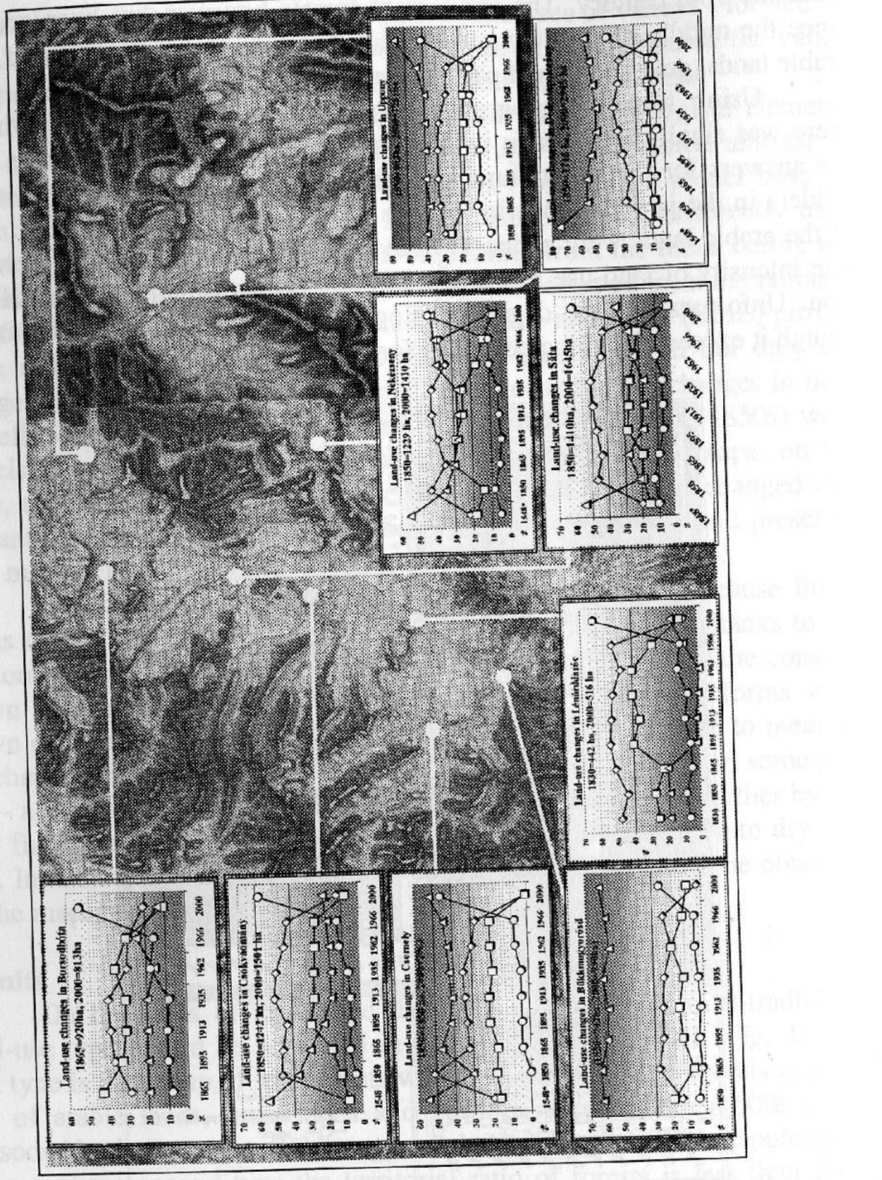

Fig. 3. Temporal changes in the spatial distribution of differently used territories in the catchment area of Csernely stream[3]

and other sources (FÉNYES 1837, 1851, The magnitude… 1865, Csíkvári 1939, Csorba 1990, 1991, Pintér 2000)

Tab. 1. Settlements endangered by erosion in the 18th century

	flood	erosion on hill-sides in vineyards and arable lands	accumulation on grass-lands and pastures
Arló	X		X
Borsodszentgyörgy	-	X	X
Bükkmogyorósd	-	-	-
Csernely	-	X	X
Borsodnádasd	-	X	X
Csokva	-	X	X
Omány	-	X	-
Sáta	-	X	X
Borsodbóta	-	X	
Uppony	-	X	X
Nekézseny	X	X	X
Dédes	-	X	X
Tapolcsány	-	X	X

We also analysed the differences in the density of valleys formed by fluvial erosion and mass movements in the case of each settlement. The valley types and densities of the area are demonstrated on *Fig. 4* and *5*. Correlation can not be proved between the land-use types and the dominance of valley types occurring on the administrative area of settlements (*Fig 6*), though it is worth mentioning that in case of Járdánháza and Sáta (both are grouped in the arable land dominated land-use category) dry valleys are dominant. (The values of 2 settlements are not shown on the diagrams because a significant part of their administrative area is out of the field of research.)

It is remarkable on the military maps that in many cases, one-time gullies were reshaped by mass movements and changed into dry valleys (e.g. in the vicinity of Járdánháza and Csernely, see *Fig. 7*).

Finally, according to the separated historical-traditional land-use types we analysed the maps made for the consolidation of land-strips (1850s). The regression of erosional valleys during the last 150 years was examined in the case of Csernely and Bükkmogyorósd, the territories of which are dominantly covered by forests. From among the settlements which have quite big arable lands the map of Lénárddaróc proved to be satisfying for this examination. As the scale of the old maps differs from that of the today used EOTR maps, to avoid inaccuracy we took no notice of the changes smaller than 25 metres. The results are summarized in *Table 2*.

More than half of the gullies did not change significantly, although their total length increased (100-200 meters/village). On the territory of Csernely gullies changed into dry valleys in 4 cases and into erosion-derasion ones in 2 more cases. It is interesting that valley regression did not increase considerably even in Lénárddaróc where arable lands are dominant.

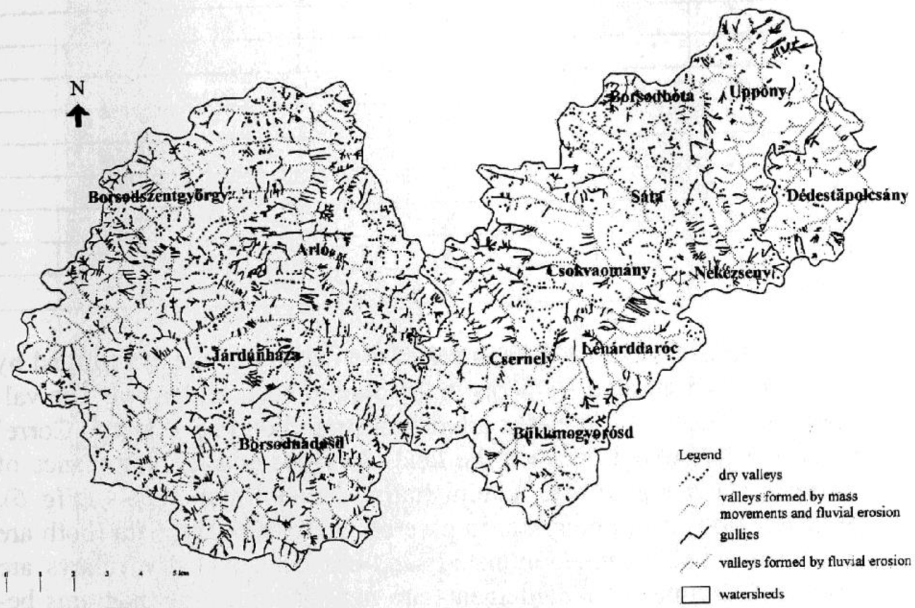

Fig. 4. Valley types in the research area

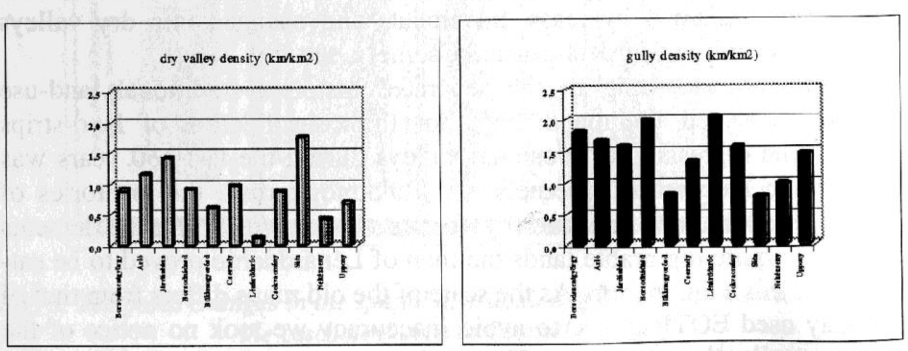

Fig. 5. Dry valley and gully densities in the area of the settlements

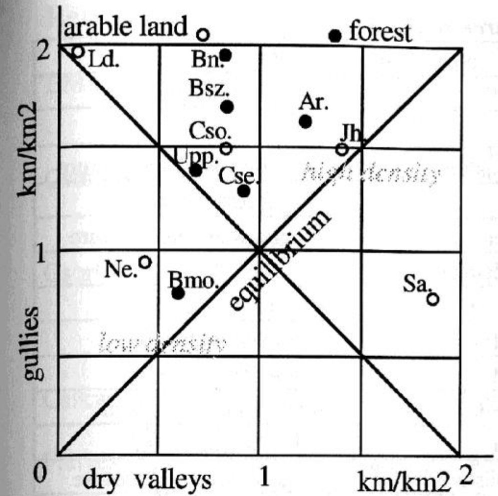

Fig. 6 *Correlation between between land-use types and valley densities*

On the territory of Lénárddaróc the average degree of regression is 15 meters per gully while in Csernely and Bükkmogyorósd it is 9 and 8 meters. Because of the formation of dry valleys the filling up and the shortening of gullies were significant in Csernely. A similar shortening could be proved in Lénárddaróc too. The differences in land-use can not be strictly correlated with the degree of regression, but there is a connection in the cases of frequent change of land-use and clearings. The spatial distribution of differently used territories within the administrative area of the villages remained stable in the last 150 years. There were no sudden changes – except for the disappearing of vineyards after the vine-pest disaster of 1886. Today the danger of erosion is getting smaller owing to spontaneous forestation.

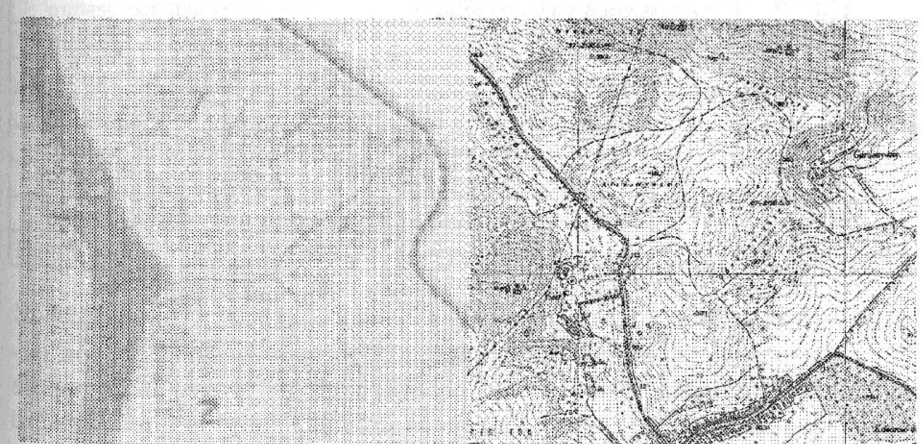

Fig. 7 Some typical gullies that changed into dry valleys by now

Table 2 Regression of gullies in case of three settlements

growth in meters	type of land-use	
	in 1850	nowadays
BÜKKMOGYORÓSD		
100	forest/grass-land and pasture	clearing/ grass-land and pasture
40	forest/forest	forest/forest
40	forest/ grass-land and pasture	forest/ grass-land and pasture
no measurable changes in 7 cases		
CSERNELY		
30	forest/arable land	forest/arable land
50	forest/arable land	forest/arable land
-80	arable land/arable land	arable land/arable land
230	forest/arable land	forest/arable land
-80	forest/grass-land and pasture	forest/grass-land and pasture
80	forest/grass-land and pasture	forest/grass-land and pasture
-40	forest/grass-land and pasture	forest/grass-land and pasture
40	forest/arable land	forest/arable land
120	grass-land and pasture/ arable land	grass-land and pasture/ arable land
no measurable changes in 32 cases		
LÉNÁRDDARÓC		
100	forest/grass-land and pasture	forest/grass-land and pasture
30	forest/grass-land and pasture	forest/grass-land and pasture
-40	forest/grass-land and pasture	forest/grass-land and pasture
30	forest/grass-land and pasture	forest/grass-land and pasture
80	forest/grass-land and pasture	forest/grass-land and pasture
30	forest/grass-land and pasture	forest/grass-land and pasture
50	forest/grass-land and pasture	forest/grass-land and pasture
no measurable changes in 12 cases		

Conclusions

The intensity of land-use influences the speed of linear erosion determinatively, whereas a definite connection can't be proved between the way of land-use and the intensity of linear erosion. There is a relationship between the change of land-use, the frequency of this change and the intensity of linear erosion. New gullies of significant size were not formed during the last 200 years but the regression of the older ones can be measured. Although the formation of dry valleys from gullies is not general in areas which were formerly covered by forests and today are used as grass-lands or arable lands, we found dry valleys that used to be gullies in the past.

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THE EFFECTS OF THE RIVER REGULATORY WORKS ON THE BEREG PLAIN

Enikő Félegyházi*

Preliminaries

It may be stated on the basis of the so far 150 years of experience that the regulation of the River Tisza changed the flood subsidy parameters of the river. Concerning the amount of the flood waves ten years after the regulation and in the past thirty years a large-scale rise may be observed in the course of the Tisza above Tokaj. (Fig. 1)

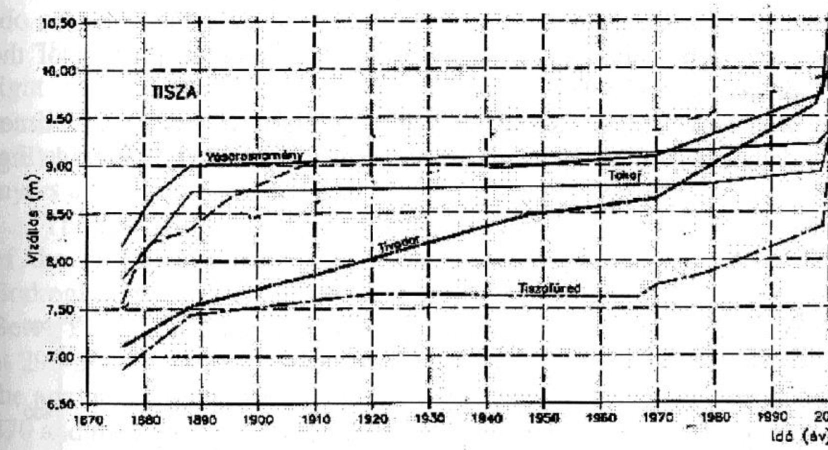

Fig. 1. Flood levels on the River Tisza (Source: Nagy I. et. al. 2001)

In 2001, a flood of a never experienced size caused devastation in the Upper Tisza Region. The River Tisza overflowed its banks 10 metres above the culmination level. The fine silty sediment covered the flood plain with an about 20-50 cm thick layer. At some places the river widened its bed while at other places deepened it. Undercut banks developed at several places after the flood has subsided.

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The natural bed deepening process of the River Tisza has accelerated since the regulation of the river. The extent of the floods demonstrates it well. The largest etching was measured between Kisar and Tivadar as the flood plain is the narrowest here. The lowering of the mid-water at Tivadar was measured as 70 cm between 1889 and 1920 which means a lowering of 2.3 cm annually, and it was 100 cm between 1920 and 1956 meaning 2.8 cm/year. (Károlyi, Z.1960). As a consequence of the deepening, the river etches more and more into the surface and at the times of low water the flood-free banks turn into natural exposures showing the layers of the area.

In the summer of 2003 the water level of the River Tisza subsided 260 cm below the zero point of the fluviometer in the Upper Tisza Region. The escarpment bank nearby Gulács rose above the surface level of the river as a ten and a half metres high steep wall. At the time of the low water, the sediments of the stream alluviation of the neighbouring areas might be observed in the high walls and the history of the alluviation process of the Bereg Plain becomes visible.

The water level of the River Tisza was similarly low at several times which is demonstrated by the water level curve measured at Dombrád (Fig. 2).

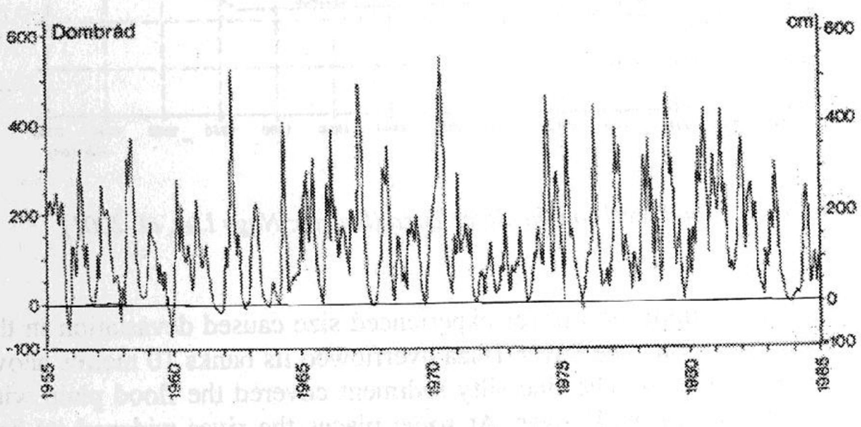

Fig. 2. The water level of the River Tisza at Dombrád between 1955 and 1985

Owing to the observations by Zoltán Borsy there are data available from 1956 and 1980 as well. At Kisar the sediments of the riverbanks at 9.5 me-

tres in 1956 and at 7.8 metres in 1980 were compared with the layers of the flood-free bank exposed in 2003.

We made palynological evaluation from the layers of the banks at Kisar and Gulács and compared the levels of the former surfaces containing organic matters which appeared at different heights in the case of the two banks. It became clear on the basis of the palynological evaluations that the layers can be identified. The ^{14}C age determination of the samples taken from the layers of the banks at Gulács enabled us to identify the age of the formerly taken samples as well. Even so, the buried meadow silt levels of the plain areas blended with flood plain lowlands and natural levees could be also rendered parallel at many places.

Results

The river wall at Gulács is an exfoliated floating debris consisting of light yellow silty and clayey sediments which is dissected by darker meadow clay levels at 200-260, 290-310 and 520-540 cm and peat accumulations at 710-720 and 850 cm consisting of plant remains. The exposed layers are closed by a light grey carbonate layer at 920 and 1050 cm.

The age of the two upper layers could not be determined with the help of the radiocarbon method but there are exposures available from the Bodrogköz region whose layers may be identified with the layers of the Bereg Plain. Thus, the radiocarbon age of the layers at 200-260 cm is 2400, at 290-310 cm they are 4000, at 520-540 cm they are BP 6130-5990, while the age of the peat layer at 850 cm is 21 000-20 000, at 920 cm is 29 790 ± 870 and the age of the sediments at 1050 cm is 32 130 ± 1130 years.

The clayey-silty river wall at Kisar, according to the analysis of Borsy, Z. et al (1988), is dissected by meadow clay stripes at 190-210, 280-310 and 400-410 cm and by peaty layers at 710-720 and 850 cm. The carbonate layers are missing. It may be explained either by the fact that the water level of the River Tisza used to be higher or the river did not cut as much into its bed at that time.

The meadow clay levels are the sediments of the lowlands behind the former levees. They do not always contain pollens but they are rich in organic matters. Swamping is rather frequent on this area which does not promote the accumulation of pollen. The material of the flood plain lowlands is fine silt and clay. The granular composition of the sediment changes with the distance of the deposition from the river. The further away it is, the finer granules constitute the sediment. The alluviation of the lowlands is a slow process (Nagy, I.- Schweitzer, F.- Alföldi, L 2001; Kiss, T. et al 2002., Gábris, Gy et al. 2002.). According to our data, its average value is 0.3 mm/year which is a rather long time (32130 years). The shorter the research interval is, the larger the extent of the alluviation is.

The speed of alluviation in the Bodrogköz region differed by phases: Finiglacial and Pre-boreal phase – 0.2-0.3, Atlantic phase – 1-2, Sub-boreal phase 0.8 mm/year (Borsy, Z. –Félegyházi, E. 1989). Similar trends may be detected on the Bereg Plain and it may be complemented by the values of the Upper Pleniglacial which were 0.08 mm/year and 0.3 mm/year respectively.

These values changed as a consequence of the human intervention. The active flood plain of the embanked river narrowed. The alluviation is considerable on the narrowed flood catchment areas reaching even 1-1.5 m. As a result of the intensive etching, the river is filled with sediment and an intensive silting starts since the sediment is deposited on the flood catchment area. (Károlyi, Z. 1960).

The riverbed does not only deepen but it also changes its place. The binding of the banks was intensified by the river regulations and the extent of erosion decreased by 40% on this part of the Upper Tisza Region. (Károlyi Z. 1960)

A bar was formed below the bridge at Kisar which could not be detected on the map from 1906 but could be well seen on the 1:25000 map drawn in 1969. It developed from the bottom of the previous riverbed in a way that the wider main branch of the river now runs in the channel line of a younger and the narrower branch flows in an older riverbed. The water of this branch subsides so much – or even dries out – at low water that the island melts into the left bank and becomes a bar. (Fig. 3) As an island it is seen at mid-water developing from the alluviation of the nip bank of the younger riverbed. (Fig. 4) It becomes clear from this as well that the riverbeds with various ages are built upon/into each other, the negative forms are filled up and they may even become mounds. The process takes 30-40 years.

Summary

Prior to the river regulatory works, alluviation happened in a natural rhythm depending on the climate – presumably at an average speed of 0.26 mm/year (Rónai, A. 1985) on the lowlands. The flood-free bank at Gulács demonstrates that 10.5 m sediment accumulated in 32000 years at an average speed of 0.3 mm/year which was exposed by the deepening erosion of the River Tisza accelerated by human intervention. The river regulatory activities of man changed the paces of alluviation and etching to a large extent as a consequence of which the phenomena of intensive etching, silting-sedimentation-alluviation and island formation may be observed.

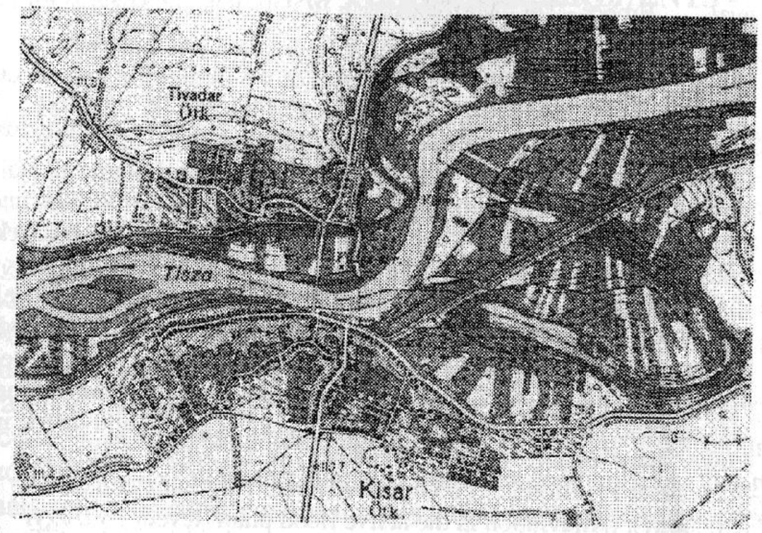

Fig. 3. Island nearby Tivadar and Kisar

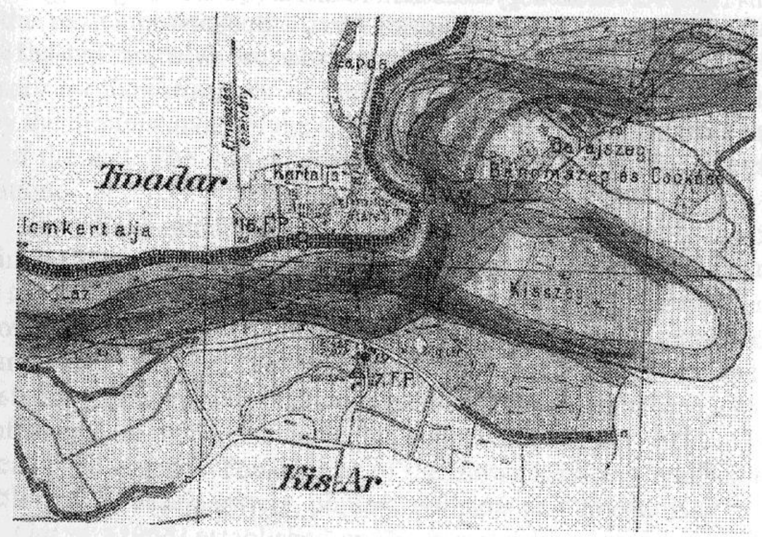

Fig. 4. Changes in the riverbed of the Tisza after the regulatory works (VO. 1906)

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WIND EROSION PROTECTION EFFECT OF THE VEGETATION – BASED ON WIND-TUNNEL EXPERIMENTS –

József Lóki* – Gábor Négyesi*

Introduction

Wind erosion causes serious problems and considerable damages all over the Earth and similarly in Hungary as well. This phenomenon primarily endangers the sand soils but in the case of applying wrong agrotechnological methods it may cause serious devastation on the more cohesive soils as well. The wind carries away and redeposits the uppermost fertile layer of the soil with the sowing-seeds in it as well and thus it decreases productivity. It may also transport the dispersed chemicals which has deleterious effects on other plant cultures and on the surface and ground waters. As a consequence of the siccative effect of the wind the soil moisture decreases and the roots of the plants get to the surface when there is a thicker layer of soil carried away which will lead to withering.

The process of wind erosion is started with the blowing out, therefore, the most important task is to impede blowing out which effectively means the hindrance of the wind to reach the critical starting speed that is necessary for the movement of the soil particles. This may be achieved either by the diminishment of the speed of the wind or by increasing the resistance of the soil. The present paper focuses on the protective effect of the vegetation.

The afforestation programs in Hungary were initially specifically done in the spirit of the fight against deflation. This affected almost exclusively the sand areas. In Szabadka there were experiments for the binding of the blown sand in 1770-71. Joseph II ordered the implantation of the blown sand areas in 1788. The Diet held in Buda in 1807 brought an Act on the afforestation of the blown sand areas *(Ballenegger, R.-Fináły, I. 1963)*. The sand-afforestation works started at that time which actually affected the entire area of the country. The binding of the blown sand was realised through the settlement of acacia groves, poplars, orchards and vineyards.

Gál, J. (1968) established on the basis of his researches that one of the most effective tools for the protection against wind is the plantation of

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shelter-belts. The forest belts, tree rows and wind-breaking bush rows are all capable for moderating the speed of the wind and for avoiding damages.

In the beginning of the twentieth century the barren sand soils were added chemical fertilizers *(Grabner, E. 1927)* and straw manuring *(Szabó, L. 1928)* to make them more fertile. The green manure rotation system of Westsik *(Westsik, V. 1944, 1951)* and later the layered sand melioration introduced by Egerszegi meant important steps in the agricultural utilisation of sand soils.

In the 1980s it was noticed in Hungary as well that the wind erosion is not only harmful for the sand areas but causes serious problems on the more cohesive – agriculturally more valuable – soils as well (Hajdúság, Nagykunság, Mezőföld). The experiments focusing on the deflation sensitivity of the various soils started at that time at the University of Debrecen *(Lóki, J.-Szabó, J. 1993)*.

Material and method

The experiments were carried out in the wind tunnel of the University of Debrecen. The effect of the vegetation was studied with the help of wheat, oat, triticale and corn. The wheat, oat and triticale were sowed into the rectangular sample holding dishes in a way that the rows were 10 cm away from each other in the length of the tray (Photo 1). Following the sowing, the plants developed into 10-15 centimetres high plants in two-three weeks. The tray with the plant rows was placed in the wind tunnel into soil brought in from plough-lands. Blown sand, humus sand and calcareous chernoziem soils were used for the experiments. The experiments were conducted at different speeds in two ways: the rows of plants were either perpendicular to or parallel with the wind direction.

In the case of the experiments with the corn, the plants of 20–30 cm height were planted into the 5 cm thick levelled soil layer together with the earth ball. The stem distance between the plants was 12–15 cm and the distance between the rows was 38– 42 cm (Photo 2).

The experiments with the plants were partly aimed at the measuring of the protective effect of the different plants and partly of the different direction of the rows against wind erosion. The experiments on erodibility were conducted on soils without vegetation cover too. It provided grounds for the comparative analysis of the erodibility of the covered and uncovered soils.

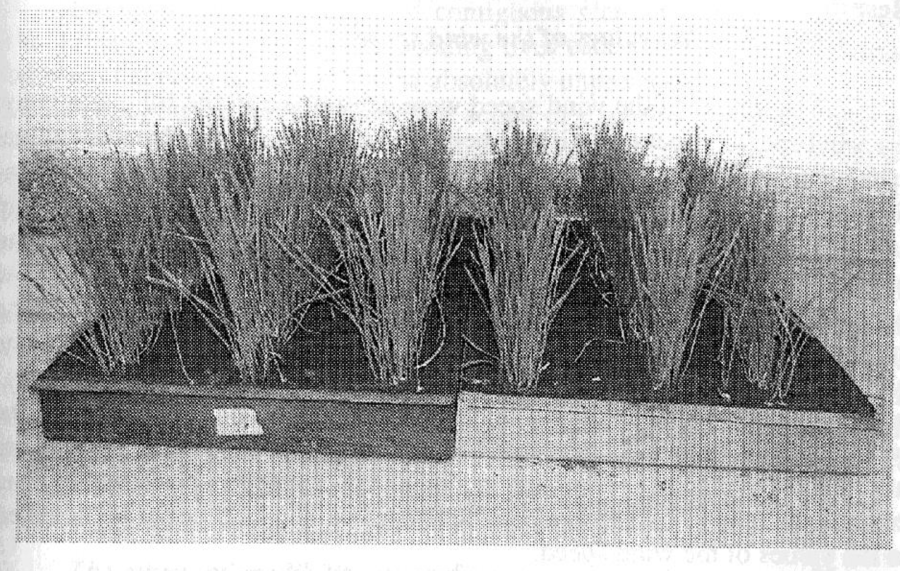

Photo 1. Wheat rows prepared for the experiment

Photo 2. Corn rows prepared for the experiment

Results

Changes in the values of the wind speed

The values of the wind speed were determined in the following way: the wind speed measured at 10 cm height was always higher than the critical starting speed of the soil in front of the plants where the effect of the vegetation could not be felt yet. The speed values measured between the second and third wheat rows which ran in perpendicular to the direction of the wind were always considerably lower. The values measured behind the third row were especially impressive since they did not even reach the critical starting speed. A smaller scale of decrease may be experienced when increasing the wind speed in a higher speed domain 5 cm above the soil surface (Table 1) which may be explained by the fact that the strong winds have beaten the weak plants and thus the height of the wheat rows flattened by the wind did not exceed 5 cm. In the heights of 20-30 cm above the surface the wind could flow freely and therefore no considerable decrease could be detected in the values of the wind speed.

Table 1. Wind profile functions interpolated with the measures taken in front of, between and behind the plant rows

plant			in front of (the rows)	between (the rows)	behind (the rows)	R^2
wheat	perpendicular	rows	$y = 4E - 05e^{1.0204x}$	$y = 0.0182e^{0.5541x}$	$y = 0.132e^{0.4135x}$	0.9
wheat	parallel	rows	$y = 4E - 26e^{4.8106x}$	$y = 3E - 10e^{1.961x}$	$y = 2E - 08e^{1.6726}$	0.9
corn			$y = 1E - 21e^{4.0504x}$	$y = 4E - 07e^{1.425x}$	$y = 1E - 04e^{1.0188}$	0.9

When placing the rows of wheat in parallel with the wind direction the movement of the air was less impeded by the vegetation (Table 1) and thus the values of the velocity of the wind did not decrease significantly between the rows between the beginning and the end of the sample-holding dish. The stronger winds flattened the weak stalked wheat during the series of experiments too which formed contiguous plant stripes in parallel with the direction of the wind while bending over each other so that the surface between the rows remained almost absolutely unprotected.

Looking at the results of the series of experiments it was also observed that the decrease in the speed of the wind varied by the different soil samples which can be only explained by the difference in roughness resulting from the granular composition which can be perceived on the surface as well.

In the case of the experiments with corn, it may be established on the basis of the average of the data measured at three speeds above the soil that the speed did not decrease to that extent between and behind the corn rows as it did in the case of the wheat (Table 1). It may be explained by the fact that the stalks of the densely sown wheat provided greater resistance to the flowing air than the sparsely sown corn-stalks. The "flapping" movement of the corn-blades at some places resulted in the whirling flow of the air.

The extent of erodibility on surfaces covered and not covered by vegetation

When studying the protective effect of the vegetation, the erodibility of the soils covered and not covered by vegetation were also measured. It was experienced in the case of the experiments with wheat that the erosion was much more considerable at the two edges of the tunnel where the surface was not covered by vegetation than it was in the protected zone. The weakened wind mainly transported finer granules between the rows of plants therefore the surface in front of the sample-holding dish was covered by rough sand by the end of the experiment. Correlation was studied between the values of the velocity of the wind and the amount of the transported material and the functions and formulas which best fit the points were determined (Fig. 1-2).

Conclusions

The following were established on the basis of the wheat experiments:

- The erodibility of the selected four soils differs. The sand of the mounds in the confines of Fülöpháza was the most eroded by the wind, while the sample from the eastern part of Nyíregyháza was the least eroded. The difference between the erodibility of the samples can be explained by the differences in the granular composition.

- ➢ The wind always transported less material from the surfaces covered with vegetation thus the protective effect of the 10 cm tall wheat against deflation could be well demonstrated.
- ➢ The rows of plants sown in parallel with the wind direction provided a smaller scale of protection for the surface than the perpendicular ones.

The corn, in the initial phase of its development, diminishes the energy of the wind only to a small extent due to the large row and stalk distances. The starting sand granules were slowed down at the lower wind speed and no sand movement was observed behind the rows of plants. At the higher speeds the erosion was more considerable on the surface covered with vegetation.

- ➢ The differences in the erodibility of the uncovered soils had the same pattern as in the case of the wheat.
- ➢ A considerable part of the eroded material moved ahead with a saltating movement close to the surface. The amount of the sediment in the heights of 10-40 cm never reached 10% of the eroded soil.
- ➢ In the case of the typical blown sand of the Danube-Tisza Interfluve the deflation was already considerable at 6–7 m/s. In the case of the soils from the confines of Gödöllő and Nyíregyháza an acceleration of the erosion was observed at the wind speed of 7.5 m/s.
- ➢ A large amount of transported sediments (2.5–4.0 kg) was measured in the case of all soils at the highest speed (12–12.2 m/s) during the series of experiments. In three minutes 0.5 – 1.0 cm thick soil was eroded from the three metres long surface.
- ➢ The protective effect of the corn resulted in the diminishment of the amount of transported sediments but this effect was of much smaller extent than in the case of the wheat.

Several things need to be taken into consideration when choosing the proper vegetation cover. The structure of crops needs to be determined in a way that it provides protection coverage for the soil for the longest time possible, especially in the wind-stormy periods. From this aspect, the production of the perennial fodders, especially of the lucerne plays an important role because it provides complete cover for many years. The autumn corns in the ear also provide quite good protection for the soil because they properly cover the surface by the time o the wind-stormy spring period. After the harvests their stubbles should be left behind to cover the soil.

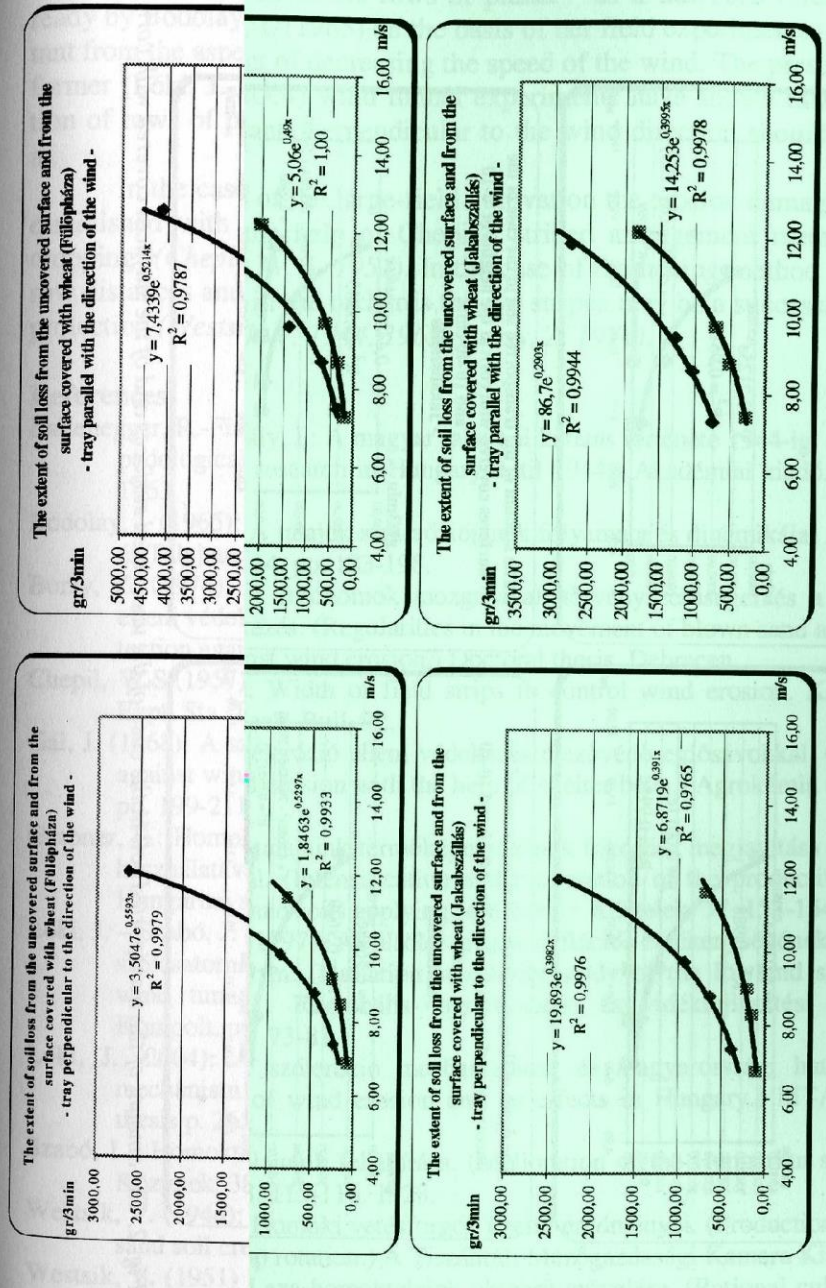

Fig. 1. The extent of soil loss on the uncovered surfaces and the surfaces covered with wheat

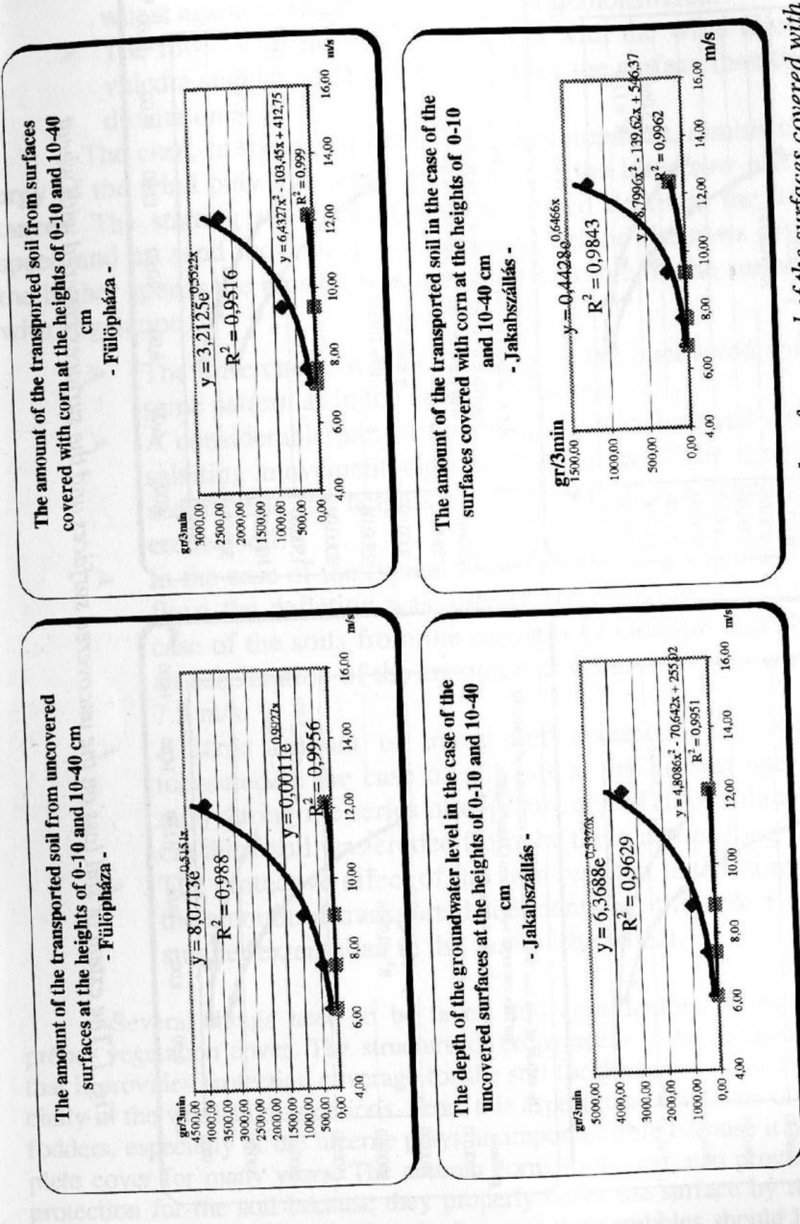

Fig. 2 The amount of the transported soil in the case of the uncovered surfaces and of the surfaces covered with corn

The direction of the rows of plants – as it has been referred to already by Bodolay, I. (1965) on the basis of her field experiments – is important from the aspect of decreasing the speed of the wind. The present and the former (Lóki, J. 2004) wind tunnel experiments have shown that the creation of rows of plants perpendicular to the wind direction should be aimed at.

In the case of the large-field cultivation the erosion damages may be diminished with the help of Chepil's striped arrangement method (strip-cropping) *(Chepil, W. S. 1957)*. In the case of the hoeing method with wide row distances and in the orchards the rye stripes may be a successful way of protection *(Westsik, V. 1944, 1965; Borsy, Z. 1974)*.

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SURVEYING THE ACCURACY OF THE GPS SYSTEM USING DIFFERENT SAMPLE AREAS

Gergely Szabó*

Abstarct

A recent study was performed to examine what the accuracy of a code-phase measuring is using GPS rover and base receivers. Data were collected from two sample areas, on ten points from both of them. The reference coordinates were geodetic mapping points, because these coordinates are available from topographical maps (less accurate) or from Institute of Geodesy, Cartography and Remote Sensing (FÖMI) (highly accurate). In the study the raw, differential corrected and reference points were compared, then lines and two-dimensional figures (surfaces) were compared before and after correction.

Introduction

Nowadays the localization of our geographical position is essential in numerous fields of science. Its role in geomorphologic researches is very important because to analyze any surface form (e.g. artificial heaps – *Tóth – Szabó, 2002*), phenomenon, or process it is essential to know the scene and the range.

Among the numerous local fast positioning systems the Global Positioning System (GPS) has became the leader in the past years. Today the only complete operating system is NAVSTAR (USA-Pentagon), thus furthermore in this article the GPS means this system.

There are significant differences in the various types of measuring methods, thus surveying the accuracy of the measuring is important.

With this survey our goal was to estimate the accuracy of the GPS system owned by the Department of Physical Geography and Geoinformatics, using field data and GPS base station data, within the frame of the method "code-phase-measuring".

The goal was to study the changing accuracy during the processing of the GPS data, on the other hand to prove that moving away from the base

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station the farther we are from the base receiver the smaller the accuracy is in the Differential GPS (DGPS) system.

Methods

The method used for locating the geographical position

During the study the distance of the satellites was fixed with code phase measuring method, when the receiver acquires the signal of the satellites, which contains atomic clock time data. The receiver measures the transit time delays to triangulate the position.

Though it is possible to acquire position within a few minutes (*Lóki, 1998*), the accuracy is higher using more receivers (relative measuring), or keeping the receiver fixed on the point to be measured for a longer time (static measuring). The highest accuracy using the C/A code during 1 sec. is 20-50 meters (*Tamás – Lénárt, 2002.*). Measuring with a moving receiver the accuracy is significantly worse (kinematic measuring).

Using the code phase method the theoretical maximum accuracy is between 3m and 30 cm (*Tikász-Krauter - et al., 1995*).

The receivers and software use din the survey

The measuring were achieved with two receivers.
The base station was a Trimble Pro XL receiver.
The rover receiver was a 12 channel Trimble Geo Explorer IV. Geo XT model with StrongARM processor, using TerraSync 2.30 Professional software.
The differential correction were achieved with Trimble GPS Pathfinder Office 2.90 software.
For summarizing data MS EXCEL XP was used.
The final maps and datasheets were made in ArcView 3.1.

The selected sample areas

Two sample areas were chosen (*Fig.1.*) for the series of measuring.

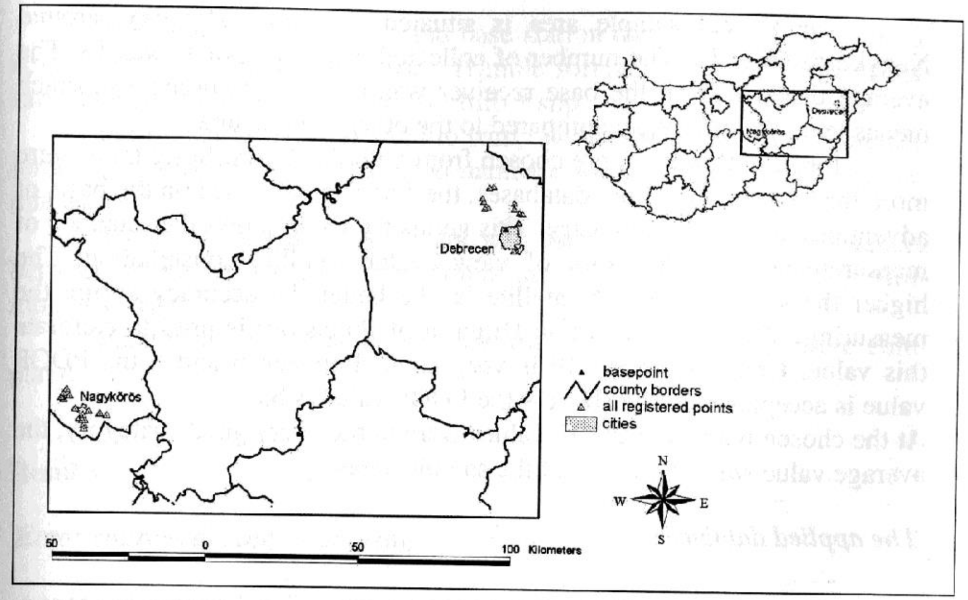

Fig.1. The situation of the sample areas

11 geodetic points were collected around Debrecen. One part of the points was concrete buildings above the ground, the rest of the points was marked by a ground-level concrete cube (*Photo 1.*). All of these points were near the base receiver; the largest distance was about 16 kilometers.

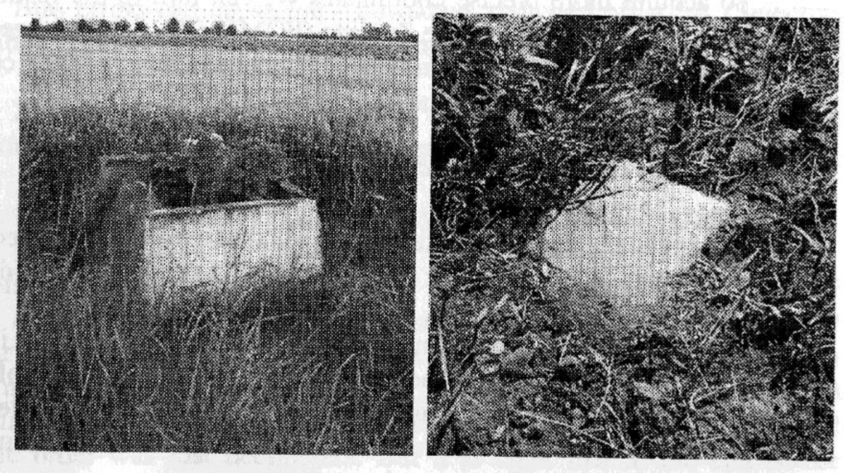

Photo 1. Geodetic point with and without concrete building

The second sample area is situated in central Hungary, around Nagykőrös (*Fig. 1.*). The number of collected-measured points was 18. The average distance from the base receiver was about 150 kilometers, which means tenth the difference compared to the other sample area.

Finally 10 points were chosen from both databases. Since there were more than 10 points in both databases, the filtering happened on the basis of advantageous satellite geometry. This geometry value shows the accuracy of measurement from the point of view of the satellite constellation. The higher the spreading of the satellite is, the better the accuracy during the measuring. The PDOP (Position Dilution of Precision) is used to calibrate this value. Under 4 the PDOP is very good. Between 5 and 8 the PDOP value is acceptable, while above 9 the PDOP value is bad.
At the chosen points the PDOP values were in the "very good" category, the average value was 2.6 in both of the sample areas.

The applied databases

As a reference of the satellite measuring, official Hungarian topographic maps were used. The coordinate system is EOTR, the scale is 1:10 000. The geodetic points were localized in these maps.

The accuracy of these maps is about 1meter, but 1 mm faults on the map can occur, which would mean a 10 m difference in reality (*Chrisman – McGranaghan, ed., 1994.*). On the other hand incorrect reading of the coordinates may enhance the inaccuracy further.

To acquire more precise coordinates we can turn to the Institute of Geodesy, Cartography and Remote Sensing (FÖMI). The measured geodetic coordinates, which we received from FÖMI, were highly precise (cca. 50 cm), and were regarded as "reference-gauge".

The course of measuring and processing

The approximate coordinates were uploaded into the rover receiver, and using car and bottom-receiver antenna the geodetic points were discovered.

On the points the measuring coursed over 1 minute, which is high above the minimum time using code-phase measuring. The period of coordinate receiving was 5 seconds thus 1 minute meant that we were able to fix 12 points. If for some reason the receiver did not measure for 1 minute, the measuring went on up to 12 measured coordinates.

The collected rover data and base station data were uploaded to the computer. Since the receivers uses Trimble format, conversion was necessary. The chosen format was the Arc Info *.shp.

Pathfinder Office was used to trim raw databases and to execute differential correction. The differenced database were exported into *.shp format as well.

To summarize data Ms Excel was used. To definine the distances between reference and measured points the SQR$\{(X_2-X_1)^2+(Y_2-Y_1)^2\}$formula was used.

Finally the three databases (raw, differenced, reference) were compared.

Results

Error sources during measuring

Basically there are three types of errors during measuring (*Fig 2.):*

- Noise
- Bias
- Blunders

Noise can cause about 1 meter difference, its effect is static, and applying longer time measurement we can reduce it.

Bias errors can cause the - nowadays switched off – SA (Selective Availability), ephemeral data errors, atmospheric errors, or satellite orbit errors.

Blunders can result in errors of hundred of kilometers. They are commonly human errors, and filtering them is the easiest.

During the examinations there were two types of the errors found:

- Noise:

A good example is the 2 minute static receiving at the point number 10 near Nagykőrös (*Fig. 3.).* It is notable that according to the measurement of the receiver the point never "stopped", continuously "wondered" around the point. Regarding to the low PDOP value, the error was very small, its numeric order was just decimeters. But it is clear that at the end of the measuring the error abruptly became high, belike "disappearing" a satellite.

Executing longer measuring, the average of these coordinates provides the almost real position.

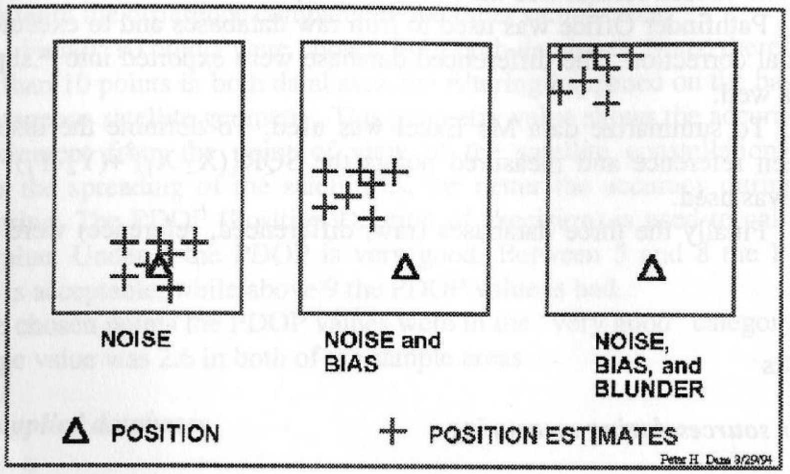

Fig. 2. The results of noise, bias and blunder (based on P. H. Dana)

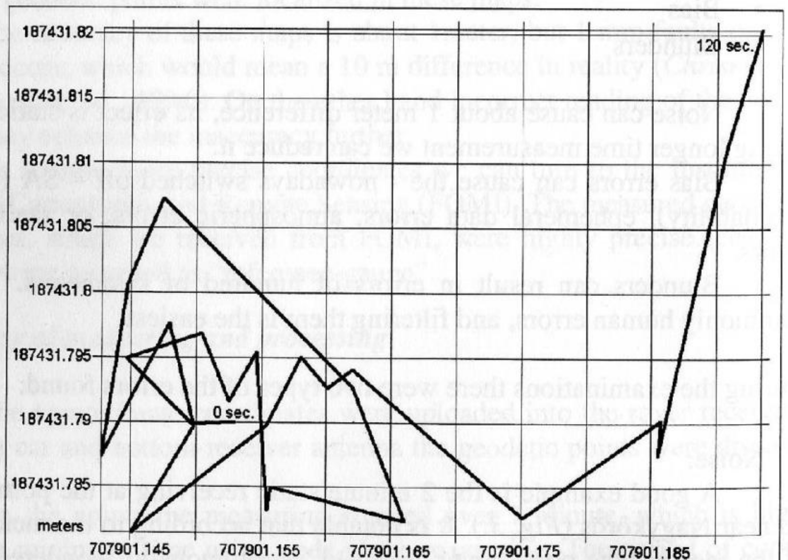

Fig. 3. 2 minutes static receiving at the point number 10 near Nagykőrös

- Bias error

At the points around Nagykőrös an eastern- north-eastern shifting can be experienced. The error-reducing effect of differential correction can be seen well (Fig. 4.).

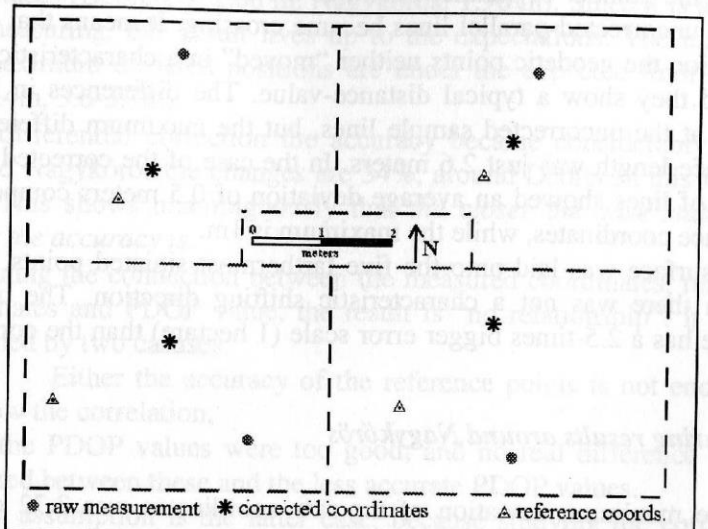

Fig. 4. The eastern- north-eastern shifting of sample points near Nagykőrös

Measuring results around Debrecen

During the measuring there were different degrees of the foliage hiding. The minimum hiding was 0 %, the maximum was 85 %. The statistical test did not show a relationship between the PDOP value and foliage hiding.

The maximum deviation of the raw coordinates was 3.61 meters, the minimum deviation was 10 centimeters. In the latter case the accuracy is under the reference accuracy, thus in practice it means perfect fitting. The average deviation from the reference coordinates was 2.06 meters.

After differential correction the maximum deviation was 1.97 meters, the minimum 0.66 meters. The bigger minimum can be explained by the fact that in this case the raw result was too perfect by chance. This hypothesis can be justified by the fact that after differential correction not the more exact raw coordinate became the best. Thus in this case the correction degraded the accuracy. The average deviation from the reference was 1.07 meters, therefore *accuracy doubled after differential correction.*

Five lines were surveyed among 10 arbitrarily chosen points concerning their position and length. Before differential correction 3 lines were parallel with the reference-lines, two of them were crossing. After correction, though the number of parallel lines was the same, other lines became parallel and uncorrected-parallel lines became crossing. It means that during the correction the geodetic points neither "moved" in a characteristic direction, nor did they show a typical distance-value. The differences in lines were bigger at the uncorrected sample lines, but the maximum difference to the reference length was just 2.6 meters. In the case of the corrected points the length of lines showed an average deviation of 0.5 meters compared to the reference coordinates, while the maximum is 1m.

A surface was laid onto the five farthermost situated points. After correction there was not a characteristic shifting direction. The uncorrected surface has a 2.5-times bigger error scale (1 hectare) than the corrected surface.

Measuring results around Nagykőrös

The maximum deviation of the raw coordinates was 3.72 meters, the smallest deviation was 0.44 meters. The average deviation is 1.96 meters that value is the same as the value of deviation of the points near Debrecen. This result was expected.

After differential correction the maximum deviation is 1.36 m, the minimum is 0.74 m. The average deviation is 1.27 m so the accuracy during the correction *became35% better.*

Laying lines onto the arbitrarily-chosen points shows the following results:
Among the uncorrected lines there is just one crossing, the others are parallel with lines laid onto the reference points. The deviation in length is bigger than in the case of the lines around Debrecen, the maximum is 3 m, the average is 1.5 m. There is a characteristic shifting to East.

In the case of the corrected lines, there is a eastern shifting, and all of the lines are parallel with the reference lines. The length of them – as expected – is closer to the reference lengths, and the error is only submeters.

Surveying the surface laid onto the five farthermost situated points we found that shifting to the east is not consequent, but determinant. After the correction the value of the error fell by 60%.

Comparing the raw and corrected values of Debrecen and Nagykőrös, we can point out the following:

- Before differential correction the standard deviation is about the same in both places (Debrecen: 2.06 m, Nagykőrös: 1.96 m). Since it is an absolute measuring, this result lives up to the expectations. The minimum and maximum deviated positions are under the expected limit as well (0.1-0.4m, 3.6-3.7m).
- After differential correction the accuracy became considerably better. Around Nagykőrös the changes are 34%, around Debrecen this value is 48%. This shows unambiguously that *the closer the base station the bigger the accuracy is.*
- Examining the connection between the measured coordinates, reference coordinates and PDOP value, the result is "no relationship". It can be explained by two casuses:

Either the accuracy of the reference points is not enough to show the correlation,

or the PDOP values were too good, and no real difference can be demonstrated between these and the less accurate PDOP values.

Our assumption is the latter case, because studying the correlation between raw coordinates, corrected coordinates and PDOP values, the result is "no correlation" (Debrecen: -0.26, Nagykőrös: 0.42), thus most probably the good PDOP values cause the lack of correlation.

Conclusions

The accuracy of the rover GPS receiver owned by the Department of Geography is 2 meters and even in the worst case it is about 3.5m – in the case of absolute measuring.

Executing differential correction using the base station data accuracy is about 1 meter.

The accuracy in forest or foliage-hidden surface does not depend on the density of foliage but on the number of satellites.

Within the PDOP category "very good" the better PDOP does not gives better coordinates. Worst coordinates would be expected at worst PDOP category.

In the case of joined geometric shapes (lines, surfaces) the effect of differential correction is significant, during the correction the value of the error falls to 30-50%.

Table 1.Distances of the raw and corrected points from the reference points int he sample areas, and the PDOP values.

	Code	Distance: reference-raw (m)	Distance: reference-corrected (m)	Max. PDOP
Debrecen	69-2113	3.612305773	1.143126415	1.9
	79-3423	2.515635307	0.939246507	2.8
	69-1201	2.268285696	1.403214168	2.3
	79-3416	1.346698556	0.91760558	3.2
	79-3415	0.778386151	0.662529999	2.3
	79-3404	0.103310212	0.850461639	2.1
	79-4338	1.737460791	0.978141605	2.3
	69-2105	2.65548489	0.934004818	2.7
	69-2108	3.318154306	1.970073349	2.8
	69-2111	2.31641037	0.942541776	1.9
Nagykőrös	46-2220	3.719775531	1.287186855	3.3
	46-2103	1.174756145	1.189958403	1.7
	56-4349	0.938407694	1.176588288	1.5
	56-4336	2.07941939	1.360903376	3.9
	56-4075	0.436664631	1.201379624	3
	46-2191	0.606874781	1.228287426	3.3
	46-2057	2.615893729	0.738281789	2.7
	46-2197	2.397299522	0.933782094	2.4
	46-2177	3.087052478	1.191026868	2.7
	46-2221	2.504861872	0.96702637	2.2

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THE ROLE OF THE IMPACTS OF COAL MINING IN THE GEOMORPHOLOGICAL EVOLUTION OF THE CATCHMENT AREA OF THE MINE AT LYUKÓBÁNYA (NE-HUNGARY)

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Introduction

Direct or indirect anthropogeneous impacts on surface evolution have received more and more significance and attention in the 20th century. Our research investigates the effects of mining, one of the special types of such impacts in one of the heavy industrial centres in NE-Hungary. The study area involves the catchment areas of the Pereces and Lyukó streams in the East Borsod Basin covering a part of Miskolc as well (*Fig. 1.*). Most of the two catchment areas each covering about 20,6 km^2 are covered by the mines of the still operating Lyukóbánya and the abandoned mines of the Borsod Mines.

Human impact caused no irreversible damage in the study area until the 19th century due to its low effectiveness. After the development of the Sajó valley industrial area, however, it suffered – among others – from the effects of deep coal mining. The pit-heaps with different maturity of the 200 years long excavation and the surface movements were concentrated in this small area. The built-in area of Miskolc extends towards the areas affected by mining thus it is practically important to know the surface effects of mining in detail.

Geological framework and natural geomorphological development

The East Borsod Basin is an intramountain depression lying between the Bükk and Aggtelek Mountains. Its pre-Alpine basement depicts a fan-like stripped structure. As a result of the Alpine orogene the area was unevenly uplifted and imbricated along these stripes. The basement lies in a depth between +200 – -200 m in the northwestern part of the basin while it can be found deeper than 1000 m in the southeastern part where our study area is situated (JUHÁSZ ed. 1979). With the deepening of the basement the

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interfluves become lower while the sediments overlaid by the Quaternary become younger. The study is lowers from 250-380 m to 200-250 m from W-NW towards E towards the city.

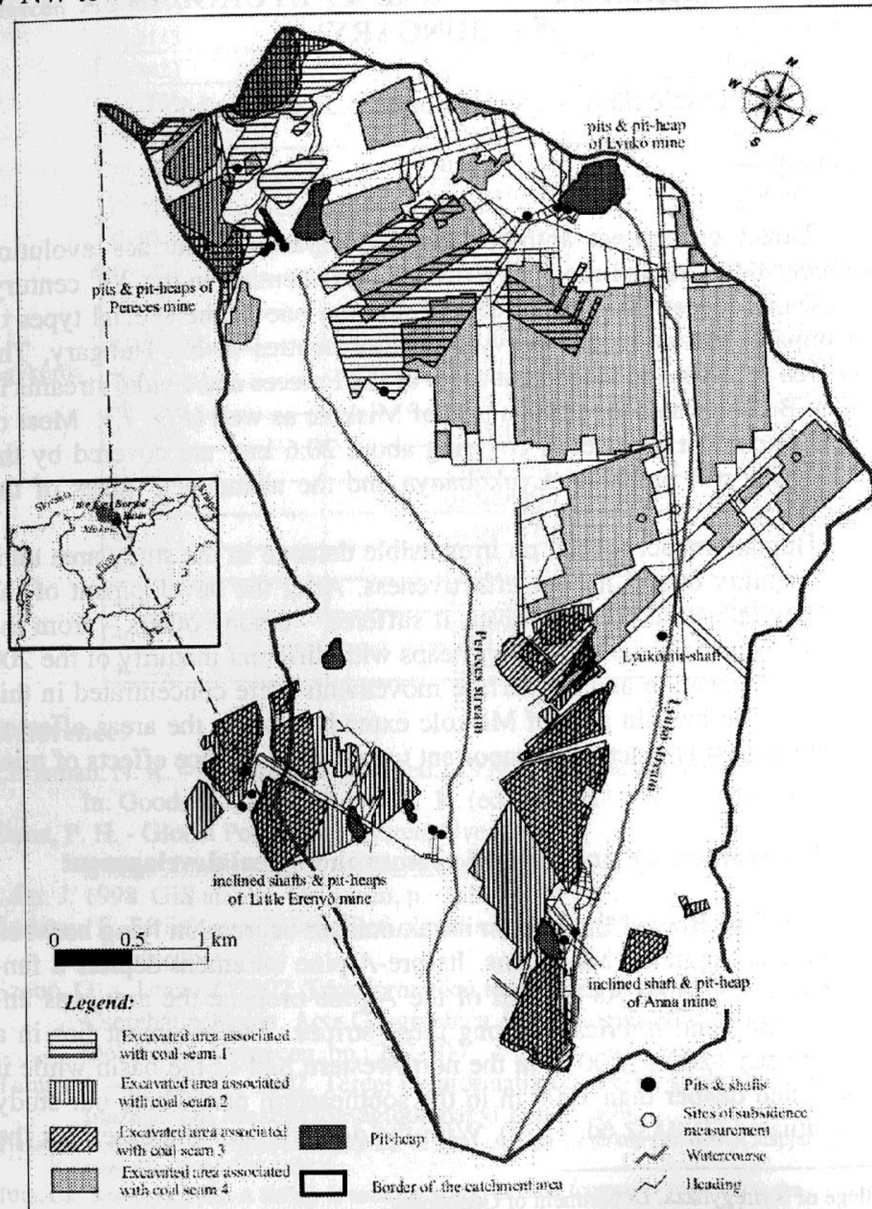

Fig. 1.: The mining objects and excavated areas of the study area

Coal formation is associated with the Cenozoic development of the East Borsod Basin that is characterised by alternating periods of uplift and subsidence. The unevenly eroded and blocky Oligocene surface is overlain by several hundred metres thick Tertiary basin filling sediment series with significant hiatuses and frequent facies changes and with inner unconformities (KOZÁK, PÜSPÖKI, 1995, PÜSPÖKI, 2002). This primarily sandy shallow marine sediment series contains all of the five Ottnangian-Karpatian coal seams. In the cyclic series of the Salgótarján Lignite Formation the coal seams sloping with an angle of 2-4° (JUHÁSZ, 1961) occur embedded in siltstone and tuffaceous clay beds that are reasonably resistant. The only exception to this is coal seam II the cover of which is sand. Tectonic structures characteristic for the coal seams were produced by movements at the boundary between the Karpatian and the Badenian however, NNE-SSW oriented faults formed after the Sarmatian are also proved (KOZÁK et al. 2001, PÜSPÖKI, 2002). Although the area is dissected by only smaller faults (10-30), it is well fragmented because of the closeness of the Bükk Mountains (JUHÁSZ, 1961). Due to the favourable sedimentological characteristics water inrush and stability problems are rare, however, the strong fragmentation may have increased the volume of the movements.

Structures occurring in the near surface series are associated with the gradual uplift of the Bükk from the Pannonian (KOZÁK et al. 2001). The study area at the edge of the Bükk was also uplifted and the still ongoing denudation of the basin sediments had started (KOZÁK, PÜSPÖKI, 1995, PÜSPÖKI, 2002). The initial stage of denudation was characterised by the development of pediments then valley formation became dominant. Side valleys of torrents accompanied the main valleys and therefore only parts of the Pliocene-Pleistocene pediments remained as gradually thinning and lowering interfluves. Intensive out-wash of sediments was intensified by the southeastern shift – from the vicinity of Kazincbarcika to beyond the Miskolc gate – of the Sajó outlet with the retreat of the Pannonian sea (SZABÓ, 1979).

Pre Quarternary surfaces are overlain by dominantly valley floor sediments developed along Pleistocene rivers. 0,5-1 m high terrace remnants can be found scattered in smaller side valleys. Only the still infilling plains of the two main valleys represent greater flat surfaces, however, parts of these were almost completely destroyed by the spreading of Miskolc and by mining. Due to elevation and geological differences the general sloping of the Pereces stream is 7-8 % while that of the Lyukó stream is only 2 %. Therefore the fluvial platform of the steep sided valley-head of the Pereces stream is fragmented by scars resulted from the intensive denudation and it is formed by rock falls and landslides. On the eastern side of the main valleys derasion alcoves are frequent and wide dish-like valleys frequently occur. On the southern part of the catchment area the side valleys are nearly perpendicular to the main valleys. Their valley-heads can be found almost along the same axis on both sides of the main watershed. This phenomena is interpreted as the surficial appearance of the transverse faults. The loose material is denuded by mainly linear erosion transforming the derasion valley-heads (Fig. 2.). At least two main stages of valley development can be determined on the basis of the relative position of the erosional and derasion valleys. One part of the derasion valleys formed during periglacial conditions – like those found southwest of the mine of Pereces – are hanging valleys above the main valley. Their floor ends at the level of the fluvial platform marking the local base level at the time of their formation. Later in the inter- and post-glacial times increasing linear erosion deepened the valleys and the derasion valleys partly became erosional and partly became hanging valleys. It can be detected in several places that smaller derasion alcoves had been formed in the valley-head of the larger derasion valleys during the periglacial climatic periods being repeated several times or erosional trenches were formed as a result of the increasing linear erosion. The other type of erosional valleys was formed along landslides. Erosional trenches and torrents were cut into the undulating slopes like in the Lyukó valley. This process is intensified by deforestation and occurrence of new local base-levels as a consequence of subsidence of undermined areas.

The relief can be regarded as strongly dissected on the basis of morphometric factors among Hungarian hilly regions. The average relative relief is 96 m/km^2. Lowering from NW towards SE is reflected by the decrease of the value of relative relief from 120 m/km^2 at the source area of the Pereces stream to 30 m/km^2 at the stream outlet. The difference between the smallest and greatest relative relief value is twentyfold while 2,5-fold between the smallest (150) and the highest (381,5) elevation. The explanation for the high portion of slopes steeper than 10-15° lies in the fact that these sediments are rather consolidated (JUHÁSZ ed. 1979). In the northern part the harder brown ironstone cemented sands and gravels and the volcanics and cemented Sarmatian gravel tops were uncovered to the surface.

Considering the surface stability of the area as a whole we can classify it as weak moderate. This is the result of the alternation of more cemented Sarmatian-Pannonian and less consolidated Ottnangian sandy formations. The Ottnangian-Karpatian sediment series covering most of the surface has preferable consistency due to its environmental geological characteristics; however, the montmorillonite content of the pelitic sediments

may reach 60 % (JUHÁSZ ed. 1979) intensifying the possibility of mass movements. The silty and sandy rocks of the Karpatian – Lower Pannonian sediment series form complex slopes where a change of rock type occur. Considering their cementing material and diagenesis they form instable slopes in the case of greater steepness, however, they form moderately stable slopes when less steep. Due to their relatively low clay content they are less sensible to water and they are only sensible to the effect of oversaturation when near surface clayey interbedding is saturated. Complex slopes can be found in the vicinity of Miskolc and in the western margin where greater strength is produced by the brown ironstone cementing coming from neutral volcanics (CSÁMER, 1999) and by the already mentioned variable lithology.

Mass movements dominate in the Sajólászlófalva Member, which contains several tuffaceous clay stripes. These may have acted as a preformed sliding plane due to their higher-than-average smectite content (VICZIÁN et al. 1998). When reaching the critical shear stress a series of landslides were triggered leaving stagey steps (PEJA, 1956; SZABÓ, 1979 – *Fig. 2.*). The heaps of former larger block slides were further formed by later slides and and erosional sides. South from the Lyukóbánya the slopes are dissected by landslides triggered at different times along several 100 m length and in 4 levels. The oldest ones appear as gently sloping flat valley sides, however, in front of the youngest one wide landslides are found with a 10 m wide hollow ("hepe") lake and with waterlogged depressions behind it (*Photo 1.*).

Impacts of coal mining

The most striking human induced morphological changes were produced by mining in the course of pit-heap disposal and indirectly by surface subsidence (*Fig. 2.*). The resultant forms can be classified into 3 groups according to engineering geological and anthropogeneous geomorphological aspects: concave accumulation forms, convex denuding forms and flat neutral forms (JUHÁSZ ed. 1979, JANKOWSKY, 2000).

Mass movements are only accessory processes associated with tunnel construction. Therefore they were ignored for a long time. However, surface changes induced by the extracted area occurred within a few days or a week after ceasing excavation. This is caused by the fact that the shear strength of the Miocene rocks holding the coal seams is so low that they were fractured and moved towards the excavated chamber under the increased confining pressure (MARTOS, 1958).

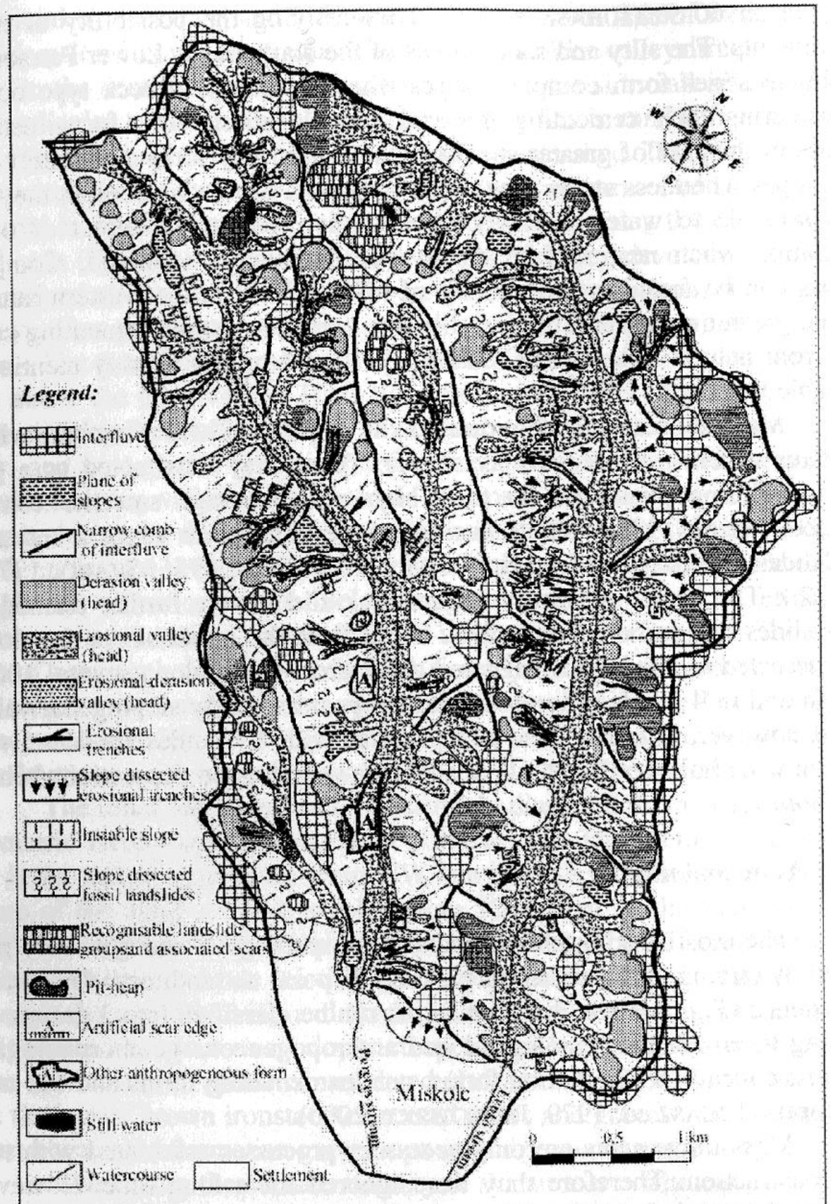

Fig. 2.: Geomorphological map of the study area

The mining technologies were wood securing hand chamber excavation and self-securing machine frontal excavation in our study area. Aftercare was usually simple abandonment. Infill was only applied in the case of

serious damage. In the upper I. and II. (occasionally III.) coal seams that were excavated earlier wood framework was used (*Fig. 1.*). Where the height of the tunnels was around 2-3 m almost 1 m deep sinkholes occurred in the near surface layers. With the development of technology steal support was used in the course of the excavation of the deeper IV and III. seams. Since the end of the 1950s frontal excavation was introduced and much larger volume of material was excavated. This led to the production of larger continuous tunnels. Therefore numerous sinkholes with different size were formed on the surface above the excavated area. In theory steal support remains resistant to the upper rock mass for over 100 years but the deformation of the steal securing ring in the abandoned tunnels indicate the danger coming from the overload (*Photo 2.*). This suggests that 1-2 centuries after the maximum of the great movements a second maximum may occur of surface subsidence as a result of the ageing of the tunnel supports. Although these do not appear on the surface if the tunnel smaller than a certain critical size but mass transportation near the surface may influence the subsequent surface development.

In our study area the volume of the undermined area is 20 623 590 m^2 in total – according to the detailed mine maps – splitting between 4 seams. If the excavated parts were distributed evenly a 3 m thick empty space would be formed at a depth of 100 m all under the catchment area. More than half of the area is in fact undermined and in several places the excavated seams lie above each other (*Fig. 1.*). Different districts were separated on the basis of the affect of mining and the number of excavated seams.

- In the valley-head of the Pereces stream and West of the Lyukó air-shaft *three seams* were excavated above each other. The situation is better in the Pereces valley-head as the excavated seam I was deeper than 100 m and the area is covered by forest. However, the area near Lyukóbánya is a built-in area and the uppermost-excavated coal seam was above the 100 m depth (*Fig. 1.*). Scars, torrents and a mass movement form found on the geomorphological map indicate the probable increase in the intensity of the surface forming processes (*Fig. 2.*).
- The next type is where two seams above each other were excavated. Such are the area between the New-mine of Pereces and Lyukóbánya; the air-shaft of Lyukó; the Kis-Erenyő valley and the vicinity of the Anna mine (*Fig. 1.*). In the case of the first two sites the excavated seams are situated more than 200 m deep therefore major morphological changes should not be caused. However, mass movements bear a significant role as the geo-

logical framework is unfavourable and undermining is not excluded from their triggering. In the two latter areas the excavated seams were situated 50-100 deep. The Kis-Erenyő valley and the Anna mine are situated at the edge of the built-in area of Miskolc. In the case of the Anna mine the overload of a pit-heap increases the danger. The rate of surface movement is indicated by the fact that as early as 1957 a new transporting shaft had to be constructed due to subsidence.

- In the northern part of the Lyukó valley only seam IV was excavated – except for the above mentioned area (*Fig. 1.*). This seam has the greatest depth, which is found to be above 200 m only in the deepest part of the valley. On the two sides of the Lyukó stream and along the road in the valley the subsidence curve measured by miners slowly decreases from a 1,8 m deep maximum point. The uncertain profile is probably the result of the effect of the road foundation, the safety pillar and the loose surficial sediments. The valley sides are strongly undulating the new erosional grooves and the slid patches indicate that surface development, although in small-scale, was affected by mining.

An indirect consequence of subsidence is that the changing slopes change the rate and intensity of erosional and derasion processes and a new local base level is developed (WACH, SZCZYPEK, 1996). The sinkholes, scars and deformations formed on the surface exhibit different sizes and types from slope edges to lake filled depressions (*Fig. 1.*). Besides subsidence the disposal of a pit-heap may also cause the development of a new base level. The pit-heaps of the New shafts at Pereces and the older pit-heap of Kis-Erenyő present good examples for the blocking effect as they block half of the valley-head resulting in the formation of a temporary lake behind them (*Photo 3.*).

The most significant artificial relief change is presented by the *pit-heaps* on the study area (*Fig. 1., 2.*). Frequently the disposal of pit-heaps crosses the route of natural denudation. To forecast the following surface changes the determination of the natural surface development stage of the pit-heaps is necessary (HOMOKI et al. 2000) because the disposal of the heap only produces the initial form on which natural denudation creates secondary forms (ERDŐSI, 1987).

Pit-heap disposal was most intensive between 1950s and 1980s. The amount of heap material is associated with the development of the mining technology. Machine driven frontal excavation did not follow the line of the coal seams resulting in shorter excavation time and greater amount of waste containing more coal. The material found in the pit-heaps is fine sandy – clayey silt with varying inter-beddings and secondary minerals resulting from the self-combustion of the heap (SÜTŐ, 2000, HOMOKI et al. 2000). Erosion processes observed on the surface of the pit-heaps are faster than the natural erosion characteristic for the area. Therefore these can be regarded as a short period monitoring model (HOMOKI et al. 2000). The surface development of pit-heaps shows close correlation with the change of the weather. Mechanical weathering is striking in burnt rocks as the freeze-thaw effect of a few weeks at the beginning and at the end of winter intensifies mechanical weathering. The snow melts in spring and the wet weather in early summer and November induced mass movements on the bare coal slate containing surface of the pit-heaps due to the saturation and weathering of the heap material. On slopes of loose more burnt material erosion triggered rock falls. The role of vegetation is indicated by the fact that significant erosion did not occur even on steeper slopes where trees and shrubs were grown. However, bare surfaces experienced stronger erosion on gentler slopes as well. The occurrence of vegetation indicates the slowing of surface development and the cooling of the pit-heap (HOMOKI et al. 2000)

The pit-heap of Lyukóbánya is the largest in the study area and it was continuously studied but measures were only taken in the case of emergency. Thus spontaneous processes form its surface (*Photo 4.*). In the course of the disposal a completely inhomogeneous heap was created in the valley-head. That is a denuding surface instead of a concave form ("anthropogeneous morphological inversion") diverting local relief development towards a new orientation. In this stage several physical factors act together: weathering, mechanical weathering, burning of the heap and deflation, linear erosion and mass movements. It is natural that their environmental danger is significant.

It is connected to pit-heap disposal that heap material was spread on the steep slopes for the foundation of the miner homes near the mine site at Pereces. Thus an artificially covered surface was created that made cultivating and forest expansion difficult and movements were induced along the edge of the different materials. Traffic associated with mining also caused surface changes. Along the former mine railway in the Lyukó valley on the right side of the stream dams were created across the steep erosion valleys (*Fig. 2.*). The greater ones are supported by retaining walls but intense erosion induced mass movements resulting in the formation of local base levels behind them.

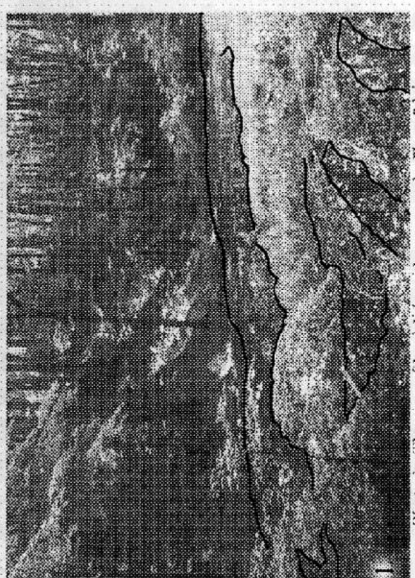

Photo 1.: The sign of landslide with a scar and a "hepe" lake on the eastern slope of the Lyukó valley in front of Lyukóbánya

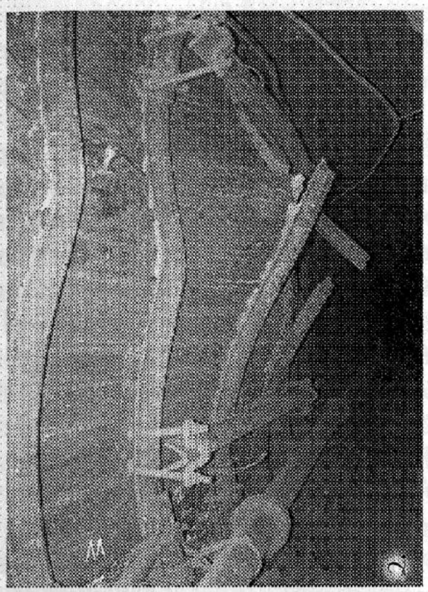

Photo 2.: The arch support is broken on the account of top pressure

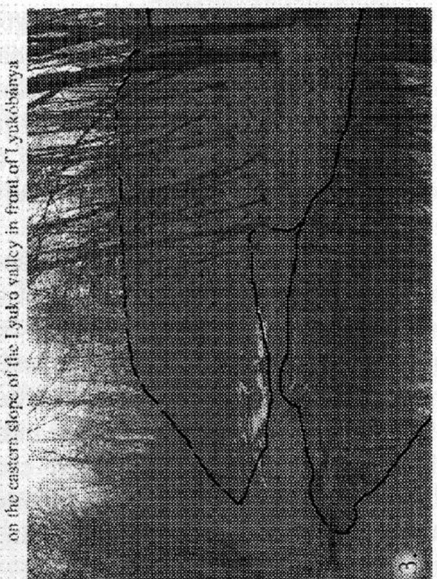

Photo 3.: Temporary lake formed in the dammed stream bed behind the pit-heap at the Pereces mine

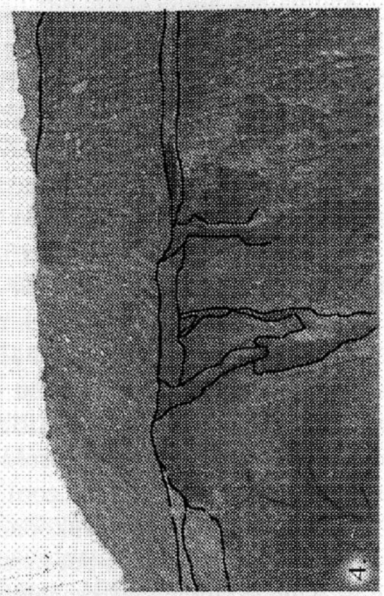

Photo 4.: The new pit-heap with slope forming trenches (barranco) at Lyukóbánya

Conclusions

Our results on the one hand supported several already known facts regarding the geomorphological effects of mining and on the other hand these results proved that numerous conclusions can be drawn from the geology, natural surface development and present geomorphology of the study area and from the time-scale and the characteristics of the more-or-less ceased mining. We highlight the followings:

- the effect of mining reaches way beyond its directly affected area. In the surroundings of Lyukóbánya mining indirectly caused significant change in the landscape structure on a ten times larger area than those required for the mines.
- mining has a significant role in the reactivation of mass movements in movement sensitive areas. The particularly anthropogeneous and the natural mass movements frequently occur undistinguishly together not just giving new direction to other surface forming processes but as semi-anthropogeneous natural threats present the most serious disturbing and endangering factors for urban development.
- the intensity of surface movements (collapse, subsidence) triggering after the ceasing of mining activity may show a time curve with double maximum depending on the mining technology. Therefore in the case of re-use of older undermined areas this delayed, hidden danger source should be taken into account.
- more accurate knowledge on the development stage of pit-heaps can solve many difficulties occurring in the course of re-use or re-cultivation. To achieve these detailed investigations of the heap materials and the processes taking place on them based on high measurement numbers is necessary.

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FUNCTIONAL CHANGES OF THE TUMULI AT THE DIFFERENT STAGES OF HISTORY

Csaba Tóth*

Introduction

The Neolithic revolution between 5500 and 5000 BC had a basic impact on the surface evolution of the landscapes of the Great Plain (HORVÁTH, F. – HERTELENDI, E. 1994) when the formerly gathering, fishing, hunting ethnic groups settled down and changed to a farming and animal keeping lifestyle which transformed the natural soil, the vegetation and the fauna as well. The original frondiferous forest and woody steppe vegetations were opened more and more intensively while forming the plough-lands and pastures which were necessary for the economy. From that time on, MAN became the main landscape forming factor. All these were not only manifested in a *change in economic methods but also in a geomorphological change* as well.

The geomorphological change partly means that there were more and more constructions of ***tells*** which artificial mounds ensured place for the permanent settlements. In the beginning, these forms meant only a small-scale heightening of the already existing natural, floodless, levee areas (natural levees, sand-hills) but later, however, they were further heightened by the newly coming and settling in ethnic groups (Early and Middle Bronze Age) and new mounds were also created. In the Hortobágy region and in its environs, the tell-settlement form characterising the Neolithic and Bronze Ages was especially widespread along the larger living water courses (Tisza, Hortobágy, Kösely, Árkus, Kadarcs rivers). Almost in parallel with the building of the tells a ***watch-mound*** chain started to develop connecting the bigger population concentrations. Besides the dwelling mounds, the ***burial-mounds*** (kurgans) also appeared from the Bronze Age on through the migration era to the Early Middle Ages which were of a different character and had a different function and which were not necessarily related to water courses.

The mound constructing processes starting in the Late Neolithic Period and ending in the thirteenth century with the activities of the Cumanians spans over almost five millenniums enriched the Great Plain with thou-

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sands of mounds which was otherwise poor in macroforms. Estimations based on the archaeological findings suggest that once there could have been as many as 40 thousand mounds in the Carpathian Basin. At the beginning of the twentieth century, Béla Kozma gave a description of 1200 of the mounds found in the Carpathian Basin (KOZMA, 1910). On the basis of the national state survey finished in 2002 there are about 1700 tumuli in Hungary at present (TÓTH, CS. 2002).

The relationship between human society and the tumuli radically changed from the Middle Ages and especially from the mid-nineteenth century. While earlier these mounds used to form an organic part of life later they became the scenes of the many-sided human destruction when being left without functions. This deleterious process did not only endanger the archaeological values of the mounds but the related geomorphological, pedological, landscape scenery, botanical, zoological and other cultural historical values too. Consequently, the number and state of the remaining mounds at the present cannot be indifferent for us and nature conservation should pay special attention to their protection. The elaboration of their protection started in the past decades as a result of many local initiatives and fortunately Paragraph 23 (2) of Act 53/1996 on Nature Conservation declares their national protection too. The present paper intends to provide an analysis of the relationship between these forms and the society at the different stages of history.

Methods

The survey of the tumuli had been conducted on three micro landscapes of the Great Plain: on the area of the Hajdúság, Hortobágy and Nagykunság regions with the help of a cadastre datasheet consisting of 24 points (TÓTH, CS. – KOZÁK, J. 1998). The name, synonym name, geographic co-ordinates (GPS), the name of the settlement and the confines section, the side length of the basis of the mound, the absolute and relative heights, the intactness or disturbance of the body of the mound, the objects found on the area of the mound, the vegetation and the type of economy of 503 tumuli were registered on the datasheet. The datasheet contains questions on the economy types of the areas in the 500 meters neighbourhood of the tumuli, the objects found there and their cardinal directions as well. The last section of the datasheet includes information related to the history of literature and culture beside the archaeological, botanical and zoological characteristics.

Topographic maps of 1:10000 and 1:25000 were used for the field survey of the mounds and for the registering of their heights, while a GPS

instrument was used for the determination of the positions. The processing of the datasheets was done with the help of a data processing software elaborated especially for this purpose (Registry System of Tumuli 1.1), and the Microsoft Excel and ArcView GIS softwares were applied for the evaluation of the data (TÓTH, CS. - SZABÓ, G. 2002).

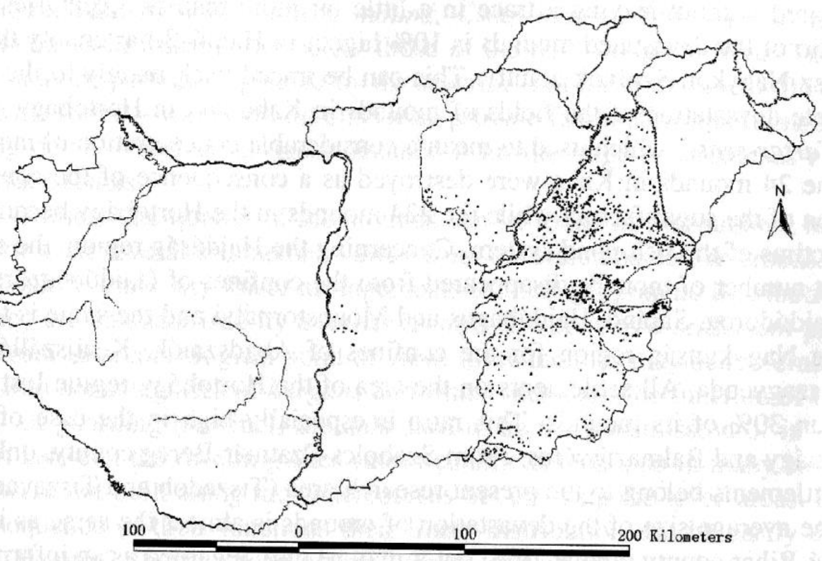

Fig. 1. Location of the tumuli in Hungary and the demarcation of the surveyed area (Ed.: Tóth, Cs.)

Results

Changes in the number of the tumuli

The changes in the relationship between the tumuli and the society are the most spectacular in the period of the Modern Times when the number of the mounds decreased drastically. The highest density of mounds may be detected on the *flat areas characterised with high flood plain situation which are poor in macroforms* in Hajdú-Bihar, Jász-Nagykun-Szolnok, Békés and Csongrád counties. Based on this, the surveyed area is one of the richest regions of the country with regard to the number of tumuli. The identification and state survey of **503** tumuli were conducted on the research area (Fig. 1).

Relying on maps and archival sources from the mid-eighteenth century, Dénes V. (1979) revealed **1638** mounds on the present survey area of Hajdú-Bihar, Jász-Nagykun-Szolnok and Szabolcs-Szatmár-Bereg counties. The two data above set an excellent example for the intensity of their devastation: almost **70%** (69.3%) of the mounds, that is **1135** of them, disappeared without leaving a trace in a little bit more than two centuries! The ratio of the devastated mounds is 10% higher in Hajdú-Bihar county than in Jász-Nagykun-Szolnok county. This can be traced back mainly to the complete devastation of the fields of mounds in Kaba and in Hortobágy called "*Tartar-seats*" which used to mean a considerable concentration of mounds. The 24 mounds in Kaba were destroyed as a consequence of the construction of the sugar factory while the 224 mounds in the Hortobágy became the victims of the fish-pond system. Concerning the Hajdúság region, the smallest number of mounds disappeared from the confines of Hajdúböszörmény, Hajdúdorog, Sáránd, Hajdúbagos and Monostorpályi and the same is true in the Nagykunság region for the confines of Abádszalók, Kisújszállás and Tiszagyenda. All settlements on the area of the Hortobágy region lost more than 30% of its mounds. This ratio is especially high in the case of Hortobágy and Balmazújváros. From Szabolcs-Szatmár-Bereg county, only two settlements belong to the present research area (Tiszadob and Tiszavasvári). The average size of the devastation of mounds is almost the same as in Hajdú-Bihar county (above 70%) but it may be only regarded as an informative piece of information due to the essentially lower number of available data.

Changes in the function of the tumuli during history

Primary functions

Almost three-quarters of the mounds were created directly along the living water-courses (Tisza, Hortobágy, Sáros rivulet, Árkus, Kösely, Pece rivulet, Tócó, Berettyó, Körösök etc.) or along their abandoned beds in the external arc of the river and river bed meanders in a snake-like distribution which are secure from floods (Fig. 2). One can never find mounds in the internal arc of the meanders, in the crevasses. The mounds found in the direct vicinity of the watercourses may be grouped into the three archaeological categories, that is there are ***dwelling-mounds (tell), kurgans and watch-mounds*** as well in this position. The dwelling-mounds characterising the end of the Neolithic Period and the times of the Bronze Age can be mainly found on the natural levees of the larger watercourses, on the sand-hills accompanying the rivers, at the crossings of the trade routes and at the meeting zones of different landscapes. The most valuable of these along the River Tisza are: Polgár – *Nagy Csősz mound*, Tiszafüred – *Ásott mound*, Törökszentmiklós – *Tere mound*; Tószeg – *Lapos mound, Kucorgó*; along the Ancient Berettyó river: Túrkeve – *Tere mound*; along the Berettyó river: Berettyóújfalu – *Herpály, Szihalom*. The size of the settlement traces from the Neolithic Period and the Bronze Age on the area of the Hortobágy region (Szeghatár mound, *Faluvég mound, Csécs mound, Büte mound*) and their richness in findings are below those of the tells along the River Tisza which may be perhaps explained by the scantiness of the landscape in floodless levee forms – which would otherwise provide favourable conditions for settling down – and by its great distance from the large watercourses and busy trade routes.

Almost one-quarter of the mounds can be found at few hundred metres – or even several kilometres – away from the watercourses, riverbeds. It is difficult to trace any linear arrangements in their geographic distribution and they are characterised by a *linear* as well as a *scattered settlement* pattern. From an archaeological point of view, these mounds may be preferably listed into the categories of *kurgans* and *watch-mounds*. The function of the watch- or guarding (sentinel) mounds used to be the transmission of information between the dwelling sites (news-chain elements), so in many cases these were not built along the watercourses but crossing the levee areas. As a consequence of their functions their linear distribution can be easily detected. Figure 2 shows a map of the kurgans and watch-mounds listed into one category because the number of the archaeologically explored mounds is very low (38) and in many cases the kurgans and watch-mounds are very difficult to be distinguished on a morphological basis.

Secondary functions

By the thirteenth century, the almost five millennium long mound constructing process ended with the burial mound activity of the Cumanians. During the Middle Ages no more mounds were built with the original functions (dwelling, burial and guarding) on the Great Plain. Accordingly, the existing mounds from the previous times were endowed with new functions. Three new functions appeared during the Middle Ages:

The drawing of the borders of the settlements, districts, counties and countries often followed the ancient mounds and thus a large number of ***frontier mounds*** were created. These perturbations which could be easily perceived from great distances were excellent orientation points and thus the running of the borders was obvious for everyone. Many administrative borders still cross tumuli even today although their above described role lost its significance to some extent with the appearance of the modern topographic maps. The most well-known frontier mounds are: *Gergely mound* (at the meeting of the three borders of Karcag, Kunhegyes and Kunmadaras); *Hármas frontier mound* (at the meeting point of Karcag, Kisújszállás and Kenderes); *Dombegyházi mound* (Hungarian-Romanian border).

The enforcement of judgement and executions in the Middle Ages happened on the mounds closest to the settlements in many cases which became known by the vernacular as ***scaffold mounds*** or ***gibbet mounds***: *Akasztó mound* (Kisújszállás, Kunhegyes, Konyár, Biharnagybajom, Tiszadob, Mezőcsát, Abaújkér).

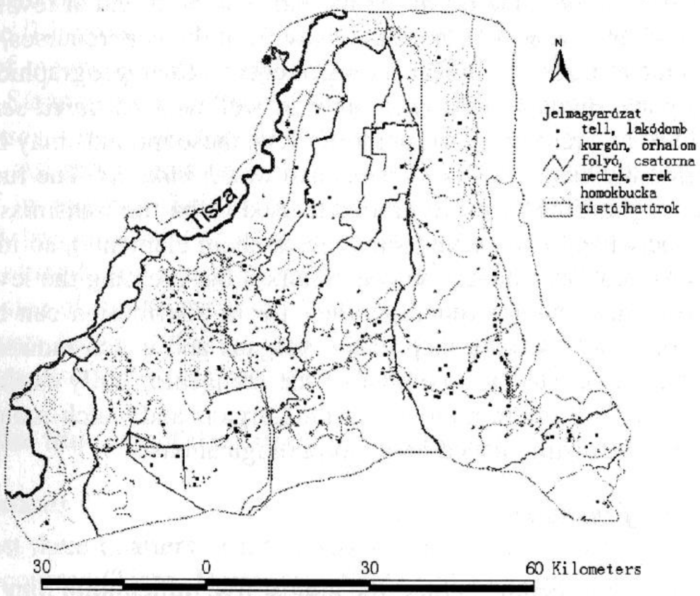

Fig. 2. Tumuli on the research area (Ed.: Tóth, Cs.)

The ancient mounds which raised 3-4 metres above their environs were favoured sites for building chapels and churches in the Middle Ages. Thus, many dwelling and burial mounds functioned as ***church mounds*** during the Middle Ages. These included, for instance, the *Zeleméri church mound* (Hajdúböszörmény); *Parlaghi church ruins mound* (Debrecen-Dombostanya); *Templomos mound* (Egyek-Telekháza).

Tertiary functions

During the Modern Times, the most spectacular change in functions was the use of the mounds for ***agricultural production***. According to the data of the survey, 48% on average of the three micro-landscapes are used as *arable lands*. This value is almost the same as the national average. Of course, in the case of the mounds in the Nagykunság and Hajdúság regions – characterised by better soil quality – the ratio of the mounds which are completely cultivated is above the average while it is much below the average in the case of the Hortobágy region and more especially on the area of the National Park (39 % – 17 %, respectively). Besides the tilling of arable land, the economic activities related to meadows and pastures, horticulture, sylviculture and animal breeding characterise altogether 12% of the mounds. Thus, 60% of the mounds are used for agricultural purposes in total (Figure 3).

Besides the tilling of arable land, there are ***other economic activities*** present on the mounds. Food industry used the mounds for building windmills (*Baghy mound* – Kengyel). National defence built observation towers on the mounds (*Ecse mound* – Kunmadaras) and also often used these perturbations as places for gunnery practices (*Bán mound* – Bánhalma). During the twentieth century the *traffic, transportation and telecommunication* more and more intensively transformed the mounds: construction of dirt-roads, roadways, pylons and mobile phone towers.

One of the most dynamically developing economic sectors of the twentieth century, ***tourism***, has not really discovered the opportunities offered by the tumuli, yet. Only the mounds with some kind of monuments (church, crypt, rood, stations, memorials) which were turned into museums or study trails have some tourist attractions. These include, for instance the *Kriptáj mound* –Dombegyháza; *Wenckheim mound* – Szabadkígyós; *Kápolna mound* – Karcag; *Nagysándor mound* – Debrecen; *Mágori mound* – Vésztő; *Gödény mound* – Békésszentandrás; *Basa mound* – Debrecen; *Szálka mound* – Hortobágy.

These artificial perturbations were favourable for establishing ***geodetic objects*** (triangulation point, height marks) because of their heights. Thus, today if we do not consider the intensively tilled mounds then 95% of the mounds have some kind of a geodetic mark on it (Fig. 4).

It may be observed that the mounds have lost most of their primary and secondary functions by today. Instead, the tumuli received agricultural, industrial and tourist functions beside the generally widespread geodetic

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It may be observed that the mounds have lost most of their primary and secondary functions by today. Instead, the tumuli received agricultural, industrial and tourist functions beside the generally widespread geodetic functions. Only three mounds preserved its ***original functions*** on the surveyed area, meaning that these mounds are either still inhabited (*László mound* – Debrecen) or used as burial places (*Kettős mound* – Fegyvernek; *Szöghatár mound* - Egyek).

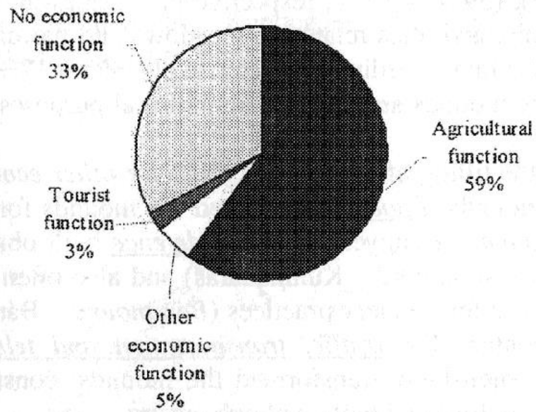

Fig. 3. Current functions of the tumuli on the studied area

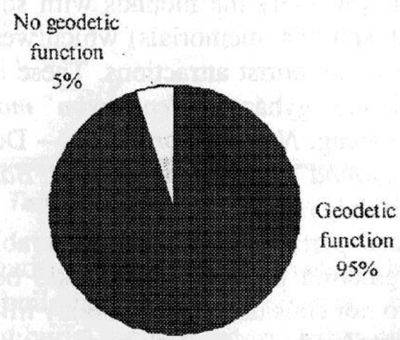

Fig. 4. The division of the tumuli by geodetic functions on the studied area

Summary

Table 1. Dominant functional types of the mounds
(Buka, L. 1994; Csányi, M. 1999; Tóth, A. 1999; Tóth, Cs. 2003)

FUNCTIONAL TYPES OF MOUNDS		
Types	*Origins*	**Characteristics**
Dwelling mounds (tell-sites) tell (Arabic, meaning: mound)	- Late Neolithic (4000-3500 BC) - Early and Middle Bronze Age (2600-1500 BC)	Corpulent 6-8 metre tall mounds with an oval base. They reached their present heights using the material of the dwelling levels of the various human cultures built over each other during many centuries. Layered sites.
Burial mounds (kurgans) kurgan (Turk-Mongol - meaning: burial mound)	- Copper Age (3500-3000 BC) - Scythian, Germanic, Sarmatian, time of the Hungarian Conquest and Cumanian burials	3-11 metres tall cone-shaped formations with a round base. Following the ground burials of the Copper Age many other ethnic groups also used it as burial places. Therefore, they mark the places of not only one but several burials.
Watch-mounds (guarding, sentinel mounds)	4000-3500 BC 2600-1500 BC	Short mounds rarely providing archaeological findings which used to ensure a chain-like connection between the tell sites with the help of light and sound signals.
Frontier mounds	Middle Ages	After the drawing of the borders of the counties, districts and settlements, certain kurgans and watch-mounds functioned as frontier mounds at the meeting of two, three or even four borders.
Scaffold mounds	Middle Ages	Many ancient mounds on the area of the Great Plain were the place of the enforcement of judgements during the Middle Ages (Akasztó mound).
Cultic mounds	Middle Ages	The churches and chapels of the settlements of the Árpád Era and the Middle Ages were often built on ancient mounds.
Mounds under agricultural cultivation	19th-20th century	With the expansion of the large-scale field growing of plants a considerable number of mounds were tilled and they are used for cultivation even today.
Mounds with other economic activities	19th-20th century	Food industry also used the mounds (windmills). National defence: military observation towers, locales for gunnery practices. Traffic, transportation and telecommunication: construction of roads, mobile phone towers and pylons.
Tourist mounds	20th century	These include the mounds with monuments (church, crypt, rood, stations, memorials) and the ones turned into museums or study trails.
Geodetic mounds	19th-20th century	There are height marks or triangulation points on the top of almost all higher mounds.

The tumuli and the human cultures had had a harmonic relationship between the Late Neolithic Period and the thirteenth century. These mounds basically had dwelling, burial and guarding functions. Besides their original functions they were mostly given a frontier marking role during the Middle

Ages and they also became the most important locales for practising executions and cultic activities. From the mid-nineteenth century another important change occurred in the relationship between the mounds and the society. This was partly expressed by the drastic diminishment in the number of the mounds. Almost 70% of the mounds became over-tilled and their materials were removed (construction of roads, railways, dykes, filling up of courtyards, gardening purposes etc.). The other considerable change was an other shift in functions, as a consequence of which 67% of the mounds were assigned various economic functions (agriculture, industry, transportation, tourism). Contemporaneously 95% of the mounds function as geodetic objects.

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SOME OUTSTANDING GEOMORPHOLOGICAL VALUES OF THE UPPER TARNA REGION

Zoltán Utasi*

Introduction

The Upper Tarna region involves the catchment areas of the Cered- and Lelesz-Tarna streams up to their joining at Pétervására (Fig. 1.). Three hilly areas that are connected by the Tarna (see map) are involved in this region. These three areas are the followings: western part of the Heves-Borsod Hills, eastern part of the Upper Tarna – Zagyva Hills and the north-eastern zone of the Pétervására Hills. The scientific exposition of this picturesque hilly region is far from complete as it is one of the marginal areas of Hungary hiding in the shadow of the Mátra and Bükk Mountains. The main goal of this paper is to highlight the values hiding in its landscape and to present the most important geomorphological values. Despite its large extent, the region exhibits a rather uniform petrological and geomorphological picture. Its morphology becomes divers only in its western part. (The settlements to which the certain forms belong are found in brackets after the name of the forms as many forms bear similar names.)

Geological framework

Geological heterogeneity is similar to that of the surrounding mountains. Its exposed rocks present the history of 30 million years. The oldest is the Szécsény Schlieren Formation which is a grey, unbedded fine sandy – clayey siltstone with small micas and fishxxx. It has a general thickness of 400-800 m. It is exposed to the surface in the western part of the area. Its superposition on the Pétervására Sandstone can be studied South of Pétervására. The majority of the area is built up by the Pétervására Sandstone Formation formed in the Upper Oligocene – Lower Miocene period. Its thickness is between 500-700 m and it can be subdivided into two parts. Its lower, larger part is a coarse, medium and fine grained sandstone with varying hardness and with a colour ranging from grey to yellowish green. It is frequently glauconitic with muscovite and biotite. It can be cross-bedded or thinbedded with clay stripes. Large concretions with regionally different apperance are also characteristic. The upper thinner part is the 50-80 m thick

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Ilonavölgy Formation, which is, separated from the underlying formation by the occurrence of coarse gravel, tuff, tuffite intercalations and bentonite fragments and lenses. Major outcrops of the sandstone are associated with larger valleys and with the middle part of the Pétervására basin (for more detail see later). Its surface is eroding rapidly, however, it can form steep walls due to its strong cement. Younger Miocene schlieren may be studied in outcrops that are situated closer to valley floors (Váraszó).

Volcanism also left prints in the landscape: The Lower Rhyolite Tuff is exposed on the tops (Fehér-kő) near the watershed West of the Ceredi-Tarna. This rhyolite tuff is also known from a deeper site the former bentonite quarry in Istenmezeje. However, the Miocene lava rocks so characteristic in the Mátra Mountains are completely missing. The forms of the younger basaltic volcanism occur like islands in the western parts forming the so-called "remnant hills" that are elevated 100-120 m above the surrounding sandstone surfaces (Nagy-kő near Bárna, Kis-kő, etc.). The united basalt mass of the Medves region and the Ajnácskő Mountain in the northwest border the Cered Basin that hides the source area of the Tarna and Gortva streams. Younger Holocene alluvia are accumulated on the floors of the larger valleys. Outcrops from here reveal the periodically repeated accumulation and cutting.

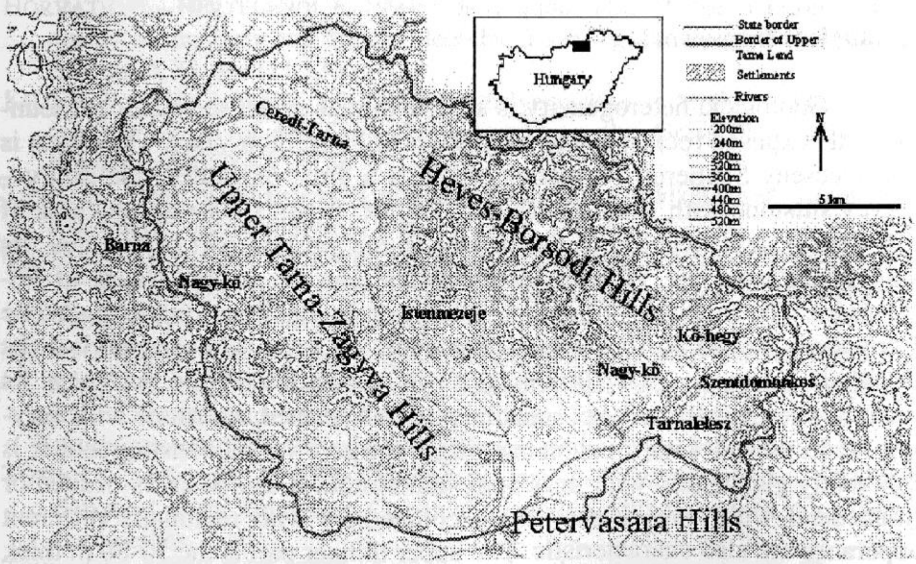

Fig. 1.: General map of the Upper Tarna Region

General morphology of the area

The three hilly regions forming the Upper Tarna region express great similarity in their geomorphology as in the case of their geological conditions. The landscape may be described as a multi basin hilly region. The bordering mountains are the Mátra and the Bükk from the South the highest parts of which may reach 900-1000 m. The Medves Region and the Ajnácskő Mountain from the northewest are much lower with ridges elevating up to 500-600 m. The next (middle) elevation surfaces are the tops of the hills on which runs the watershed of the two Tarna streams. The third (lower) elevation level is presented by the Cered and Pétervására Basin the low ridges of which are directly connected to the hilly regions, however, they represent a lower surface with an average elevation of 180-250 m. The basins are separated from the hills by a characteristic step. This paper intends to describe the two latter elevation levels.

The forms of the landscape are determined by the characteristic duality of the sandstone: on the one hand it is very resistant, strongly cemented thus frequently forming steep sometimes several hundred metres high near vertical walls, on the other hand it weathers rapidly when exposed to the surface, its upper layer can be easily eroded. More that 60 % of the area the slope gradient is greater than 25 % (Utasi Z. – Szabó G., 2002.).

The most closed and highest hilly region is the Heves-Borsod Hills that is bordered by the (Ceredi) Tarna from the West, the Hangony stream from the North, the Hódos stream from the East and the Lelesz Tarna from the South. The watershed runs in the central region of the Hills with a more-or-less East-western orientation. Considering its geology, it might be the most uniform of the Hills built up nearly entirely by glauconitic sandstone. Its major valleys are oriented North-South with slight curves. The two largest valleys are the Hosszú valley (Szalajka valley) near Váraszó and the Nagy valley near Tarnalelesz. Both valleys are 10 km long so-called floored valleys. The largest ones of their tributaries are also oriented North-South. The ones perpendicular to these extend for only a few km and are formed mostly by derasional processes. The central part of the Hills is 500-5200 m high, the highest is the Ökör-hegy (541 m). The height of the tops is gradually decreasing from the centre except for to the South and they lower to a height of 300-350 metres in the margins of the area. While the southern edge is connected to the main mass by a step as a 220-250 m high zone for a width of 2-3 km accompanies the Lelesz Tarna. The area characterised by wide flat intervalley ridges is the well-preserved terrace of the Lelesz Tarna stream. The most beautiful and largest sandstone rock walls (Kő-hegy, Nagy-kő near Tarnalelesz) are formed along the border of this two surfaces on the edge of the higher surface facing South.

The Upper Tarna – Zagyva Hills involves the area West of the (Ceredi) Tarna. This area bears a slightly more varied landscape both in terms of geology and geomorphology. Its average height is between 300-400 m from which only some basalt cones protrude (Nagy-kő near Bárna – 518 m, Kis-kő, etc.). Considering the characteristics of the valleys the are can be divided into two parts: the southern part is characterised by north-west-southeast oriented slightly curved valleys similar to that of the Heves-Borsod Hills, while the northern part is dominated by west-east oriented valleys. Therefore here the lower hilly region with an average height of 180-250 m is not directly connected to the central area as the west-east oriented valleys separate them. The hill ridges formed in this way are strongly asymmetric, gently sloping to the North and steep to the South.

The Pétervására Hills considering its height and geology is a transition between the former two Hills as it is a small hilly region lacking outcrops and geomorphological values. Its economic importance is given by its bentonite formations. It is characterised by wide and flat hill ridges and extended valleys. The Upper Tarna Region contains only its margin that is situated along the Lelesz Tarna stream as the waters of its northern part are driven away by the hanging valley like Boja stream.

Outstanding forms

Rock walls

Forms developed along the border of the middle and lower hilly region

The common characteristic of these forms is that they are formed along the border of the middle (300-500 m) and lower (180-250) hilly levels along the edge of the terrace (Photo 1.). The exposed sandstone belongs to the lower (Pétervására) member of the Pétervására Sandstone Formation. Two of these surpass by their size and form.

Kő-hegy (Szentdomonkos)

This is a characteristic rock wall divided in three in one of the side valleys on the left of the Hosszú valley near Szentdomonkos. Its highest parts elevate up to 400 m. Its bottom is situated 350-360m asl. Its walls facing South, reach 30-40 m (Photo 2.). Its surface is strongly weathered. Braking the dark outer crust, the characteristic yellowish brown colour of the sand can be seen. Due to its relatively high position we can observe the last mo-

ment of deposition. Sedimentation was relatively slow and periodical in undisturbed environment. This is suggested by the well-preserved thin beds that slope (30°) to the North (15°). Due to the varying petrology the more erodable parts are denuded and extended 1-2 m deep holes were left in their places (Photo 3.). Its concretions are small and thin comparing to that of the other wall rocks (Photo 4.). Unfortunately it is situated just outside the Tarna Region Landscape Protectional District and it is not easily accessible from the settlement.

Nagy-kő (Tarnalelesz)

One of the best rock walls of the Upper Tarna Region is found west of the Kő-hegy near the valley head of the Mocsolyás stream (Photo 5.). Its average height is between 300-700 m. The greatest height of its nearly vertical wall is 70 m. It is situated lower from the Kő-hegy considering both topography and tectonism and it is reflected in both its petrology and forms. The thick-bedded glauconitic sandstone is characterised by flat loaf-like concretions that are aligned in parallel rows (Photo 6.). Possessing an even surface it erodes less than the Kő-hegy forming steeper and more united walls. The beds slope to the North (10°) as well by 30°. Upper layer of the rock wall is red due to its higher iron content. It is part of the Upper Tarna Region Landscape Protectional District and it is accessible from Bükkszenterzsébet.

Forms developed near the valley floors

These forms are widespread throughout the area at the joining of major valleys. Their size is a few 10 m. They are covered by vegetation and only soil degradation by antropogeneous effect lead to the exposition of the sandstone in some places. The glauconitic sandstone of the Pétervására (lower) member of the Pétervására Sandstone Formation is older than the former group. Its bedding is usually more significant and occurrence of concretions is frequent.

One of the best representatives of these forms is the Válloskő near Istenmezeje. It is also called Noah's grape (Photo 7.) elevating 50-70 m above the valley floor that has an average elevation of 220 m. The history of this striking rock wall situated at the joining of the Tarna and the Kovaszó valleys is the easiest to follow among the similar sandstone outcrops. The steep mountain side lost its soil cover due to deforestation in the 1700s and it faced over the village as a barren rock surface for centuries. Its protection was coming from the presence of vegetation associations representing the different stages of succession with special regard to its lichens. Its natural reforestation started from the top and the increase of the area covered by forest is visible year-to-year. Besides its botanical value its geomorphological importance is also significant. The name Noah's grape comes from the interesting alignement of its concretions. These some 10 cm big protrusions not only give horizontal lines resulting from the bedding of the glauconitic sandstone but they are aligned in vertical columns as well. From distance this really seems like vine-stocks. However, there is no explanation for this alignement of the concretions up to today. The name Vállóskő is also expressive: the Palóc dialect calls the drinking trough as 'válló' and in fact in the upper protruding part of the rock wall a 0,5 m deep depression with a diameter of 2-3 m was formed in which small 'lake' occur after rainfall. There are other places in the Country where small holes are formed on the horizontal surface of sandstone outcrops (Kővágóörs) but they are rare in such height and on slopes. The protected are is part of the Landscape Protectional Area and it is easily accessible.

Sandstone gorges

These valleys are usually small in their size. Their height is not more than 10 m and width is not more than 20-30 m. They were formed in glauconitic sandstone in the upper or middle part of the smaller (maximum a few km long) valleys opening to the larger valleys. We may find a few on the left side of the (Ceredi) Tarna between Istenmezeje and Váraszó but the largest one is found West of Istenmezeje in the upper part of the Csengős valley (Photo 8.). This obsequens valley of the Upper Tarna – Zagyva Hills West of the Tarna exposes a different sandstone. Its glauconite content is greater it is well-bedded and concretion poor. The beds slope to the North by 10°. Its head is in a height of 280 m but after about a kilometre in a height of 203 m the valleys turns into floored valley without any transition. The lack of valley floor at the head of the valley and the occurrence of hanging valleys ending in a height of 2-3 m indicate rapid linear erosion.

Basalt volcanic forms

In the central part of the Upper Tarna – Zagyva Hills around the watershed small basalt volcanic cones occur that are elevated above the surrounding sandstone surface. This rock type becomes dominant further North in the Medves region. The highest of the lonely mountains is the Nagy-kő near Bárna (519 m) that is situated virtually in the centre of the Hills (thus giving an excellent viewpoint) (Photo 9.). The outcrop on the top of the mountain exposes the onionskin-like curved structure of the basalt. To the

East, a few km above the Cikorád valley the Kis-kő (379) is found which, however, showing similar structure is – nomen est omen (kis means small) – significantly smaller than the Nagy-kő (nagy means great). Its importance is given by a small cave.

Summary

The geomorphological values of the Upper Tarna Region are dominated by forms associated with the sandstone. These values are primarily rock walls and gorges, however, some basalt volcanoes also occur. The protection of these values is carried out by the Tarna Region Landscape Protection District founded in 1993. However, this protection do not involve all of the significant sites, therefore the extension of the protection seems to be inevitable. This region hiding in the shades of the surrounding mountains is a marginal area receiving little attention, however, considering its values and opportunities it could be one of the touristic destinations in Hungary. Certain rock walls are unique alone, however, it would be possible to create geological-geomorphological study-paths especially in the western parts. The establishment of a suggested route in the vicinity of Istenmezeje is currently under construction: Fehér-kő (rhyolite tuff outcrop) – Csengős valley (sandstone gorge) – Nagy-kő near Bárna (basalt volcano).

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Photo 1. Upper part of the Lelesz Tarna stream with the middle morphological level in the foreground and with the lower hilly level in the background while the surrounding mountains can be seen at the back

Photo 2. Kő-hegy near Szentdomonkos

Photo 3. Surface of the Kő-hegy

Photo 4. Natural erosional depressions on the Kő-hegy

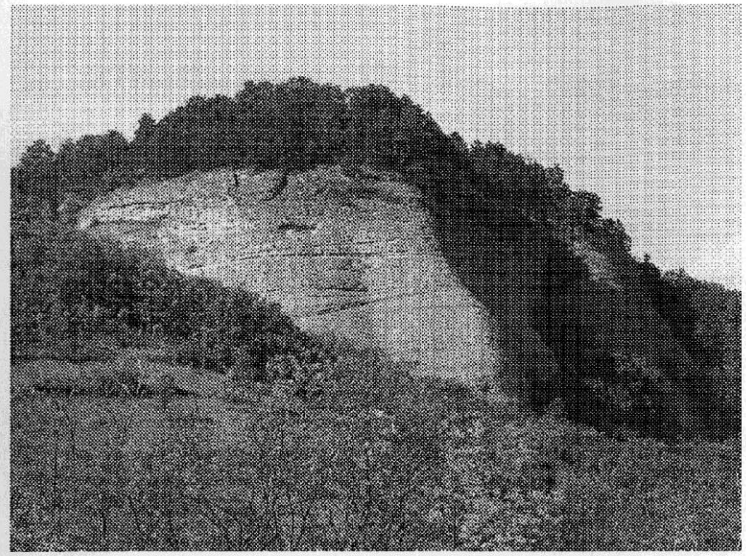

Photo 5. Nagy-kő near Tarnalelesz

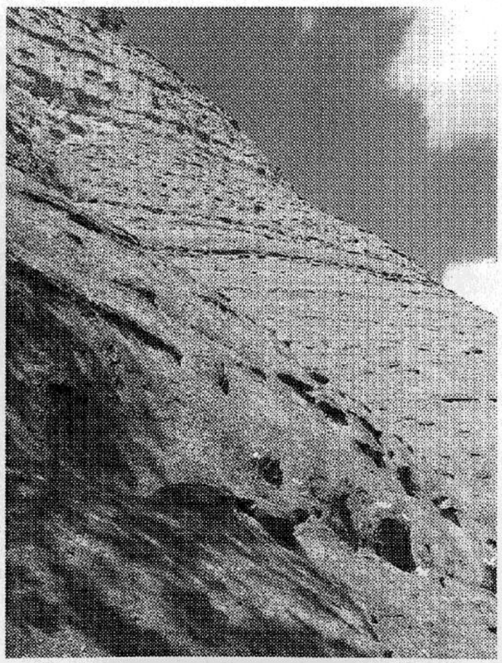

Photo 6. The surface of the Nagy-kő

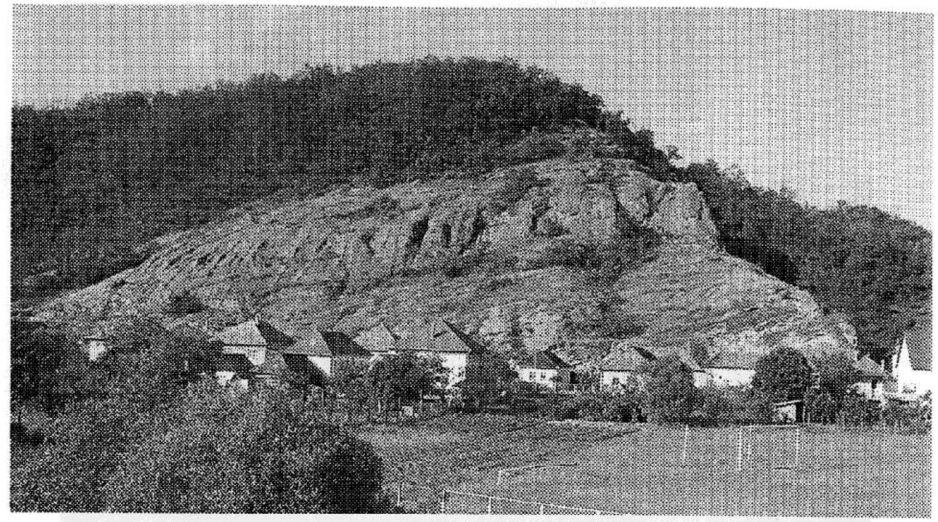

Photo 7. Vállóskő near Istenmezeje

Photo 8. The gorge of the upper section of the Csengős valley

Photo 9. Nagy-kő near Bárna

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