GEOMORPHOLOGICAL AND GEOECOLOGICAL ESSAYS

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AKADÉMIAI KIADÓ • BUDAPEST

PREFACE

This volume includes the contributions of Hungarian physical geographers and geomorphologists to the 2nd International Conference on Geomorphology, Frankfurt, September 1989.

Since the Conference is concerned with geomorphological and geoecological topics the editorial board decided to present five papers on each main topic informing the reader about major research trends in Hungary since the First International Conference on Geomorphology in Manchester.

The papers reflect the results of traditional geomorphological research, of relief evolution, however, most of the themes are related to environmental and dynamic geomorphological research of practical purposes. The interpretation facilities of aerial and space images suitable fot the interpretation of numerous phenomena and processes on the Earth surface will soon provide the conditions for the detection of changes in the geographical environment. Besides remote sensing methods computer applications including geographical information systems have become widespread also in Hungary during the last four years. Remote sensing and computer methods are considered to be the most important tools in environmental geomorphology and applied physical geography serving the practical needs of regional planning, spatial organization and land use planning.

Finally, acknowledgements are expressed to the authors, translators, and editors of this volume and to all who participated and assisted at publication and, last but not least, to the laboratories and experts both at home and abroad who helped our team of authors with analyses, comments or in any other way.

Budapest, June 15th, 1989

Márton Pécsi
Ádám Kertész
Editors

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REMOTE SENSING APPLICATION IN ENVIRONMENTAL IMPACT INVESTIGATIONS FOR LAND RECLAMATION IN A STRIP MINING AREA (VISONTA, HUNGARY)

J. BALOGH, L. BASSA, É. CSATÓ,
Z. GERENCSÉR, GY. HAHN, Á. RINGER

ABSTRACT

On the piedmont surface of the Northern Mountains, in the vicinity of the railway line between Budapest and Miskolc there is a larger lignite field with a length of 120-140 km and with a width of 8-12 km. The coal deposits dip under overburden sediments of different thickness to S, towards the Great Hungarian Plain. Due to favorable conditions of overburden removal open-cast lignite mines are to be found in the vicinity of Visonta and Bükkábrány. From the Visonta coal field 100 million tons have already been extracted and another 100 million tons are being extracted now. At both sites several 100 million tons of lignite are known. Mining and industry occupy an area of 30 km^2 at the Visonta site.

The land value before mining activity was determined and compared with the value of the stripped and recultivated land by the research team of the Geographical Research Institute of the Hungarian Academy of Sciences. It could be proved that after the exploitation of the coal resources with an in situ value of 10 billion forints the land value decreased with cca. 2 billion forints in spite of the accelerated reclamation. Methods have been elaborated to registrate the conditions of untouched resp. for mining utilized surfaces and to optimize the sequence of strata in the course of reclamation.

GENERAL REMARKS

Mineral and fossil fuel resources located near the surface can be extracted economically using surface mining techniques. Overlying geological materials are removed in order to expose and subsequently extract a resource. These mining methodologies alter the physical environment more profoundly than the deep mining activities. Vegetation and soil cover are nearly homogenized. Steep hillslopes of spoils and depressions are produced. Drainage networks and channels are obliterated, runoff conditions are modified. When studying surfaces of strip mining, three major time periods are considered and corresponding areas distinguished (TOY, T. J. 1984):

1. Pre-mining period, prior to the disturbance,
2. The active-mining period, during and immediately following resource extraction,
3. The post-mining period, following reclamation of the disturbed lands.

In the international practice environmental impact assessment precedes each major activity which involves environmental trasformation. Moreover, in the USA the Surface Mining Control and Reclamation Act of 1977 prescribes pre-mining reclamation planning. This planning process embraces five basic steps of soil reclamation and landscape reconstruction (National Research Council 1981):

1. Predisturbance inventory of soils and land productive potential,
2. Decision on post-mining land use,
3. Preparation of a reclamation plan based on the results of the inventory to accomplish the chosen goal,
4. Reconstruction of the soil and landscape after mining is completed, in accordance with the reclamation plan,
5. Management of the resulting soil and
   Monitoring to determine success of reclamation.

THE CASE OF VISONTA

Along the southern foothills of the North Hungarian Mountains between Budapest and Miskolc a lignite productive area stretches in a length of 120-140 km E-W with a N-S width of 8-12 km. Due to a relatively high thermal value (above 7000 kJ/kg) and favourable conditions of overburden removal (maximum 1:20 m/m) several of these sites offer economically recoverable resources. Of the reserves at the foothills of the Mátra Mountains about 100 million tons have been extracted and also about 100 million tons are to be produced in open-cast mines, which represent 10-10 billion Forints value respectively. Annual output of the Visonta (Thorez) mine is 6-7,5 million tons and produced by three pits (NY: West, K-1: East N1, K-2: East N2). To protect surface constructions another 100 million tons of reserves had to be retained subsurface. Lands involved in strip mining and the adjacent "Gagarin" thermal power station together occupy an area of about 30 km^2 (HAHN,GY. et al. 1985).

Strip mining seriously affected the adjacent region and had environmental and socio-economic consequences. Lands abandoned by agricultural production appeared, dewatering of the mining area reduced the groundwater table. This caused troubles in the water supply of eight surrounding settlements. A regional plan had to be compiled and new waterworks to be built. Air pollution by the power plant based on the lignite extracted can be observed in more than ten-kilometre zone (as it is shown by a Landsat image acquired in winter time). It damages one of the most important recreational area of Hungary -- the Mátra mountains. Among the social consequences manpower problems in agriculture should be mentioned (HALÁSZ. T. 1983).

Besides the environmental and social issues surface mining and power plant siting problems embrace legal and economic criteria (TÓTH, S. 1983). Among the complex and often interlocking assemblage of (cca 40) statutes in force the Mining Act (1960) and the Land Protection Act (1981) are the most relevant which prescribe that:

a/ In case of using cropland for other purposes the users are obliged to pay compensation, part of which is being allotted to the reclamation of areas of poor fertility.

b/ Users are obliged to reclaim areas deteriorated and return them to the farms in their original state.

An attempt has been made to assess the economic effectivity of land reclamation by the collective of the Geographical Institute of the Hungarian Academy of Sciences .

1. The plots of the 'reference area' on external spoil heap were referred to land quality classes prior to expropriation.
2. Reclaimed lands were classified on the basis of cadastral net income

and categories and present land value established in gold crowns for each type of cultivation and plot.

3. Each plot and the total area were evaluated: by cultivation and quality classes as well as by gold crown values and prices of expropriation before and after land reclamation computed according the Land Protection Act in force.

Results are shown in Figs. 1 and 2.

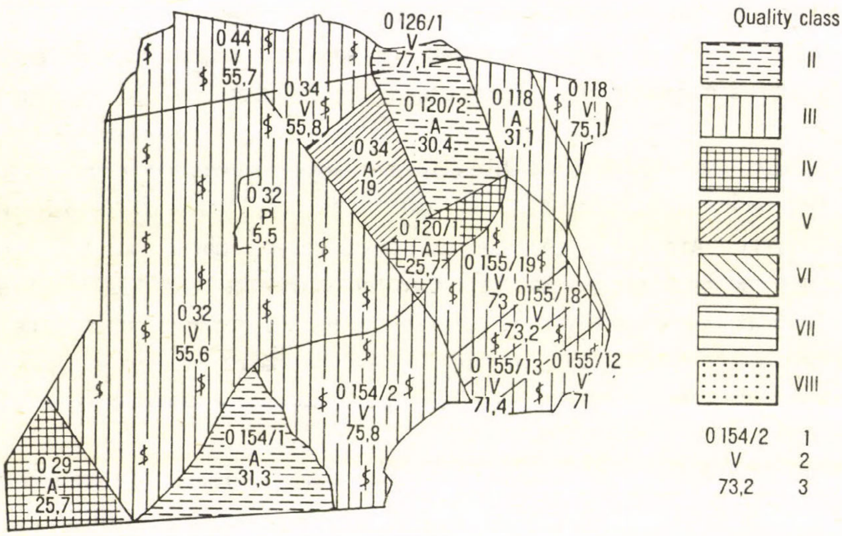

Fig. 1. Reference area before mining (by J. BALOGH and Z. GERENCSÉR). – 1= plot number; 2= type of cultivation; 3= land value in gold crown per hectare; A= arable; V= vineyard; O= orchard; F= forest; P= pasture

For the total area 205 million forints land value was computed whereas for plots on the reclaimed surface land value totalled 11 million forints. It seems to be unrealistic taking into consideration the low differences between yields achieved before and after disturbance. Calculations extended for the total strip mining area show 1.8-2.0 billion forints compensation costs to be allotted by the coal mining company, i.e. 1/5 part of the in situ value of the lignite extracted. This very high sum causes permanent debates between the mining company and collective farms, the owner of the land.

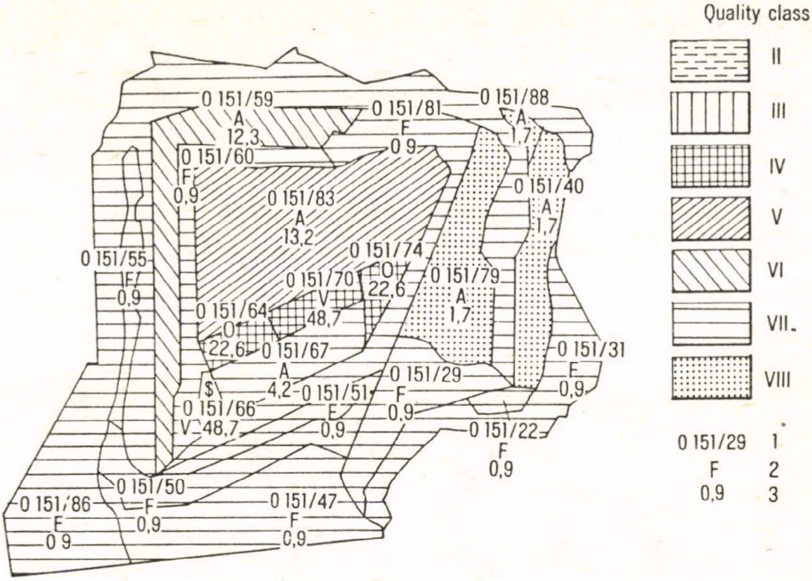

Fig. 2. Reference area after reclamation (by J. BALOGH and Z. GERENCSÉR). - For explanations see Fig. 1.

A new method of assessment of reclaimed lands has been elaborated by the Institute for Soil Science and Agrochemistry Hungarian Academy of Sciences, subsequently adopted by the Ministry of Food and Agriculture. Taking into consideration that the land evaluation in force is based on the genetic types of soils but genetic horizons do not occur in profiles disturbed by strip mining, this evaluation refers to parameters such as microrelief, amount of skeletal particles, textural and hydrophysical properties, identifiable horizons, soil reaction (pH) and carbonate content, humus content, heterogeneity and climatic conditions.

A medium-term landscape reconstruction project was developed by the Forest Survey Service of Ministry of Food and Agriculture in 1981, that is about 15 years after the mining had started in the Visonta region. As it was emphasized in this project in the future it should be attained that both mining and the reclamation plan be prepared simultaneously and entirely coordinated. It also draws attention to the necessity of complex amelioration and soil conservation, development of a contiguous green belt, physical planning of settlements located in the vicinity. Subsurface waters are suggested to be pumped out to ensure mining activity and to be utilized properly, with water quality protected and controlled (HALÁSZ, T. 1983).

According to the project on landscape reconstruction 63 % of East N1 mining unit (internal spoils) should be returned to (mainly large--scale) farming and 37 % (mainly steep slopes and flue-ash disposals) afforested or grassed. Fields with area less than 50 hectares are to be used for part-time farming (e.g. as hobby gardens) (Fig. 3).

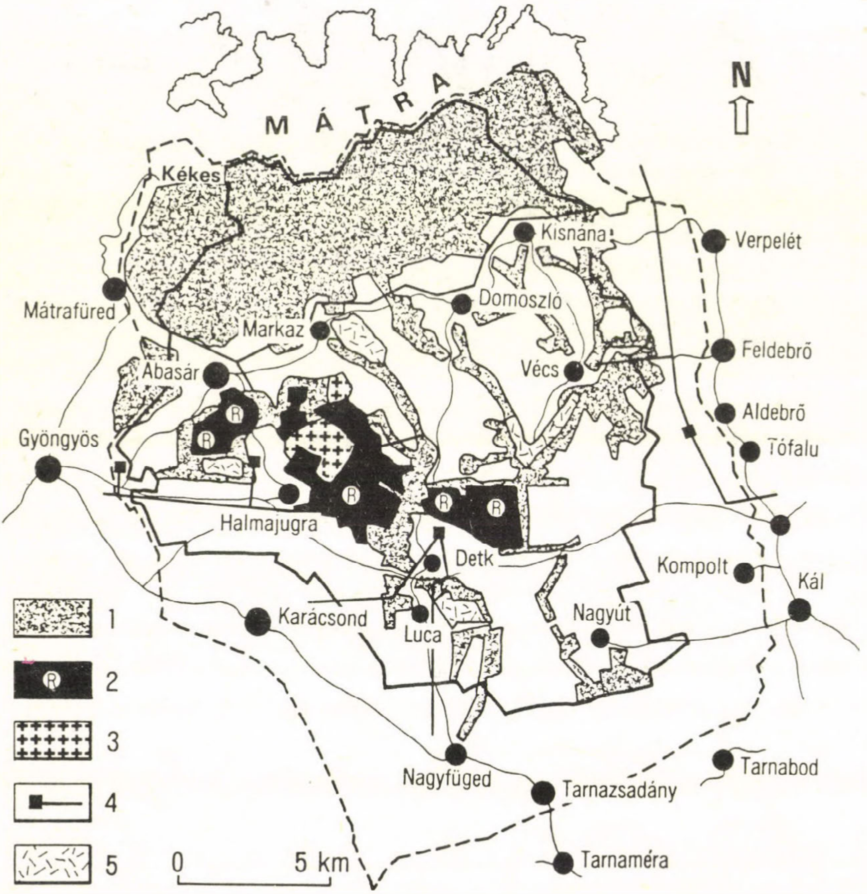

Fig. 3. Long-term physical plan of the Visonta strip-mining area (after T. HALÁSZ). - 1= forest and grassland; "= reclaimed pit; 3= afforested, grossed flue-ach disposal; 4= regional waterworks; 5= reservoir

REMOTE SENSING APPLICATIONS

Aerial photos and satellite images prove to be instrumental in monitoring of the environment, especially of changes in land use (land cover). Landsat MSS colour composites acquired in 1973 and 1979 in 1:200 000 scale show the major objects of coal extraction: units "Thorez West (NY) and East N1 (K-1)", the external spoil heap under cultivation, hobby garden area on the internal spoils and also of the industrial area: "Gagarin" power plant, flue-ash disposals. Comparing these false colour images, the expansion rate of strip mining is discernible (0.5-1.0 km^2 per year which depends on the amount of the coal extracted).

VISUAL INTERPRETATION: A LAND COVER MAP

The higher resolution of Landsat TM images and the progress of colour composite techniques both have contributed to a more exact interpretation of the land cover categories concerned. An experiment using colour composites obtained from Landsat TM images of 19.05.1984 (late spring), 04.04.1985 (early spring) and 20.09.1985 (autumn) resulted in the compilation of a map on the basis of multitemporal interpretation (Fig. 4). This mapping primarily aimed at the identification of land cover categories on areas disturbed by strip mining and also on undisturbed surfaces. Ancillary materials: aerial photos at 1:10, 000 and 1:1, 000 were also involved in the interpretation.

a/ **Areas of active mining and refilling**

Prior to mining the agricultural utilization of the land was abandoned as shown by fading tones for arable. Overburden is removed by drag-lines, shovels and scrapers. After the coal seam is exposed it is loaded and transported by production lines (clearly discernible on images in the West unit area) to the nearby power plant . This information on mining methods functions as a priori information, essential for interpretation. Procedures of removal and extraction create long linear pits which can be detected on space images as dark stripes on the background of the surrounding areas of higher reflectance where overburden is to be removed or pit refilling after extraction is already started. Reflectance depends on the mechanical composition of bedrock and its hyd-

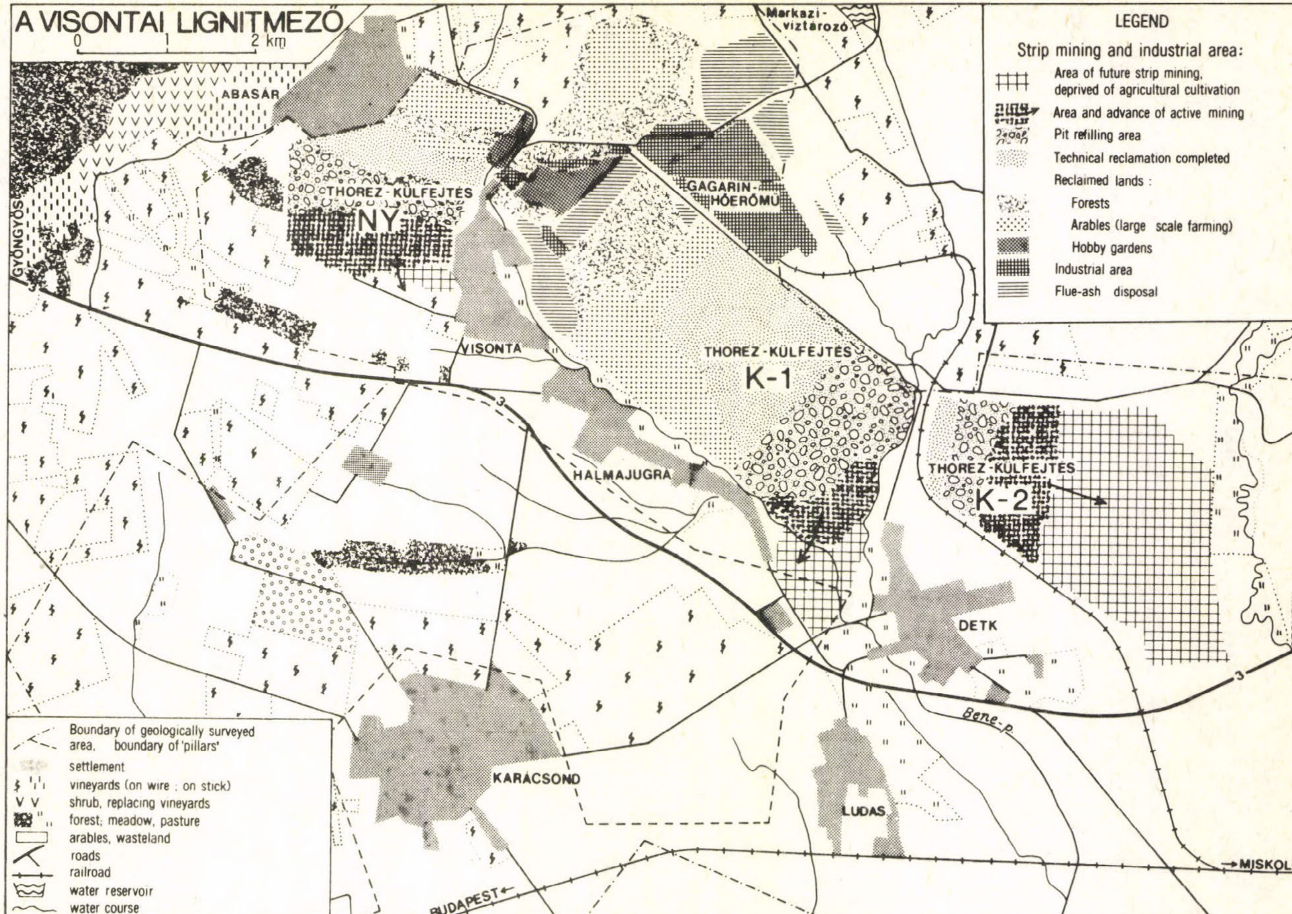

Fig. 4. Land cover map of the Visonta strip-mining region as interpreted visually from Landsat PM images(reduced) (L. BASSA).

rophysical properties. On each of the three images studied these differences are discernible. In pit West (NY) overburden is represented by Upper Pannonian yellow and greyish-yellow sandy deposits which also occur on surface after refilling. Moving eastwards the material of internal refuse dumps gradually becomes loamy as indicated by darker tones. The properties of the surface layers play a decisive role in subsequent agricultural cultivation. It is desirable that upper horizons be shaped using materials of yellow sandy loam mixed with fossil soils encountered in the upper 10 metre sequence. The water holding capacity of these layers in higher but they are less cultivable owing to heavier texture. Refilled areas (i.e. where technical reclamation is completed) show a more or less homogeneous texture.

b/ **Reclaimed lands**

On 600 hectares (1/5 part of the total area disturbed by strip mining and industry) biological reclamation has already been accomplished. A 'reference area' on the external spoils (NE from the West (NY) unit) experienced the complex fast revegetation without topsoiling, introduced from 1969. After the spoil heap had been shaped (grading and levelling), its surface layer was improved by fertilizers and low-grade lignite powder vegetation (nurse'crop) with extensive root system developed which subsequently was ploughed in, thus promoting soil formation. From the second year different crop species were grown and good results reported (OLÁH, J. 1983). Graded slopes have been afforested. Three large fields of this type have been created by now as it is shown on the late spring image but bare soil surfaces (early spring and autumn pictures) reveal substantial inhomogeneities. Also the hobby garden area (NW part of the East N1 (K-1) unit) shows differences in the mechanical composition of surface and vegetation cover. When communicating with local farmers they mentioned their painstaking work in clearing the surface from stones. Flue ash disposals (dark blue patches) have partly been filled and afforested but some of them still exist exerting a strong adverse impact on the environment.

c/ **Areas of further expansion of mining**

As the mining is extending southwards and eastwards (Fig. 4), more fertile soils are affected by excavations (categories with 40-49 soil value number vs the former 30-39 according to the 100-point assessment system in force). The West (NY) pit advances at the expence of vineyards; East N1 (K-1) has already moved close to the N^{o} 3 main road and the southern part of which will affect arable lands and vineyards, and there is a large derelict land stretching east of the East N2 (K-2) pit. An economic assessment on the productive potential of these lands and reclamation planning is considered to be an urgent task.

DIGITAL IMAGE PROCESSING: A CLASSIFICATION MAP

In the course of the study of the strip mining area one of the images involved in visual interpretation (19.05.1984) was processed. A supervised classification was carried out on the PERICOLOR 2000E image processing device in the Institute of Geodesy, Cartography and Remote Sensing using Remote Sensing Package. Based on sources from literature in classification initially were included spectral regions TM1, TM2, TM3 (visible wavelengths), TM4 (near IR) and TM5 (medium IR).

The digital plotter image covers an area of 9 km x 12 km and contains 300x400 pixels. Training sites were chosen using the ground truth (reference) data as shown on the map (Fig. 4) obtained by visual interpretation and field survey. The 12 lands cover categories occurring in the region were identified and used for training: active mining, refilling area, technical 'reclamation' completed, reclaimed land, industrial area, flue-ash disposal, settlement, vineyard, forest, grassland, arable land, water surface. During training statistics referring to the sites identified: pixel number, average density and the band covariance matrix of the pixel intensities were applied.

After the analysis spectral bands TM1 and TM2 were left out and processing was accomplished using the three, most informative bands: TM3 (red) TM4 (near infrared) and TM5 (medium infrared).

Classification was carried out by minimum distance decision rule. For each main point x and each average vector x_j $(j=1,..,m)$ a decision function

$$g_j(x) = i=2,n \; x_i - x_{ij} \quad j=1,..,m$$

is computed and x classified by the minimum of this function.

The resulting 12 classes are not entirely identical with those of the training sites. This is primarily attributed to the fact that while the training sites show broad comprehensive categories (for example settlements), on the plotter image pixels with identical spectral features are grouped together (within settlements, reflectance varies with gardens, paved surfaces or roofs of houses).

The classification map was produced by OPTRONICS Colormation 4500 plotter.

A POSSIBLE FUTURE APPLICATION: THE BÜKKÁBRÁNY STRIP MINING AREA

The location of a new strip mining area on the southern foothills of the Bükk mountains (Northern Hungary) is shown on Fig. 5. The extraction of lignite has recently started and annual output amounts to 1,5 Mt. Somewhat similar in environmental impact to its counterpart at Visonta (appearance of derelict lands and necessity of their reclamation, changes in hydrogeological conditions and surface water configuration, air pollution and noise) this area also needs monitoring and this task may partially be fulfilled by remote sensing. A Landsat TM colour composite was obtained fixing the initial stage of surface mining (08.07. 1987) (KISGYÖRGY, S. - MADAI, L. 1987)

SUMMARY

Multitemporal, multi-level and multispectral remotely sensed images can provide useful information to the monitoring of man-induced environmental changes in general and of implementation of reclamation projects in particular.

The achievements reported here represent only a modest contribution to the solution of a major problem of landscape reconstruction in strip mining regions of Hungary: which is the most effective way of land reclamation from economic and environmental viewpoints:

1/ Technical 'reclamation' (exclusively), accompanied by financing of amelioration in other areas of the country to counterbalance loss of fertile lands in the strip mining regions,
2/ Complex fast revegetation method ('reference area', Visonta),
3/ Optimization of surface layers (how to achieve loose, friable and loamy structure without topsoiling),

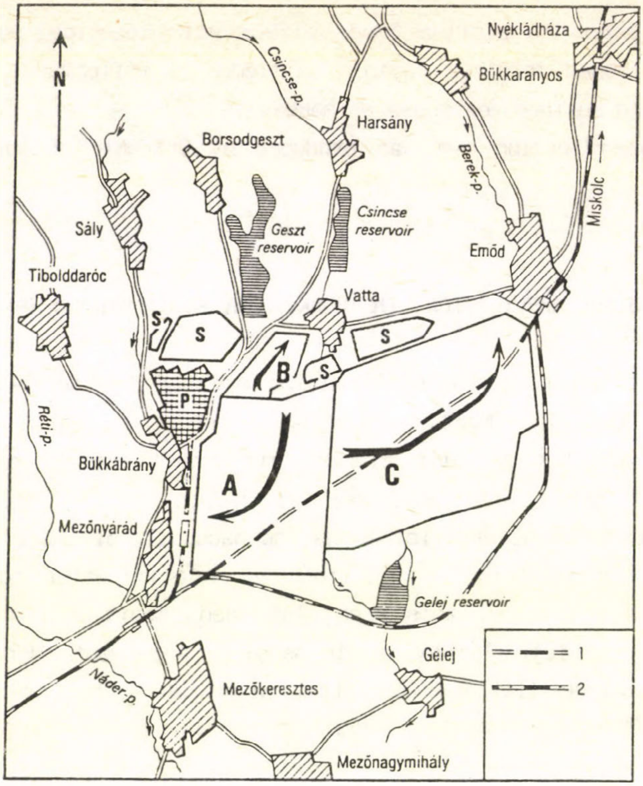

Fig. 5. Allocation plan of the Bükkábrány open-pit mine and power plant (after Gy. HAHN, Gy. OSWALD and L. SÁG). - 1= present railway to be relocated; 2= planned new railway alignment; P= power plant; S= spoil-heap; A, B, C = open-pit mines

4/ Spreading of the stockpiled topsoil upon the surface (a stringent rule of reclamation in several countries).

ACKNOWLEDGEMENTS TO

Dr. MÁRIA DOMOKOS (Budapest Technical University), who let authors use Landsat MSS colour composites and a Landsat TM5 Image),
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INVESTIGATION OF PIPEFLOW ON A LOESS-COVERED SLOPE

A. KERÉNYI

ABSTRACT

The task of preventing erosion on loess-covered sloping surfaces requires a lot of careful planning of experts working in the field of mechanical soil conservation. To prove this statement measurements have been carried out on a system of terraces established on a loess-covered slope. The terraces were built 25 years ago and are of counterslope character. A few years later the process of pipeflow started on the lowest-lying planes of the terraces. Loess wells, pipeflow ducts, cave-ins were produced, which made part of the terraces unsuitable for cultivation. The loss of soil amounted to 476 m^3/ha in the most heavily degraded areas.

For the better understanding of the mechanism of the process of pipeflow laboratory experiments and measurements were carried out. The study was concerned with dissolution processes taking place in soil-covered and uncovered loesses. It was established that the dissolving effect of water is more efficient in soil covered loess. It was demonstrated that pipeflow starts quickly on counterslope terraces due to the emergence of excess water. The primary factor in the start of the process is the dissolving effect of water. Our experiments provided quantitative data on the intensity of the dissolving process. On the grounds of the investigations we made suggestions how the shape of terraces to be established in loess areas.

PREVIOUS INVESTIGATIONS

One of the main tasks of Hungarian loess research is the elucidation of the genetics and chronology of our homeland loesses. In this field a number of internationally outstanding results have been published by Hungarian authors: M. PÉCSI (1965, 1966, 1975, 1979); M. PÉCSI - M.A. PEVZNER (1974); M. PÉCSI - É.PÉCSI-DONÁTH et al. (1977); GY. HAHN (1977); Z. BORSY - J. FÉLSZERFALVI - P.P. SZABÓ (1979); Z. BORSY - J. FÉLSZERFALVI- J. LÓKI (1984); Z. PINCZÉS (1954); J. SZILÁRD (1983).

The other line of the investigations is represented by the mapping of the forms of loess degradation and the detailed characterization and genetical description of these forms. In this field mention must be made of the works of L. ÁDÁM (1954, 1964); L. ÁDÁM - S. MAROSI - J. SZILÁRD (1959) and L. ZÁMBÓ's (1971) maps of erosional gullies.

The quantitative study of the intensity of loess degradation is the characteristic feature of the third aspect of the investigations. Field measurements and, on the basis of these, calculations were performed by L. ÁDÁM in 1964. Attention must be called to the field experiments and measurements by Z. PINCZÉS (1968, 1980) and Z. PINCZÉS-L. BOROS (1967). The direct antecedents of the present investigations are the field and laboratory experiments by A. KERÉNYI (1984). In this paper we served to solve the following problems: What ions and in what quantity are transferred into solution by water seeping through or running off the surface of loess? Further examination was performed to clear up the effects of the various ways of treatment on the dissolving power of water.

RESULTS

Measurements have been carried out in the worldfamous Tokaj viticultural region on a terrace system extablished on a loess-covered slope. In a certain section the terraces are countersloping thus, in a rainy weather and in the periods of snow melting thaw pools developed at the deepest points (Fig. 1.). Three to five years later the first pipeflow

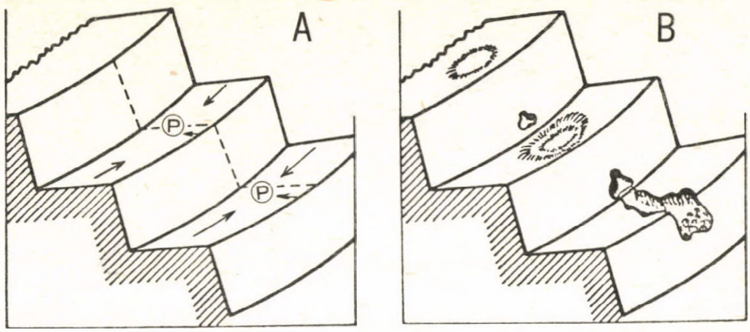


Fig. 1. A section of the terrace system under study (by A. KERÉNYI). - A= Immediately after its construction; B= After 25 years; P= pool formation. The arrows denote the main directions of runoff, the broken line shows the potential sites of pipeflow ducts and cave.-ins

ducts appeared which, in the course of the subsequent 25 years, were transformed into a large pipeflow system (Fig.2). In the area of the ducts cave-ins (loess sink holes) and loess wells evolved, the ducts constituting the system of caves fell in at places and were formed into erosional ditches. Vine cultivation had to be abendoned in this area. The loss of loess was determined - on the grounds of accurate field surveys - with volumetric calculations (476 m^3) and its areal distribution was represented on a cartogram (Fig.3).

To study the process of loess degradation, concomitantly with the field survey laboratory examinations were carried out on loess monoliths with original structure (Figs. 4 and 5). The rainfall simulator operated with distilled water, and the concentration of various ions was determined in the runoff from the surface of the loess monoliths,then in the water seeping through them (Figs. 6, 7 and 8). It was established that in the water seeping through the loess the amount of dissolved ions was, on an average, five-fold of that in surface runoff. Under these circumstances a considerable role is played by the higher CO_2 content of the air in the soil and the duration of seepage. When exposed to the dissolving effect of water with high CO_2 content, the structure of loess

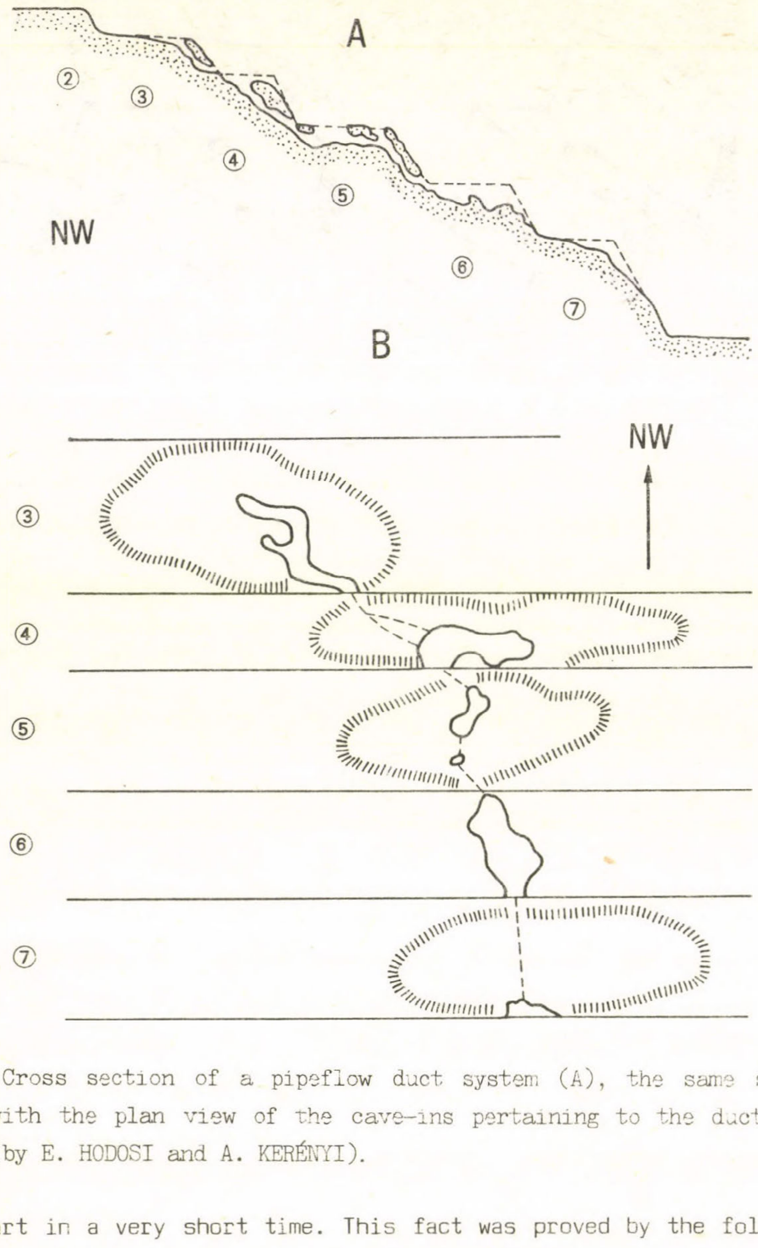


Fig. 2. Cross section of a pipeflow duct system (A), the same system with the plan view of the cave-ins pertaining to the ducts (B) (by E. HODOSI and A. KERÉNYI).

falls apart in a very short time. This fact was proved by the following experiment.

The loess surface was artificially rained with the result that the loess was compacted by the impact of the rain drops. In such loess the pore size is primarily determined by the grain size and shape of the loess

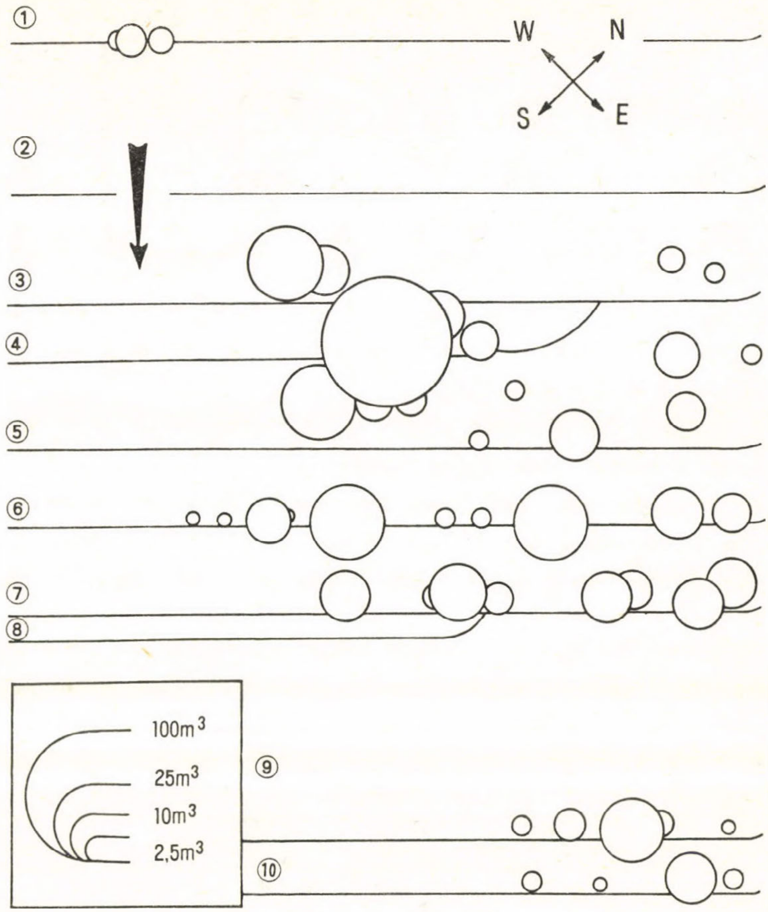
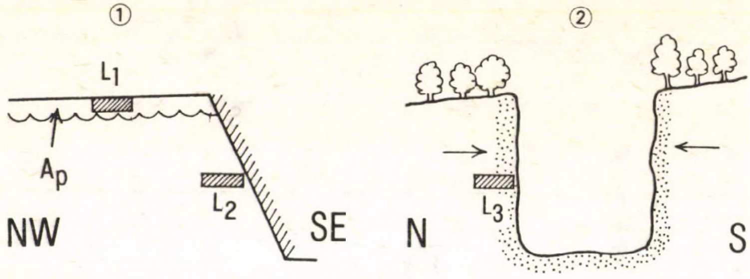


Fig. 3. Areal differences in loss of loess on the terraces under study. (25 years after the establishment of the terraces the total loss amounted to 476 m^3 in an area of 1 hectare) (by E. HODOSI and A. KERÉNYI).

grains. In the experiment the pores were of the hundredth-of-a-millimetre order (Plates 1 and 2). A small piece of loess was lifted out from the loess surface, and half of it was treated with water with high CO_2 content (500 mg/litre). The structure of the loess treated in this way collapsed in a very short time, ducts of some millimetres in diameter were formed (Plate 3).



Fi 4. Place of origin of the loess samples of original structure (monoliths) (by A. KERÉNYI).

1. L_1= from the ploughed layer of the terrace (A_p)

L_2= from the bank of the terrace

2. L_3= loess monolith taken from the wall of the deep-cut track. The arrows show the direction of the current of soil solutions, the dotted area denotes the layer rich in precipitated salts

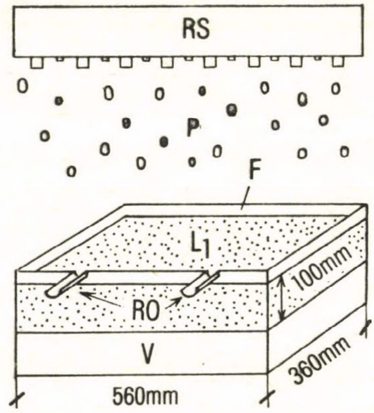


Fig. 5. Experiment on a loess monolith. RS= rainfall simulator, P= artificial rain (distilled water) (by A. KERÉNYI).

L_1 = loess monolith; F = metal frame; RO = pipe for draining runoff; V = plastic vessel to collect seepage water

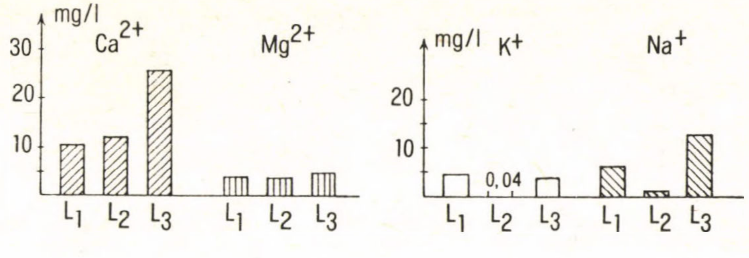


Fig. 6. Concentration of different cations in runoff from the monoliths (L_1, L_2, L_3) (cf. Fig. 4) (by A. KERÉNYI).

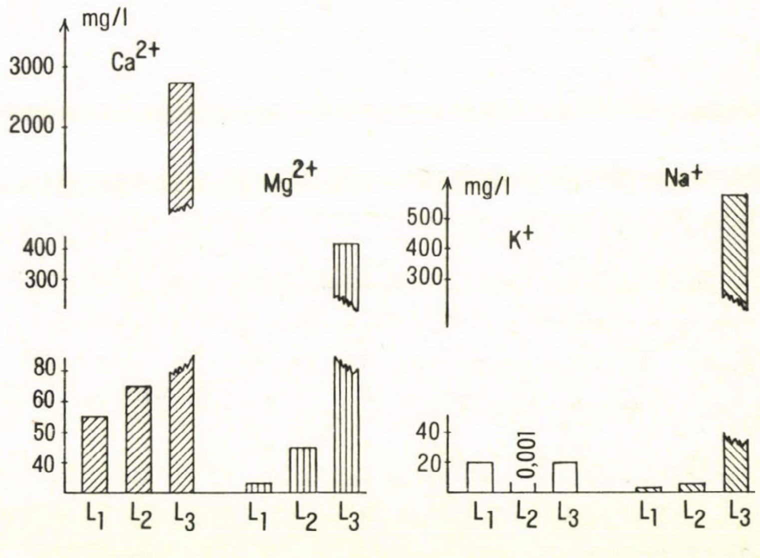


Fig. 7. Concentration of the differenct cations in the seepage from the loess monoliths (L_1 L_2', L_3) (cf, Fig. 4)(by A. KERÉNYI).

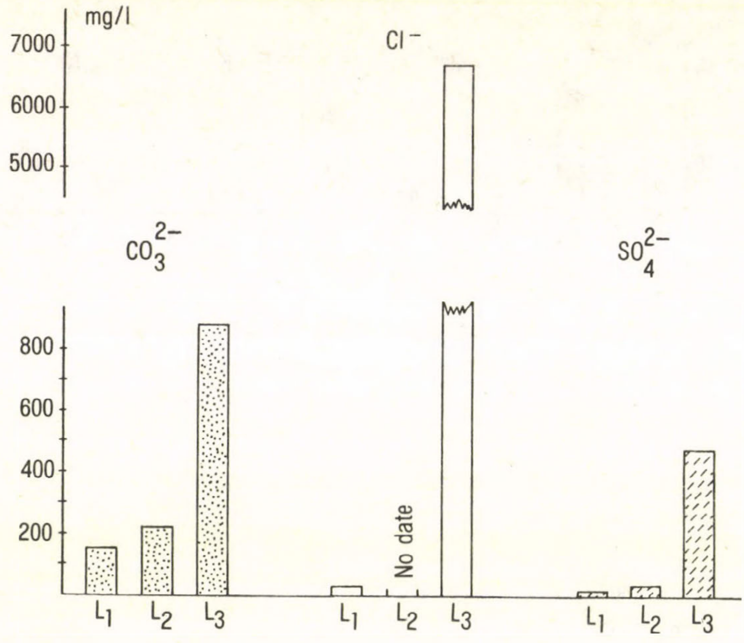


Fig. 8. Concentration of carbonate, chloride and sulphate ions in the seepage from the loess monoliths (cf. Fig. 4)(by A. KERÉNYI).

In the first stage of loess degradation dissolution is predominant - except when the formation of ducts has been initiated by human mechanical interference. It was observed for instance that the holes along the vine-stakes driven deep into the ground gave rise to mechanical pipeflow (Plate 4).

In another experiment it was proved that the dissolving effect of the water flowing in a duct of 2-3 cm in diameter decreases as compared to the same effect of water moving in pores of tenth-of-a-millimetre or smaller size, and it becomes similar to the effect of runoff. In ducts of such and larger sizes the mechanical decay becomes prevalent.

As for the ions, the relatively high concentration of potassium in the seepage from L_1 (Figs. 6 and 7) can be attributed to artificial fertilizers. The presence of artificial fertilizers can be ruled out in L_3. In the wall of the loess deep-cut track, due to the horizontal capillary tension gradient, salty solutions are seeping horizontally, and get

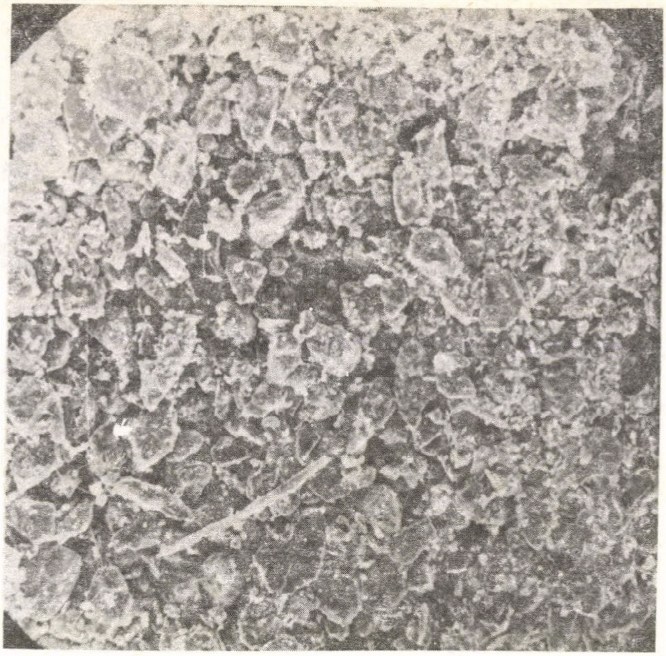


Plate 1. Loess grains on the surface of a monolith after artificial raining. M = 200 x

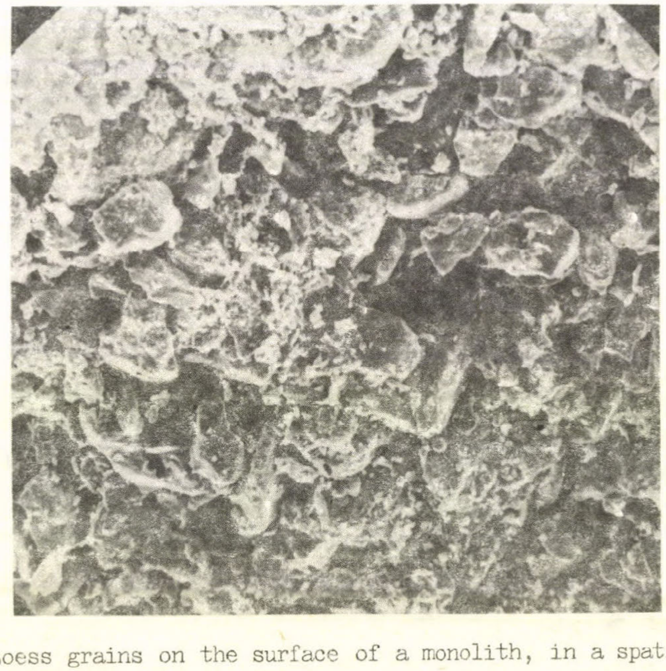


Plate 2. Loess grains on the surface of a monolith, in a spatial arrangement different from the previous one (cf. Plate 1). M = 200 x

Plate 3. Ducts of the order of millimetres, evolved as a result of acidic dissolution in loess. Above: original, artificially rained loess surface. M = 10 x

precipitated in the surface layer (Fig. 4). In the course of centuries this layer was primarily enriched in chlorides, however, the amount of sulphates is also considerable in addition to carbonates always present in large quantities in loess. The chlorides are readily soluble, thus in the seepage from the monolith L_3 the chloride concentration has reached an extreme level (Fig. 8). The material of the wall of the loess deep-cut track displays lower mechanical resistance than that of the walls of the pipeflow ducts, thus the physico-chemical changes described here accelerate the mechanical degradation. This process is still at an initial

Plate 4. In the lower-lying areas of the terrace pipeflow ducts have evolved along the vinestakes driven deep into the ground. Tokaj, Rákóczi Valley

stage on the terraces in the walls of the caved-in pipeflow ducts transformed into erosional ditches.

Further examinations were performed to clear up the effects of the various ways of treatment on the dissolving power of water (Fig. 9). It has been established that the dissolving action was most enhanced by a 3 cm thick soil layer (pH= 6.8: $CaCO_3$=0 %, humus= 1,6 %) spread over the loess monolith. This also proves that on soilcovered loess, in the establishment of the terraces special care must be taken of the water economy of the soil. Pool formation must be avoided on terraces built on loess. For this reason the terraces must not be countersloping, the downward sloping of 1-2^{o} is the most recommendable. In view of our observations,

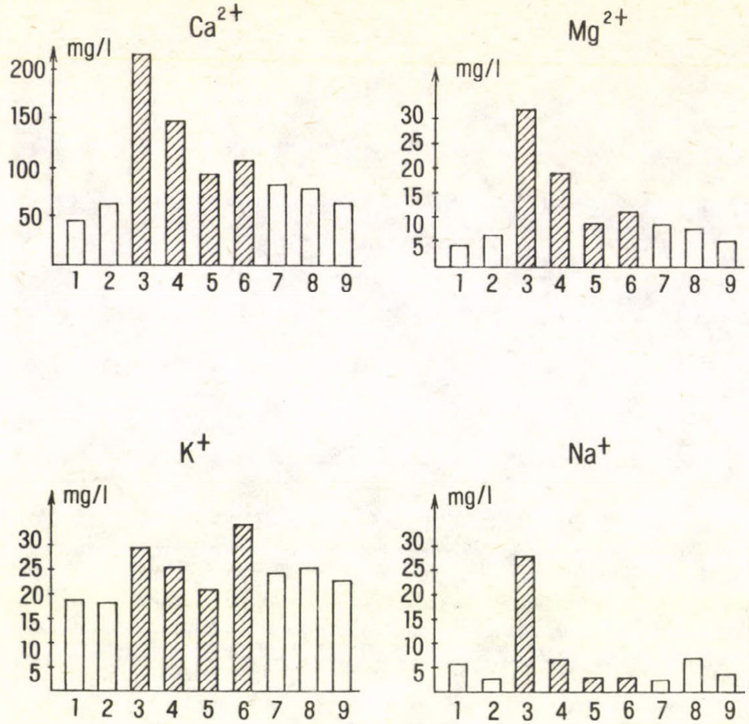


Fig. 9. Changes in concentrations of cations in the water seeping through loess monolith L_1 as a result of various treatments (by A. KERÉNYI).

1. Basic experiment,
2. Coverage for 5 days,
3. Stratification of the deluvial sediments of forest soils,
4–5. Experiments leaving the deluvial deposits of forest soils unchanged,
6. Mechanical compaction of the soil and loess,
7. Removal of the deluvial deposits of forest soils,
8–9. Experiments performed 65 and 68 days after the removal of the deluvial deposits of forest soils

in the traditionaly cultivated vineyard with many vinestakes there is enhanced danger of pipeflow, thus, the cordon training is more suitalbe.

The actual terrace system can be made cultivable again by filling in the pipeflow ducts and caved-in ditches, the former concave shape of the terrace plain must be made stepwise in the way shown in Fig. 10.

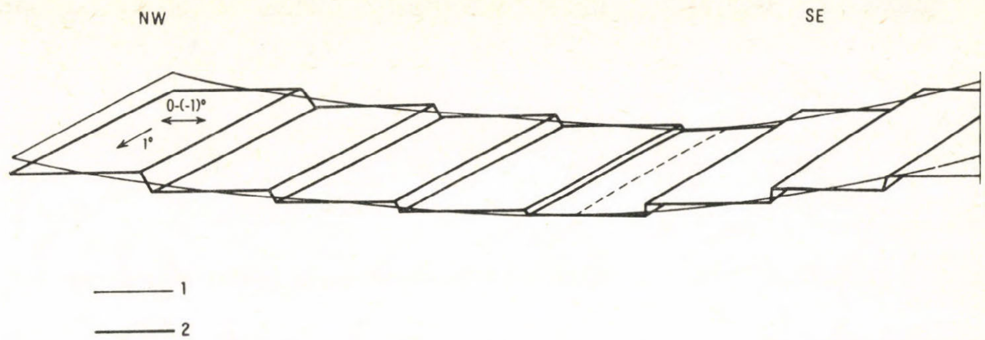


Fig. 10. Transformation of the terrace plane results in the evolution of small water-collecting pools and prevents the gathering of excess water along the bottom-line of the terrace plane (broken line). The thin line shows the present-day position of the terrace plane (no pipeflow ducts are shown), the thick line is the proposed stepped plane of the terrace. On the left the sloping of the terrace plane is given in degrees (by E. HODOSI and A. KERÉNYI).

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GENETICS AND OCCURRENCE OF HOLOCENE TRAVERTINES IN HUNGARY

GY. SCHEUER - F. SCHWEITZER

ABSTRACT

There are several known travertine occurrences in Hungary connected either partly or fully to karst mountains or to only parts of them. A greater part originates from Pliocene or Pleistocene according to geomorphological and paleo-karsthydrogeological examinations. Beside these older ones Holocene accumulations are also quite common and at many places there are travertines being formed recently.

Their accumulation in the mountains and in their surroundings can be explained by the precipitation of calcium carbonate transported by the springs.

In the course of surveying the Hungarian travertines there was a possibility to examine the accumulations on these mountainous territories. We examined their occurrences and genetics and tried to define their types (Fig. 1. and 2.).

Among the examined Holocene travertines some have very spectacular forms, because of continuous precipitation (Szalajka, Lillafüred). These occurrences are officially protected. Their preservation and the continuity of lime-depositing in guaranteed. The observations are important because the process of travertine sedimentation can be examined directly at the site and the recognition of forms under development can help to explain the advantages properly. That is why we thought, that the study of Holocene and recent travertines is essential.

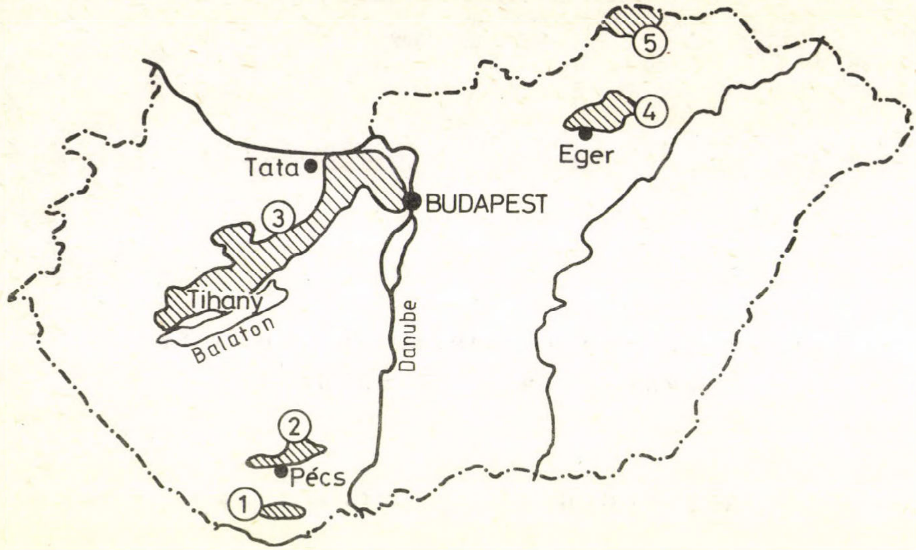

Fig. 1. Schematic layout of the karst hydrogeological regional units (after Gy. SCHEUER - F. SCHWEITZER). - 1= Villány Mts.; 2= Mecsek Mts.; 3= Transdanubian Mts.; 4= Bükk Mts.; 5= Aggtelek region and Szendrő Mts. The shaded part shows the extension of carbonate rocks

TYPES OF HOLOCENE TRAVERTINES AND THE CLIMATIC CONDITIONS FORMING THEM

In the course of the examination of Hungarian and foreign recent travertines we can state that the accumulation of lime is connected to springs differring from each other from the point of view of origin and type (Fig. 3.).

The springs depositing carbonate spring-deposits can be divided into 4 groups:

a/ cold-water karst-springs and water-courses of karstic origin

b/ karstic thermal springs and their waters

c/ ground-water, lithoclase springs

d/ springs of polygenetic origin (springs of post-volcanic areas)

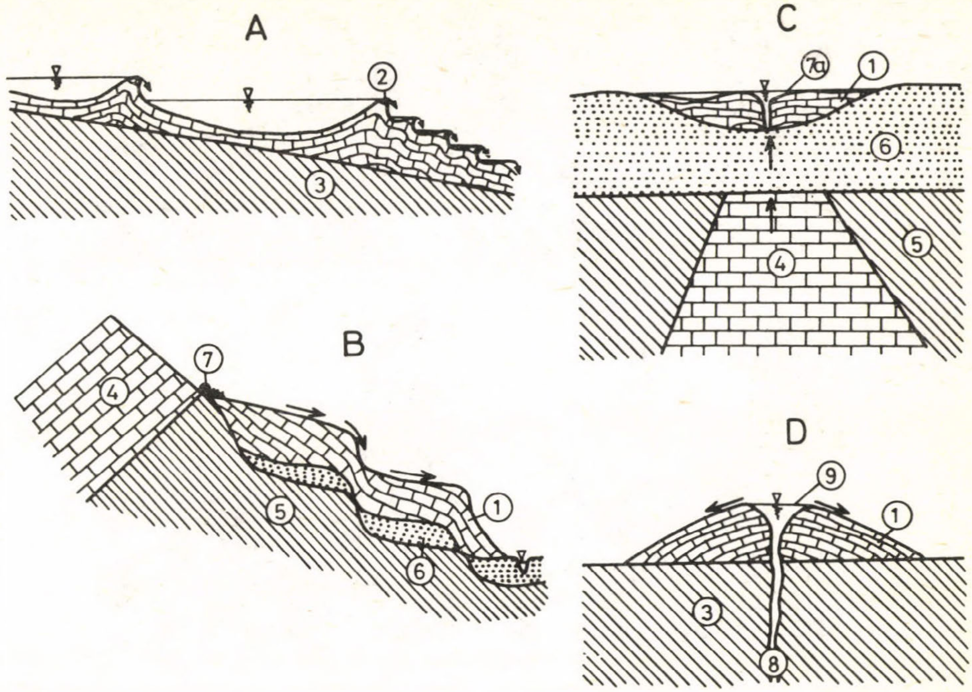

Fig. 2. Various types of freshwater limestone (after Gy. SCHEUER - F. SCHWEITZER). A= valley type; B= valleyside type; C= palustrine and paludal type; D= sinter cone type.

L e g e n d : 1= Freshwater limestone; 2= Lakes due to streamwater damming by tetarata accumulations; 3= Underlying rock; 4= Water-bearing carbonate rocks; 5= Impervious strata; 6= Fluviatile or slope sediments; 7= Karst spring; =A= Spring-lake; 8= Spring vent; 9= Spring crater

Any of the above mentioned springs are able to accumulate travertines in their vicinity under favourable environmental conditions.

Examining the Hungarian sites and comparing them to the former ones we can state that most of the Hungarian Holocene travertines originate from springwaters belonging to group a/.

We have collected and processed the data of those karstic springs

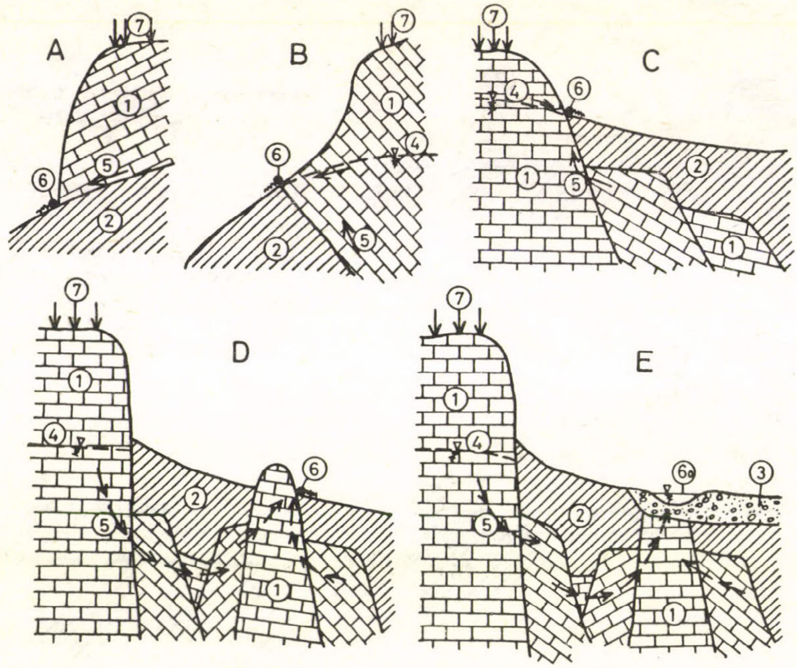

Fig. 3. Main types of Hungarian karst and hot springs (after Gy. SCHEUER). - A= Gravity spring; B= Overflow spring; C= Impounded spring; D= Overflow spring directly from the aquifer; E= Overflowing spring percolating through detrital sediments. L e g e n d : 1= Water--bearing carbonate rock; 2= Impervious strata; 3= Fluviatile sediments; 4= Karst water table; 5= Flow directions; 6= Karst springs; 6a= Spring-lake; 7= Drainage area

in karst-water units where travertine accumulation could be found. We give the mean-value of their calcium-content in Fig. 4. We can read from it that the quantity of calcium varies between 90-140 mg/l. We have not found direct correlation between the calcium-content and the quantity of precipitation. It means that the dissolved calcium of the springs gives only the potential condition for travertine forming. The concrete precipitation is, however, effected by the conditions of the environment. Some karstic thermal springs (group b) have also originated travertines. In Hungary the ability of depositing calcium of springs, coming from

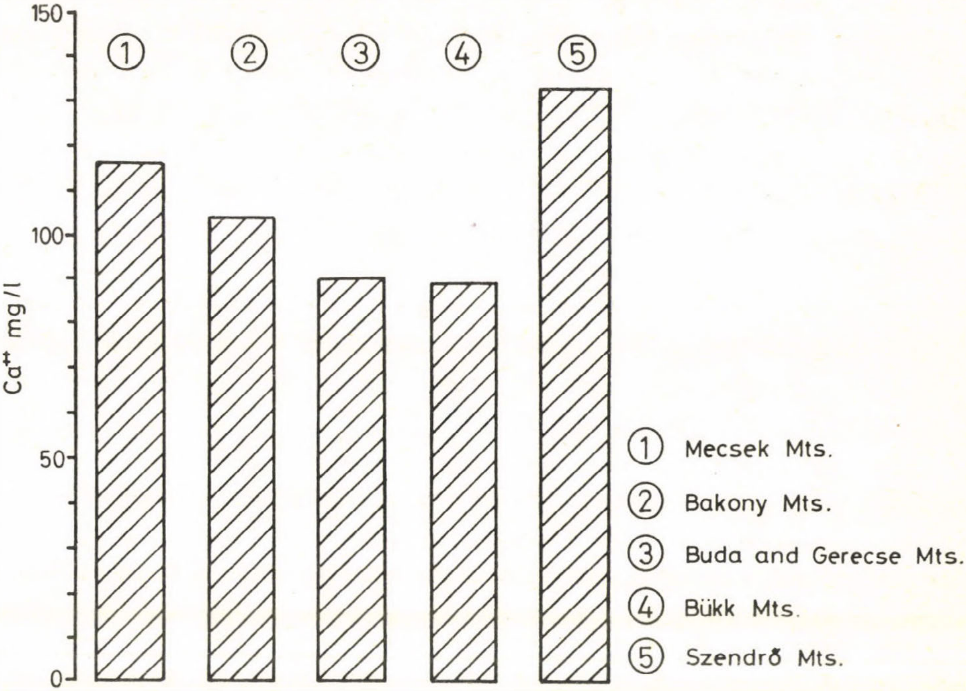

Fig. 4. The average Ca-content of the springs-depositing recent travertines, by karsthydrogeological regional-units (after Gy. SCHEUER).

ground-waters or lithoclase waters, in the Holocene is not important. They could not form big quantity of travertines. Only the favourable local conditions can produce a thin lime sediment on small territories.

The sources of the springs depositing travertines are at various morphological sites. The forming of travertines showing unique character, depending on the morphologic conditions, can be proved. They can be divided into two big groups. Travertines being formed on:

a/ valley flood plains

b/ valley sides slopes

1. The travertines being formed in valleys are connected to the water-

courses of karstic mountains. One can see such depositions in the beds of water-courses that hinder them. At such places smaller or greater waterfalls are formed. This type is very frequent in Hungary and can be found in almost all karstic mountains. We have described it as a valley-type rock. The largest and most beautiful (spectacular) accumulations (Szalajka waterfalls and Lillafüred in the Bükk Mts.) belong into this group.

The springs of valley-flood plains are quite common in Hungary, where spring-lakes or swamps have been formed. In these cases lake-type limestones were formed. The most important occurrence can be found at Tata in the Gerecse Mts. and at Római-fürdő in Budapest (Fig. 5.).

2. Most of the travertines were formed on various slopes. Such depositions were formed by springs on the slopes under it, having their source above the erosion base. Such formations (tetaratas) and structures are characteristic only for these types (Fig. 6.).

The deposition of travertines depends on the lime-capacity of the springs and on the morphologic conditions of the slope. At some places it covers a 1-5 metres wide territory of the slopes and the travertines accumulate in the form of a fan. Its characteristic forms are the tetarata bars and pools (Fig. 2.A.).

In Hungary these tetarata limes, coming from springs above erosion base on slopes, are quite frequent.

THE EFFECT OF HOLOCENE CLIMATIC FLUCTUATIONS ON THE FORMATION OF TRAVERTINES

Travertines could be formed any time, when the necessary conditions and advantages were given (precipitation, vegetation).

So the limestones reflect the environmental conditions of the era of their formation. We can trace back the age of deposition and of the climatic conditions of their formation from the imprints of plants and the fauna, from the loose sediments (like loess, sandy loess, sand, fossil soils) which have been formed during various climatic conditions, or from the cryoturbational phenomena and archeological finds, too and from the data concerning the age of geologic formations and geomorphologic levels on which all these were deposited. From the evaluation of the results from the joint examinations we can get information about the age of travertine-formations (Fig. 7.).

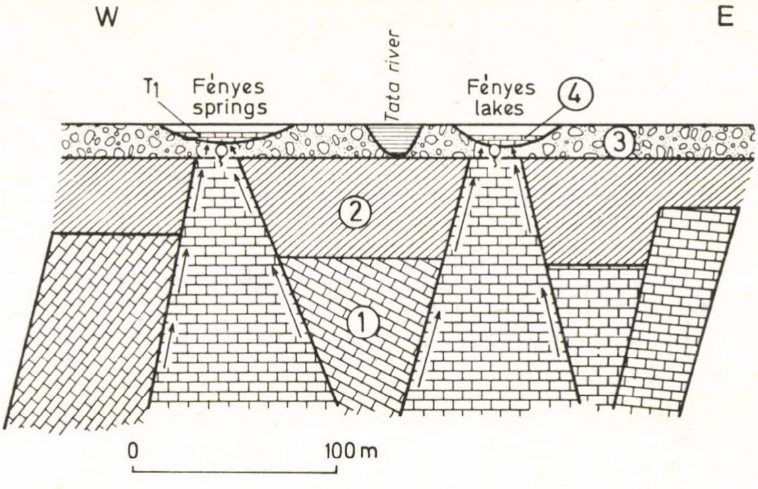

Fig. 5. Flood-plain-lacustrine-marshy travertine formation associated with spring issuing from covered horst through fluvial sediments (after F. SCHWEITZER). - 1= permeable Triassic sediments; 2= impermeable Tertiary sediments; 3= recent sediments of the Által-ér; 4= travertine

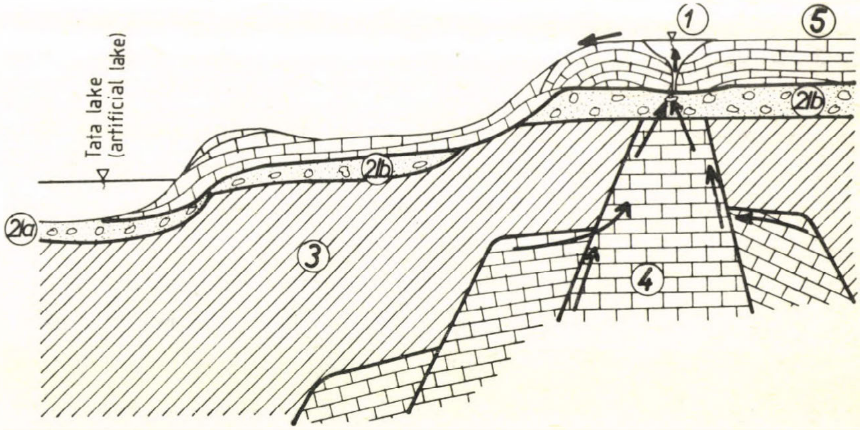

Fig. 6. Terrace springs of Tata and the geomorphological position of the travertine (after F. SCHWEITZER). - 1= spring lake and spring crater; 2a= recent sediment of the Által-ér; 2b= younger terraces of the Által-ér; 3= impermeable Tertiary rocks; 4= permeable Triassic rocks; 5= travertine, direction of water flow

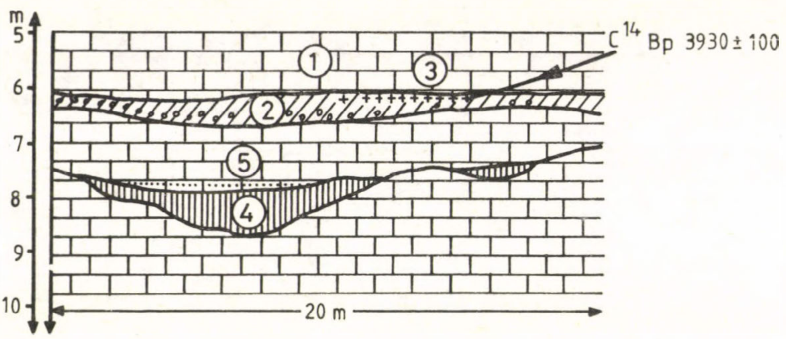

Fig. 7. A fragment of the travertine profile at Mónosbél (after Gy. SCHEUER - F. SCHWEITZER). 1 = slope travertine; 2 = deluvial clay with Triassic rock fragments; 3 = charcoal-bearing horizon; 4 = hydromorphic soil; 5 = lime mud

CONCLUSIONS

The examination of travertines proves that there was an interruption in the activity of the springs forming them, or their ability to deposit lime has greatly decreased. This can be explained by such climatic conditions, which were not favourable for it.

Most of the Holocene travertines were settled on young relief-forms (like valley-floors). Where they are lying on older relief-forms there is a spring activity and travertine-accumulation at present, too. From this we can deduct their age.

There have been several climatic conditions within the Holocene period, which were not all favourable for the formation of travertines e.g. the Boreal phase had a warm continental climate. There was not enough precipitation, the infiltration decreased, so the springs had a smaller delivery. The soil covering of the karst had a restricted biological activity, so there was less lime in the springs, too. Therefore the accumulational activity decreased or stopped. This unfavourable period was followed by the next Oak (Atlantic) period, with a duration of 2500-500 years; it had a submediterranean climate and was very favourable for the formation of travertines. We can say that this was the culmination of this process. Of course it continued later on and it is still continuing, but with a less intensity.

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GEOMORPHOLOGY OF THE INTRA- CARPATHIAN VOLCANIC RANGE

A. SZÉKELY

ABSTRACT

The paper deals with the 800 km long Neogene volcanic range bordering on the inner side of the Carpathians (Fig. 1.). After a short review on geological and geomorphological research of the area the three main volcanic phases are described. On the basis of 30 years investigations the author proves that primary volcanic forms have been transformed in the Pliocene to erosional forms but the primary forms did not disappear totally (A. SZÉKELY, 1960). As a result of his further research work direct (relict forms) and indirect (controlling) influence of the primary volcanic forms could be shown dominantly characterizing the relief of today. The reconstruction of the volcanic forms was performed with up-to-date methods. Six main types could be defined after a thorough research of the volcanic ranges in Hungary (Fig. 2.). The author compared his observations in Hungary with other volcanic mountains of the Carpathians and of the Appennines and extrapolated his conclusions for these ranges as well.

The significant influence of the postvolcanic tectonic movements is also shown in the paper. Further the paper deals with the piedmont surfaces of the volcanic ranges and methods of the reconstructions of volcanic ranges are discussed in detail. The volcanos are generally built on a series of morphological inversions and they are eroded also that way.

The inner side of the Carpathians is bordered by a Neogene volcanic range of 800 km length (from the Danube Bend relict volcano, Visegrád Mountains on the NW to the Hargita Mountains on the SE (Fig.1.). The volcanoes erupted along the fault system which separates the Carpathian orogenic belt from the enclosed basement. Thus they are exact and conspicuous indications both tectonically and morphologically of the boundary between the mountain area and the lowlands. The outer side of the volcanic range borders on the Carpathians and the inner side on the basin. This location has controlled its evolution and all physical geographical features.

This is the most perfect and continuous volcanic range in Europe (Fig. 1.), only seemingly surpassed by the inner volcanic range of the Appennines (from Monte Amiata to Stromboli) of 1500 km length, but the latter is volcanic only along some sections (altogether 400 km long), but interrupted along others (altogether 1100 km). The volcanic range of the Appennines has lent itself most easily for comparative volcano-morphological investigations (SZÉKELY, A. 1975, 1986).

Volcanological and volcano-morphological research have been prominent topics of geological and geomorphological investigations in Hungary since until 1920 the entire Carpathian volcanic range was on Hungarian territory. At present only 2 per cent of the country are low to medium-height mountains.hut one-third of this are of volcanic origin.

There were **three major stages** of volcanic activity in what is now Hungary during the Tertiary:

1. The first period was one of small-scale **initial volcanism** during the Upper Eocene (45 m.y. B.P.). Its andesite mountains have been heavily eroded and volcanic features only survive as subsidiary traces (Recsk at the foot of the Mátra; Velence Mountains).

2. The **main period** of volcanic activity is placed in the Early and Middle Miocene (19 m.y. - 14 m.y. B.P.). This produced the 800 km Intra--Carpathian Range, of which 250 km lies in Hungary. Most of the material produced during this main stage (about 80 per cent in the Middle Miocene) was andesite and associated pyroclastics, with some acidic rhyolites, rhyolitic tuffs and dacite.

3. The **final stage** of basaltic volcanism is much younger and it is dated to the late Miocene and Pliocene (6.3 m.y. to 2 m.y.). Again it was of minor intensity and only produced smaller volcanic hills (basalt cones and mantles in the N, around Salgótarján - 2 m.y. - and in Transdanubia, in the

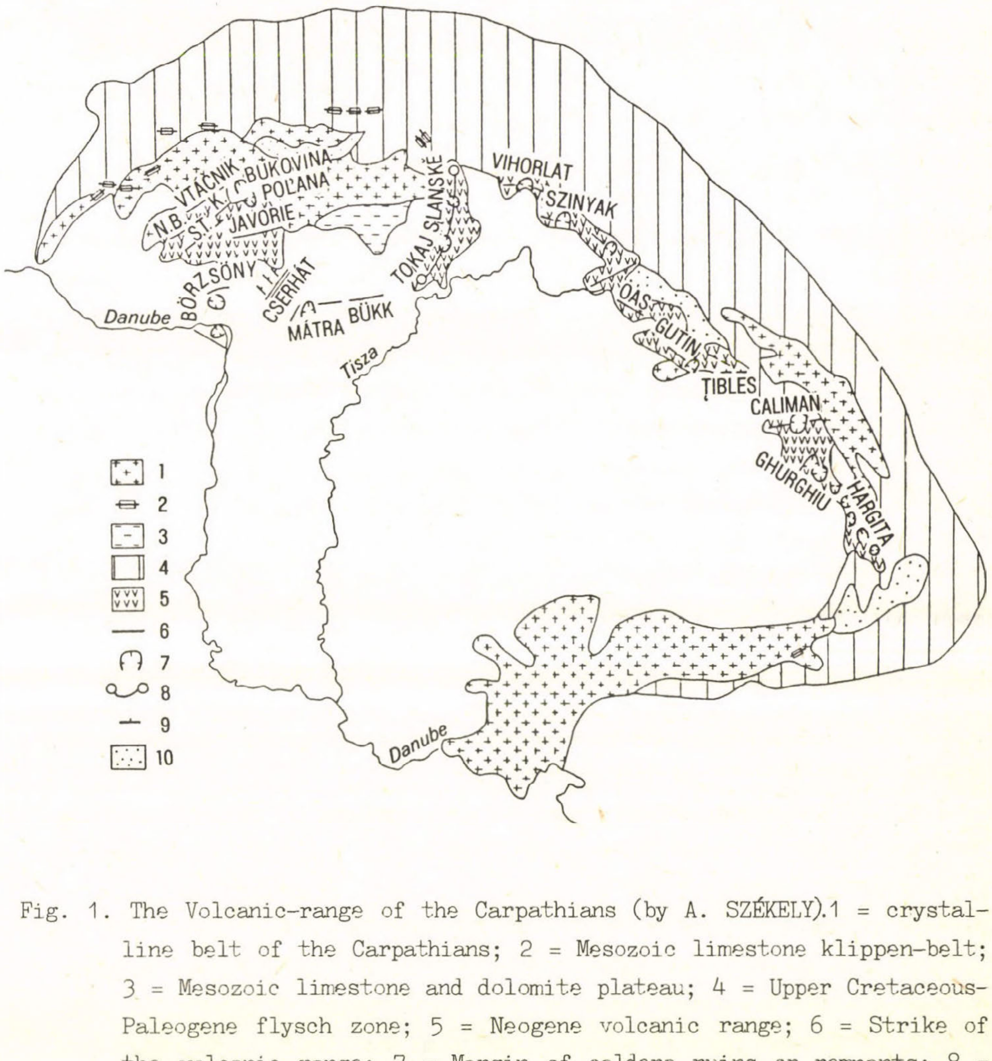

Fig. 1. The Volcanic-range of the Carpathians (by A. SZÉKELY).1 = crystalline belt of the Carpathians; 2 = Mesozoic limestone klippen-belt; 3 = Mesozoic limestone and dolomite plateau; 4 = Upper Cretaceous-Paleogene flysch zone; 5 = Neogene volcanic range; 6 = Strike of the volcanic range; 7 = Margin of caldera ruins or remnants; 8 = Range of volcanic mountains; 9 = Exposed subvolcanic forms (laccolith, dyke); 10 = Intra-Carpathian basins

Abbreviations: NB = Nova Bana; ST = Stiavnica Mts.; K = Kremnica Mts.

SW part of the Bakony Mountains - 6.3 m.y. B.P.). But compared to the andesite mountains these are only subsidiary elements.

Over the last century geologists have published many maps and data on the structure of Hungarian mountains of volcanic origin. Geological research partly aims at the exploration of ores of postvolcanic hydrothermal origin (gold, silver, zinc, lead and copper).

The first geomorphological descriptions were provided by CHOLNOKY, J. (1929), who portrayed all the mountains of volcanic origin in the Carpathians and the Carpathian basin in a comprehensive manner. As opposed to geologists, who mostly investigated material (rocks and bedding), CHOLNOKY concentrated on landform. With his characteristic, individual comparative volcano-geomorphological research attitude, which was simple and direct, he looked for primary volcanic landforms in all of the Hungarian mountains of volcanic origin: volcanic cones, calderas, and even craters, which he believed to recognise, and compared them to some active volcano. His successor, BULLA, B. (1947), denied the existence of primary volcanic forms. In his opinion, under tropical-subtropical late Tertiary climates, our volcanic mountains denuded into 'planated mountains with rolling surface'. Essentially this view was supported by his direct co-worker and successor to the chair, LÁNG, S. during his detailed field observations over two decades (1953) - even if not in the original pure form, but mixed with other concepts. In his opinion, the parts of the Hungarian volcanic mountains are peneplains elevated to various altitudes.

In the 1950s geographical research was directed by the Geographical Committee of the Hungarian Academy of Sciences, in the first place the geomorphological investigations of Hungary. In this framework mountains of volcanic origin were also studied in detail: the Tokaj Mountains by PINCZÉS, Z. (1969) and the Mátra by SZÉKELY, A. (1960, 1968), applying new methods.

When closing the first period of my investigations I underlined (SZÉKELY, A. 1960) that **primary volcanic landforms** were replaced by denudation forms as early as the Tertiary - but they **did not disappear without any trace.** Their impact on the present relief can be proved and it is manifested in double sense. Directly this impact can be traced in relict volcanic features. The major centres of eruption are - although in truncated form -

still peaks, cones or higher summits and the relict caldera margins also rise above their environs as arcuate crests. Most of the peaks are,however, erosional forms (monadnocks) or tectonic features(horsts) or the combination of the two (erosional horsts). The remnants of lava mantles are distinct in many places. Subvolcanic forms have been exposed by erosion and along the margins of the mountains their morphological role is ever increasing.

It is obvious from the above that **landforms** and **structure** have to be studied jointly and in **comparison** and this necessitated the elaboration of new methods (SZÉKELY, A. 1968). Applying these methods, the detailed analysis of cones similar at the first glance results in the identification of a truncated eruption centre, of the other as erosional cone, of the third as exhumed laccolith and of the fourth as horst.

As opposed to the remnants of primary volcanic landforms, their **indirect impact** is much more important on the present landscape. They have governed denudation. The one-time major eruption centres - although in severely eroded forms - still rise well above the planation surfaces.

As a matter of course, the first lines of drainage followed primary volcanic slopes (consequent streams). Therefore, in my investigations the **manysided analysis of drainage network** has acquired a central role and provided the most valuable pieces of **evidence.** The original drainage network, however, has survived in its major lines, although the evidence for this is indirect. The drainage pattern in itself is a source of valuable information for the **reconstruction of the original volcanic forms** (SZÉKELY, A. 1983, 1985). Major eruption centres are generally picked out by a radial pattern; the inner slopes of calderas have dendritic or centripetal patterns, while their outer slopes exhibit radial patterns. Lava and pyroclastic terrain of ridges is dissected by parallel valleys.

In the eighties my investigations tended to concentrate on the more and more detailed and comprehensive analysis of drainage pattern (SZÉKELY, A. 1983, 1985). To this end first detailed (1:25.000 and 1:10.000 scale) topographic maps and then aerial and space images ((GÁBRIS, GY. 1986) were applied, allowing even higher resolution. GÁBRIS supplemented this with the investigation of divide alignments and field checking was also employed if necessary.

Volcanism, however, is always accompanied by **tectonic movements**, subsidences and uplifts, whether of synvolcanic or postvolcanic nature. They naturally alter the primary volcanic forms and modify the whole relief, varying in degree for the various mountains.

In the further development of our mountains of volcanic origin post--volcanic tectonic movements played a decisive role. Due to intensive tectonic movements **vertical uplifts above 2000 m** have also taken place since the end of major volcanic activity in the Middle Miocene.

These movements resulted in a three-tier character of the mountains of volcanic origin:

1. Denudation was generally most intensive in the outer, N zone, the highest and earliest **uplifted parts** and, consequently, a thick volcanic series has been eroded from them and the originally deep-seated postvolcanic features became exposed to the surface.

2. In contrast, the **inner, S zone** subsided with the Great Hungarian Plain and volcanic mountains were **buried under thick sediments.** In the S foreland boreholes reveal subsided andesite mountains at several hundreds of metres depths. In the NE-Carpathians, however, the peaks of the subsided volcanic range rise as 300-400 m hillocks from the flat surface of the Great Plain (the finest are near Beregovo). In the Miocene the Intra-Carpathian volcanic range was not only much higher but also of greater areal extension, more than double of the present dimension.

3. Thus mountains of volcanic origin have only been preserved in the narrow (10-20 km) zone between the most rapidly uplifting N zone and the subsided S zone.

The subsidence of the Intra-Carpathian volcanoes began even before they became dormant (SZÁDECZKY-KARDOSS, E. 1959; KUBOVICS, I. 1962). Thus the lower parts of the volcanoes have been inundated by the Upper Badenian sea and their denudation was inhibited. Their lower-lying parts have been preserved by Badenian sediments to this day. In several places the remnants of these sediments can be found as high as 300-450 m altitude. As a consequence, more **intensive denudation** of volcanoes began **only later** when the mountains gradually uplifted and simultaneously regression took place, first in the Sarmatian and even more so after the regression of the Upper Miocene (Pannonian) sea

The Hungarian mountains of volcanic origin are consequently much younger, their geological evolution took place over a much shorter period of time than Mesozoic mountains and they were exposed to erosion of shorter duration and lower intensity. Therefore, in the mountains of volcanic origin no true planated surfaces, characteristic of block mountains could develop, only marginal and foothill surfaces could come about.

The **system of pediments**, however, is the best developed in the mountains of volcanic origin (PINCZÉS, Z. 1980; SZÉKELY, A. 1960, 1968, 1987) since for their rapid evolution the original initial surface (volcanic footslopes) and lithology (thin-bedded composite volcanoes) were the most favourable for rapid sculpturing. Periglacial phenomena, particularly frost action, and resculpturing were the most efficient here. During the millions of years of denudation even the highest volcanic centres have been heavily eroded and, mostly since the Upper Pliocene, dissected without planation. As a result, the volcanic forms have not been entirely obliterated.

The methods applied - primarily the detailed analyses of structure and drainage - proved that relief in all the members of the **North-Hungarian Mountain Range** (the Hungarian section of the Intra-Carpathian Volcanic Range) can be detected back to **original volcanic landforms** of Tertiary (mostly Miocene) age and evolved through intensive but differentiated erosion.

Six main types could be identified (Fig. 2.):

1. Relict volcanoes with double calderas (paleovolcanoes, Danube Bend relict volcano or Visegrád Mountains);

2. Volcano ruin with central explosion caldera (the Börzsöny Mountains);

3. Relict composite volcano with a semicircular caldera (Mátra Mountains);

4. Centrolabial stratovolcano system (Tokaj Mountains) with remnants of volcanic cone series;

5. Remnants of volcanic mantles (E-Mátra) dissected by parallel, consequent drainage pattern;

6. Volcanic horst series (E-Cserhát): the former volcano has been destroyed, only the rock is volcanic, the features are not. Four asymmetric andesite horst series with three dividing rows of grabens.

In addition to Miocene volcanic mountains, exposed subvolcanic features (andesite-laccolith hills and dyke ridges), older (Upper Eocene, 45 million years old) relict volcanoes and younger (Upper Miocene-Pliocene) basalt hills (basalt mantles and cones) were referred into 18 types (SZÉKELY, A. 1983, Fig. 2.).

In the meantime I have **extended my investigations** in comparative volcano morphology **to the whole volcanic range of the Carpathians.** At least one or two profiles of each mountain unit were studied and - after preliminary

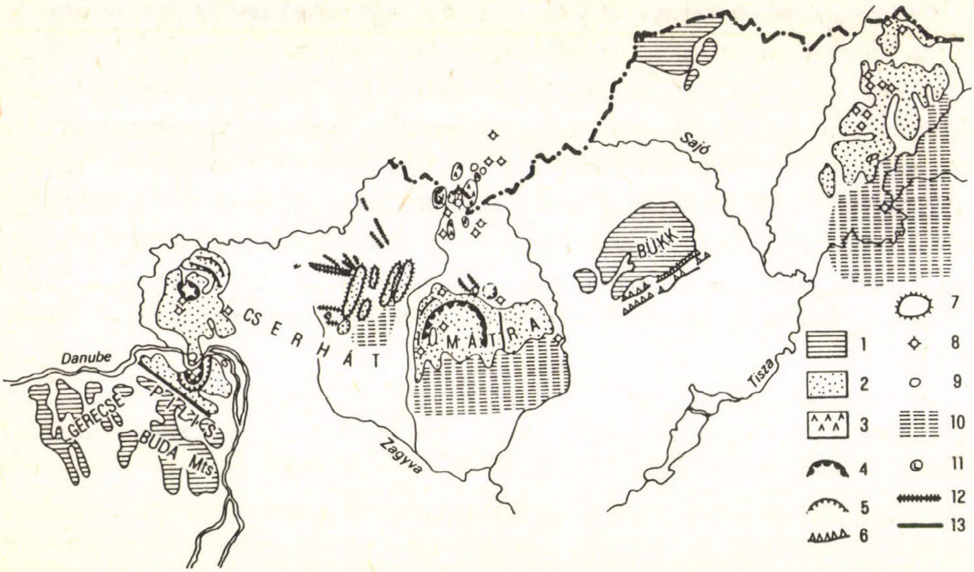

Fig. 2. Structural morphological types in the Hungarian Central Mountain. Range with special regard to volcanic mountains (by A. SZÉKELY). 1= Mesozoic mountains of horst series; 2= Miocene volcanic (mostly andesite) agglomerate and tuff and secondarily rhyolite and rhyolitic tuff on the surface; 3= Pliocene basalt; 4= remnants of the inner caldera margin; 5= hypothetic relict outer caldera margin; 6= remnants of rhyolite and dacite tuff; 7= horst series of volcanic material; 8= volcanic cone remnants; 9= vent remnants; 10= buried volcanic forms; 11= laccolith; 12= dyke; 13= main structural lineament between Mesozoic rocks and Miocene volcanics

studies on geological and topographic maps - evaluation was made applying the above methods followed by final checking on maps. In our department team morphometric procedures were also applied for the investigation of the volcanic mountains of the Carpathians. In his doctoral thesis, A. NEMERKÉNYI * used measurements to separate crater and caldera remnants and in some mountains identified eruption centres or caldera remnants from

* A Kárpátok vulkáni vonulatának távérzékelési módszerekkel végzett tűzhányó-felszínalaktani vizsgálata (Geomorphological investigation of the volcanic range of the Carpathians by remote sensing) - Földr. Közlem. 37 (4): 305-323.

these measurements. In his degree work D. KARÁTSON * designed new measurement methods to identify caldera remnants in eruption centres and provided detailed analyses on the evolution of the individual landforms and their resculpturing.

First I studied the Czechoslovak section of the Intra-Carpathian range, which is directly connected to the Hungarian one, from the Vtacnik to the Presov and Vihorlát Mountains. (Then I took trips to the Eastern Carpathians in Rumania and they proved to be excellent material for comparison, since this part is the youngest (mostly only 7-4 million years old) and thus preserved the most of the original forms. Finally I extended my area of observation to the volcanic range of the Northeastern Carpathians in between, transitional in many senses, in the Soviet Union from the Szinyák to the regular cones of the Saján.

The volcanic range of the Carpathians proved to be an excellent material for comparative morphological investigations, since its getting younger gradually and fairly regularly from NW to SE, from Early Miocene (21-19 million years) to Late Pliocene (4-2 million years) and this phenomenon is also reflected in the state of volcanic features. To the NW relict volcanoes are common and volcanic ruins are less numerous, to the NE the latter are characteristic, while to the E in addition to volcanic ruins truncated volcanoes are also present.

I continued my volcano morphological investigations in the **volcanic range of the** inner side of the **Appennines,** Italy, from Monte Amiata to Vesuvio and in Sicily mainly on the Etna, the Lipari islands and Stromboli (1970-71). There were many opportunities for comparisons, since the resemblances to the Carpathian volcanic range are close: it was formed on the inner side of the Appennines and gets younger to the S - although not so regularly - but to the Quaternary. Therefore, here primary and secondary (truncated) volcanoes are predominant. There I could study the evolution state of the Carpathians for 10-15 million years in its main lines, on both active and inactive volcanoes, providing for me valuable material for comparisons.

Subsequently I intended to visit as many volcanic areas of different nature as possible. The most important observations were made on volcanoes in Japan (1980), Mexico (1982) and É-Africa (1985) (SZÉKELY, A. 1986).

*KARÁTSON, D. 1989. Kárpáti kaldérák új értelmezése a morfometria tükrében (A new interpretation of the Carpathian calderas in the light of morphometry). - Manuscript ELTE TTK masters thesis, 93 p.

Relying on these observations, I could make **more detailed volcano reconstructions** at home and elaborate new methods to this end (SZÉKELY, A. 1985, 1986). These were suitable not only for reconstructing the main lines of mountains of volcanic origin as a whole, but individual volcanic hills, cones, with well-exposed structure in stone-quarries were also reconstructed. The observations on active and inactive volcanoes - particularly those on Etna erupting in April 1971 and Paricutin - allowed the conclusion that volcanoes are built up of repeated morphological inversions and their denudation also takes place through series of morphological inversions. The new methods helped me to prove this on volcanic mountains of 12-19 million years age in Hungary (SZÉKELY, A. 1985a).

The three decades of my investigations made it clear that a main task of volcano morphology is to study the mechanism and agents of **volcano denudation** on volcanoes of various characteristics, lithology and under various climatic conditions. Up to now volcano morphology set up typologies of volcanoes on the basis of original secondary forms - thus it was more properly volcano geology. A **new volcano morphological trend** had to be initiated and this attributes proper emphasis to the mechanism and products of volcano erosion. Therefore, I synthetized volcanoes by the rate of their denudation and resculpturing, by **their present state** into **six morphological types:** 1. Intact volcanoes: they preserve their original shape (primary forms); 2. Truncated volcanoes (secondary forms), which had been attacked by exogenous agents, partly resculptured, but original volcanic forms are still characteristic; 3. Volcanic ruins (third grade forms): original volcanic forms are substantially transformed, deep valleys dissect their surface, but still recognizable and control the present relief (Börzsöny, Tokaj Mountains and others); 4. Relict volcanoes (fourth grade volcanic landforms): the original volcanic landforms can primarily be traced by geophysical and geological methods, rather obscure, uncertain, but their indirect impact on present relief can be seen (Visegrád Mountains, Mátra etc.); 5. Volcanic remnants (fifth grade features): their volcanic forms have been destroyed by denudation and postvolcanic tectonic movements, only their material is volcanic, the forms are tectonic (horsts and grabens) and denudational (E-Cserhát); 6. Volcanic stumps (sixth grade forms): most of the surface volcanic formations have been removed by erosion and subvolcanic features (laccoliths, dykes and others) have been exposed over the long period of denudation and the latter control relief (N-Cserhát).

My investigations served to prove that the rate and efficiency of denudation, and thus the extent of resculpturing, are dependent on the shape and lithology of the original volcano, the relative resistence of rocks to erosion, relative height, the duration of denudation processes and the climatic conditions prevalent during this time and influencing the activity of external agents.

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IMPACT OF KARST CORROSION EFFECT OF SOILS ON DOLINE MORPHOLOGY

L. ZÁMBÓ

ABSTRACT

As a consequence of the **influence of soil** the rock basement of soil-mantled corrosion dolines is attacked by infiltrating waters of modified corrosion capacity. At certain points and in the individual soil zones of the dolines different solubility values are characteristic in regular pattern and their numerical figures can be determined for the corrosion microspaces from the integration of large number of measurements. Local alterations of corrosion activity within the doline are controlled by two main factors: the amount of infiltrating water and its aggressivity. Our investigations have revealed some regularities in these factors and the results seem to be extrapolatable to dolines of other karsts under similar ecological conditions.

INTRODUCTION

With the exception of high-mountain zones above the timberline, the dolines of karst surfaces are mostly mantled by soils of various thicknes or regolith of insoluble materials and weathered terrestrial sedi-ments. In the morphological evolution of the doline these accumulations have an important role to play. Our investigations indicate that these sediments and soils are major controls of the corrosion of the karstifying doline floor. The water deriving from precipitation percolating through soils and thick accumulations before reaching the basement undergoes significant changes as for its amount and lime aggressivity. The corrosion capacity formed on the boundary between the karstifying basement and the mantling soils is basically different from that determined for rainwater. The joint effect of all pedological factors affecting the karst corrosion capacity of infiltrating water is called **soil effect**. The concentrated effects of several pedological processes corrosion capacity under the soil can be grasped through certain parameters. Our investigations carried out for eight years allow the calculation of corrosion capacity in and under the soils with sufficient reliability as the product of the amount of percolating water and its aggressive CO_2 content. The first is expressed numerically (in g/m^2/year) and thus different karst regions can be compared.

Corrosion capacity at the floor of karst dolines depends on slope conditions and soil properties and varies even within a single doline. The differences within the doline, however, show **regular** patterns and control the morphological evolution of dolines.

In NE-Hungary, on the Aggtelek karst, observation sites operated for eight years and the summarization of measurements allows conclusions which explain the differences of the parts of the dolines by corrosion properties. (ZÁMBÓ, L. 1986, 1989 a,b)

AMOUNTS OF PERCOLATING WATER IN SOIL PROFILES

The annual and seasonal averages for percolation in the profiles of observation are shown in Table 1. The cumulative water yields for observations sites allow the formulation of the following regularities:

- with the same soil type and structure on slopes, the amount of infiltration decreases with growing inclination, irrespective of slope exposure. The relationship is linear (3/1, 4/1, 7/1 and 8/1);
- in thick accumulations water yield decreases from top to bottom and abruptly rises in the lowermost zone above the base to levels identical with the zone at 2-2.5 m (nos 6, 11 and 15).

Values and relationships more characteristic than those calculated

Table 1 Annual and seasonal amounts of percolation by observation sites (by L. ZÁMBÓ)

Observation site		Amount of water percolation (litre/m^2)														
code	depth cm	perc. period	total	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Year	Spring	Summer	Autumn	Winter
1/1	80	11,9	8,7	--	--	--	--	--	--	--	--	208,0	--	--	--	--
1/2	160	7,9	0,5	--	--	--	--	--	--	--	--	13,0	--	--	--	--
2/1	50	9,1	5,7	4,3	9,7	3,6	4,4	13,7	13,7	13,7	22,8	148,2	28,0	63,0	23,4	28,5
3/1	50	6,0	2,9	1,9	4,7	2,7	2,2	15,2	11,4	8,6	7,6	75,4	12,4	30,6	17,6	14,3
4/1	50	7,7	4,1	1,9	6,4	4,1	4,6	7,1	20,0	25,7	28,5	106,6	12,4	41,6	26,7	29,9
6/1	120	10,2	4,1	--	--	--	--	--	--	--	--	106,6	--	--	--	--
6/2	200	9,0	2,9	--	--	--	--	--	--	--	--	75,4	--	--	--	--
6/3	355	8,0	3,6	--	--	--	--	--	--	--	--	93,6	--	--	--	--
7/1	50	7,8	4,3	2,9	5,6	3,9	5,4	8,9	20,0	13,3	22,2	111,8	18,9	36,4	25,4	35,1
8/1	50	8,5	5,2	3,2	7,2	4,4	7,2	17,1	19,0	14,3	22,2	135,2	20,8	46,8	28,6	46,8
11/1	120	15,2	1,3	--	--	--	--	--	--	--	--	33,8	--	--	--	--
11/2	250	11,0	5,9	--	--	--	--	--	--	--	--	153,4	--	--	--	--
11/3	500	8,0	0,4	--	--	--	--	--	--	--	--	10,4	--	--	--	--
11/4	750	6,9	5,8	--	--	--	--	--	--	--	--	150,8	--	--	--	--
15/1	80	18,5	14,4	14,3	16,4	17,0	6,8	50,0	42,5	40,0	41,0	374,4	93,0	106,6	110,5	44,2
15/2	250	10,3	6,8	11,0	5,6	3,2	5,7	36,0	30,0	11,5	43	176,8	71,5	36,4	20,8	37,0
15/3	500	6,5	3,6	8,4	0,4	1,2	3,0	37,0	4,5	15,5	9,0	93,6	54,6	2,6	7,8	19,5
15/4	750	9,6	7,3	14,5	2,4	3,6	7,9	50,0	20,0	15,0	41,5	189,8	94,3	15,6	23,4	51,4

from infiltration figures influenced by the conditions of the individual observation sites were received from averages grouped by soil depth. The average values of infiltration calculated from 1179 data can be accepted typical for Hungarian karsts: 120-130 litres per m^2 a year.

Soil structure fundamentally controls infiltration, but the similarities in soil structure according to soil depth and geomorphological position seem to allow generalizations for infiltration in the case of certain landforms (Table 2).

In the years of measurements precipitation was ca 16 per cent lower than the many-year average, but it has to be considered that increased precipitation also involves increased evapotranspiration and the ratio of precipitation and infiltration remains approximately the same. Therefore, it was thought that the infiltrated amount of water was best given as percentage of annual precipitation.

If an accurate map of soil depths and a detailed topographic map are available, the infiltration data in Table 2 provide a sufficient basis for the evaluation of karst phenomena dependant on infiltration.

On slopes, the fundamental element of any surface karst form, infiltration is controlled by soil cover. In addition to the properties of terra rossa soils, infiltration on slopes is also influenced - as indicated by our investigations - by inclination and subordinately by slope morphology. However, all these effects are manifested in the properties of soil cover and influence the calcareous basement indirectly. The observation sites were identified to measure the processes of the widest-spread karst slope forms. Data were gathered for a karst plateau, convex, steep slope segment and doline margin (Fig. 1). The typical average values of infiltration on the slope sections studied are interpreted to include the infiltrating portion of precipitation reaching the surface in that point together with the amount of water percolating in the direction of slope which reaches the bedrock in the point in question. As a consequence, moving downslope the infiltrating portion of precipitation increases as large amounts of water are involved in throughflow. Expressed in percentages infiltration corresponds to the empirical figures for each slope segment and thus can be used for calculation, but it does not derive exclusively from precipitation in the given site.

The typical infiltration values of doline slopes and soil fills are

Table 2 Average infiltrated portion of precipitation in function of relief and regolith under temperate climate[x] (by L. ZÁMBÓ)

Relief element	Depth of percolation (cm)					
	0–20	20–50	100–200	400–500	200–700	700
Slope undifferentiated	20	–	–	–	–	–
Slope with gentle segments	22	–	–	–	–	–
Steep (30°) slope	14	–	–	–	–	–
Medium ($15–30^{\circ}$) slope	20	–	–	–	–	–
Gentle (15°) slope	21	–	–	–	–	–
Margin of doline fill	–	28	–	–	–	–
Surface of doline fill	–	20	–	–	–	–
Surface of doline fill with extensive watershed[xx]	–	70	–	–	–	–
Surface of doline fill	–	–	14	–	–	–
Regolith ($0–5^{\circ}$)	–	37	–	–	–	–
Regolith ($0–5^{\circ}$)	–	–	19	–	–	–
Regolith ($0–5^{\circ}$)	–	–	–	13	–	–
Rock basement of doline	–	–	18	–	–	–
Rock basement of doline undifferentiated	–	–	–	–	33	–
Rock basement of doline with extensive watershed[xx]	–	–	–	–	–	36

x: average of 1116 observations

xx: watershed larger than doline area

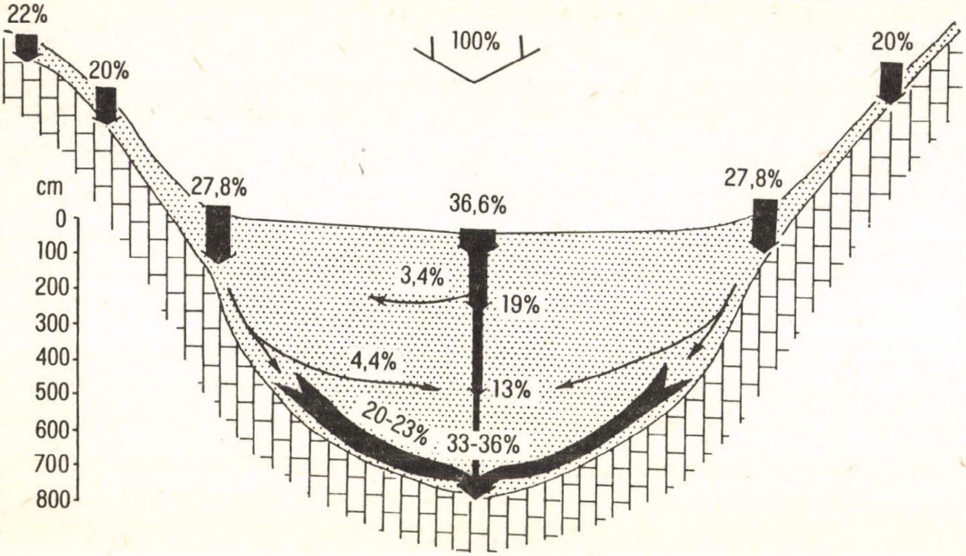

Fig. 1. Percolation conditions of doline fills (by L. ZÁMBÓ)

shown - relying on 497 measurements of infiltration - in Fig. 1. The typical infiltration calculated from annual precipitation over the doline slopes also includes the part infiltrated from throughflow into the limestone body. In the larger amounts of precipitation along the margins of doline fill, throughflow from higher slopes is also manifested. Over the almost flat surface of doline fill the infiltrating portion also includes water from overland flow. The decreasing amounts of infiltrating water in the lower layers of the fill show water storage in pores as well as throughflow. A considerable part of the high amounts of water infiltrating on the doline floor arrives here by means of throughflow, while a smaller portion comes from vertical percolation. The empirical infiltration model also shows the generalized inner hidrography of the doline.

Early spring snowmelt results in high infiltration values first of all under thick soil accumulations, while thin soil mantles with prolonged frost in capillaries cause runoff of part of the meltwater.

The early summer precipitation maximum regularly coincides with the peak of infiltration during the year, but thin and thick soils are affected in different ways.

Under thin soil mantle early summer infiltration gives 40 to 50 per cent of annual yield, irrespective of position on the relief. The secondary precipitation maximum in autumn is more differentiated and the control of relief works with lower intensities. In this latter case soils on E slopes allow the infiltration of relatively more water into the limestone basement.

The middle horizons of thick fills are regularly impermeable in the early summer humid period. As a result of this impermeability much moisture is stored in the higher layers, lost for infiltration into the karst by evapotranspiration. The yield from the lower horizon - mostly less than that of early summer - almost exclusively comes from throughflow. Water from autumn rains does not usually penetrates into the limestone basement by vertical percolation. In winter rainfalls cause infiltration into the thin soil mantles, but when the capillaries of the upper levels freeze, infiltration is interrupted until snowmelt.

Under thick accumulations a low degree of infiltration into the basement is almost continuous, probably maintained by slow throughflow in the unfrozen soil body, also fed by occasional and temporary snowmelt.

CO_2 CONTENTS IN INFILTRATING WATERS IN OBSERVATION SITES

The maintenance of the balance between CO_2 dissolved in water (as H_2CO_3) and the CO_2 content of the air necessitates continuous CO_2 diffusion between the soil solution and the air, since infiltrating water finds ever changing conditions when moving downward. In the wandering of CO_2 the changes in factors are influencing aggressivity. This supports the fundamental concept of the paper, viz. the soil and its inner conditions, soil dynamic processes shape the limestone basement through controlling the CO_2 content of the soil solution (its solution capacity).

The total CO_2 of a soil solution exists in three distinct forms. Dependent on the degree of contact and the conditions of solution, $CaCO_3$ affected by carbonic acidic water dissolves and in the form of fixed CO_2 (as $Ca/HCO_3/_2$) forms part of the CO_2 content of water. The remnant CO_2 in water as free CO_2, partly serves to keep fixed CO_2 in solution as balance CO_2 coexisting in water is not tackled here. Analyses were made on the basis of 1205 data from the soil profiles of the observation sites of the dissolved CO_2 forms. The averages of the large number of measurement reflect great diversity for the soil profiles and accumulations. From the average distribution of CO_2 forms in the whole soil mantle - 2.54 mmol per litre total CO_2, 0.7 mmol per litre fixed CO_2 and 1.32 mmol per litre aggressive CO_2 - the proportions in the individual soil horizons are markedly different and reflect soil properties concerning solution.

The average values in thin soils for all the three CO_2 forms are lower than the regional average. This even applies to the case when the values under thin soils are compared to the uppermost levels of thicker soils, where the corresponding figures are the lowest.

To increasing depths in thick accumulations the values for the various CO_2 forms are mostly growing in multi-year average (Table 3). The picture is more varied if the results of shorter observations (seasons) are studied. As an example the figures for the Béke doline accumulation (profile no 15) for 1981 are analysed in this respect:

- there is a monotonous increase of fixed CO_2 with depth, which is simply explained by more calcareous material being dissolved along a longer path of infiltration;
- the concentration of free CO_2 (H_2CO_3) first drops (with diminishing CO_2 production), then rises (in the compact middle zone both aeration and leaching are weak) and finally reduces again (throughflow and fixation of free CO_2);
- the free CO_2/fixed CO_2 ratio first decreases, then stabilizes (while dissolution becomes stronger with depth, in the compact CO_2 production falls short of it and below the compact zone the two processes balance each other);
- fixed CO_2 content varies seasonally at different depths: in spring it follows the maximum curve, while in summer and early autumn a convex and in late autumn and winter a concave curve; the decalcification of the upper horizon is at approximatively the same level from spring to late autumn; at 3 m depth dissolution varies with wet and dry conditions, but remains at the same level all over the year at 5 m depth. At the bottom of the doline dissolution fluctuates to the degree of lateral seepage;
- the fixed CO_2 contents in layers at various (0.5 m and 2.5 m) depths are stable and independent of the precipitation, while free CO_2 rapidly changes in the function of weather;
- the changes in the CO_2 contents of four horizons in a single profile show that, while leaching is more or less uniform throughout the profile,

Table 3 Annual average values of the components of the aerial and liquid phases of characteristic karstic soils and of environment factors (by L. ZÁMBÓ)

Observation site		CO_2 content of water			Soil air	Precipitation		Infiltrating water								
reference	depth	total	fixed	aggressive	CO_2	amount	intensity	moisture	temperature	Fe_2O_3	NaO	K_2O	CaO	MgO	P_2O_5	TiO_2
	(m)	mmol/l			%	(l/m^2)	mm per minute	%	(^oC)							
1/1	0,8	2,56	0,67	1,27	0,72	505	0,27	57,5	8,0	1,03	1,13	0,47	37,0	2,29	0,21	1,60
1/2	1,6	4,19	0,82	2,09	0,77	505	0,27	61,4	7,6	0,02	1,50	0,46	20,8	2,49	0,08	0,24
2/1	0,2	1,99	0,45	1,20	0,27	505	0,27	64,7	8,6	1,91	0,39	0,55	18,4	2,78	0,18	1,85
3/1	0,2	2,11	0,40	1,31	0,15	505	0,27	61,7	9,0	0,46	1,01	1,67	21,2	3,81	0,39	1,71
4/1	0,2	1,88	0,46	1,10	0,19	505	0,27	55,5	9,0	0,17	0,77	1,75	20,1	3,16	0,44	1,80
6/1	0,2	3,99	1,51	1,23	0,72	505	0,27	64,8	8,1	0,08	1,14	0,86	97,9	3,84	0,66	0,52
6/2	2,0	4,64	1,40	1,60	0,85	505	0,27	76,7	7,1	0,03	1,16	0,33	92,3	6,25	0,30	0,36
6/3	3,5	2,99	0,67	1,60	0,87	505	0,27	76,7	5,9	0,10	2,05	0,58	40,2	2,17	0,25	0,40
7/1	0,2	2,30	0,90	1,09	0,22	505	0,27	51,7	7,6	0,24	0,66	1,32	38,8	3,12	0,15	1,44
8/1	0,2	2,25	0,55	1,37	0,28	505	0,27	62,5	8,3	0,45	0,82	1,56	21,8	2,60	0,28	1,97
11/1	0,5	2,18	0,32	1,43	0,41	535	0,27	75,0	7,9	19,27	1,21	3,20	13,2	4,98	0,22	4,50
11/2	2,5	2,35	0,42	1,47	0,24	535	0,27	79,8	7,6	11,55	1,21	2,74	14,5	4,47	0,13	0,40
11/3	5,0	2,89	0,63	1,62	0,33	535	0,27	78,2	8,0	0,30	1,54	0,54	47,9	11,69	0,60	3,70
11/4	7,5	3,43	0,98	1,71	0,46	535	0,27	70,1	8,1	0,02	5,20	1,35	47,5	9,58	0,15	0,42
15/1	0,5	1,58	0,45	1,02	0,38	469	0,27	61,4	8,6	6,96	0,65	2,15	14,4	2,05	0,24	2,10
15/2	2,5	2,05	0,61	1,15	0,25	469	0,27	78,4	7,0	3,94	1,71	0,61	24,8	2,59	0,15	2,29
15/3	5,0	3,05	1,02	1,43	0,29	469	0,27	78,3	6,8	0,30	2,77	0,39	47,7	5,66	0,46	0,46
15/4	7,5	2,83	0,78	1,46	0,27	469	0,27	72,2	6,1	1,11	2,98	1,05	41,8	5,12	0,31	0,91
Total		2,54	0,70	1,32	0,43	503	0,27	68,3	7,7	2,26	1,42	1,15	34,0	3,55	0,27	1,47

free solution capacity varies on a wide range; in other words, soil decalcification hardly depends on the season or weather, but the corrosion of the basement is controlled by weather.

By grouping the data according to the thickness of soil horizons, the following conclusions can be drawn:

- CO_2 contents in the water of thin soils are lower than those in thicker accumulations and their decalcification is ca 25 per cent weaker;

- in the deep layers at the bottom of the doline weathering is less intensive and less Ca is released;

- the rate of decalcification (fixed CO_2 content) is highest in summer for all thicknesses and horizons, double the winter figure, while in spring it is somewhat higher than in autumn;

- the aggressivity of infiltrating water (but not its total solution capacity!) is seasonally declining from spring to winter in thin soils and in the soil horizon above the limestone. The concentration of solutions is on the average double in spring than in winter.

Comparing various infiltration rates and various free CO_2 contents of solutions, it can be stated that the middle zone of accumulations, a more or less closed system, is exposed to soil acidification effects (seepage of low amounts of concentrated carbonic acid and stagnant water), while the upper and lower zones are open systems, washed through by dilute solutions regularly.

Part of the considerable fixed CO_2 content of infiltrating waters derives from weathering and exchangeable Ca^{2+}, while another part reached the soil with waters flowed from upper slope segments and brought dissolved carbonates with themselves. This double origin of carbonates in the soil can be proved by the statistical analysis of analytical data.

AN IDEAL MODEL TO DESCRIBE THE POTENTIAL LIMESTONE SOLUTION CAPACITY

The sub-soil limestone solution capacity, as a complex karst-morphologic manifestation of soil and soil accumulation, shows regularities that make it possible to construct a model according to soil thickness and relief features (Figure 2.). The regular development of limestone solution capacity leads to an ideal manifestation of corrosion karstic forms after a long time. The regularity of limestone solution capacity is disturbed by other factors; therefore, it often happens that soil impact is not ideally expressed and that the forms development by solution can not be modelled.

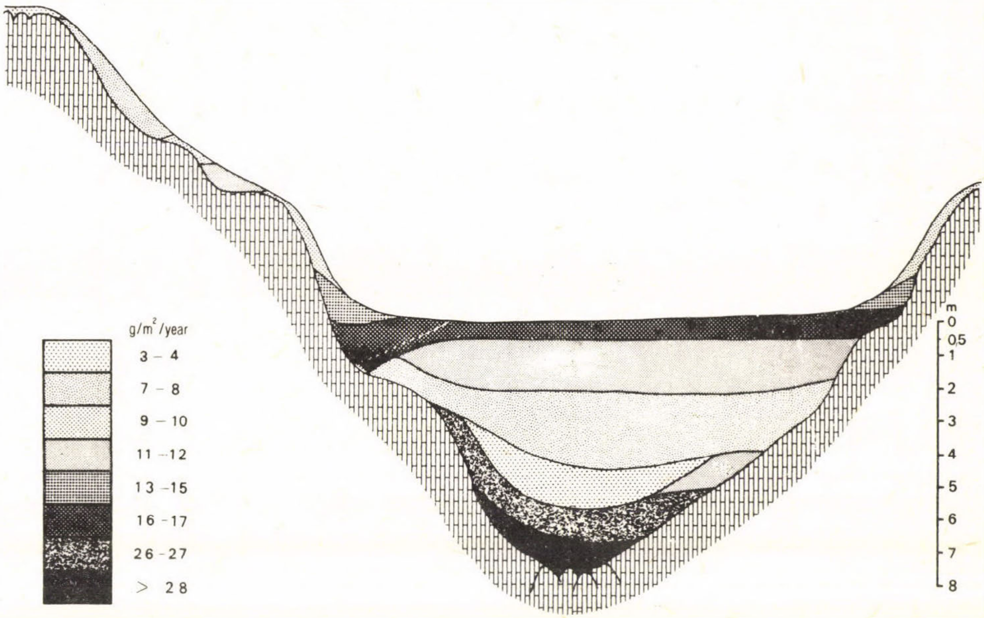

Fig. 2. Changes of corrosion capacity in slope and doline soils (by L. ZÁMBÓ)

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MAPPING ECOLOGICAL UNITS ON A DANUBIAN FLOOD - PLAIN

J. BALOGH - D. LÓCZY

ABSTRACT

A N to S transect of cca 5 km width has been selected in the Szigetköz Danubian flood-plain area (NW-Hungary) to illustrate the ecological diversity of this landscape.

A geomorphological survey of the flood-plain microforms at 1:10 000 scale (then reduced to 1:50 000) supplemented with geoecological data (from the interpretation of satellite image and field-work) allowed the classification and mapping of geoecological units. The negative features mapped include old ox-bows and backswamps in various stages of infilling, the rest is constituted by systems of point-bars, higher-level flats and ridges.

The vegetation cover reconstructed from satellite image reflects the moisture conditions of the individual surface units. The commonest type is infilled ox-bows of less than 1 m depth under arable cultivation.

Over most of the Szigetköz the projected Slovak-Hungarian Barrage System will reduce the availability of water for plant life. For designing a satisfactory groundwater recharge system, the spatial pattern of old ox-bows and their moisture conditions should be considered.

INTRODUCTION

The Szigetköz flood-plain area along the Slovak-Hungarian section of the Danube, in the impact zone of the joint barrage scheme under construction, is now in the focus of attention from Hungary and abroad (Fig. 1). When the subsidiary facilities of the barrage system are in preparation major environmental changes are expected to occur in the area. For the evaluation of the consequences of modified groundwater conditions a detailed knowledge on the microforms of the landscape is indispensable.

The identification of geoecological units was based by a large-scale **geomorphological mapping** project undertaken by the Geographical Research Institute of the Hungarian Academy of Sciences under the guidance of M. PÉCSI, in 1982. The end product of the survey was a 1:50 000 scale map of geomorphological microunits (or supplemented with fundamental geoecological information on land use, sediments, soils and depth to groundwater). The map legend was constructed through further diversifying the detailed unified legend to geomorphological maps in Hungary (M. PÉCSI et al. 1963). The starting-point of the survey were the topographic map sheets 1:10 000 scale (for 1963) and field information was added from the interpretation of 1:50 000 scale aerial photographs (taken in 1975) as well as from checking data on the spot. A typical transect has been selected for the purpose of demonstration.

TEST AREA

The area studied, the Szigetköz, is the youngest part of the Little Hungarian Plain alluvial fan (NW-Hungary) built by the Danube. Entering the Carpathian Basin, the river loses much of its gradient (although it is still higher than in the case of other alluvial fans in Hungary). It is difficult to distinguish between higher and lower flood-plain levels along this section. The higher levels are mostly artificially raised terrains with settlements. In the past even many of these were inundated during disastrous floods.

For a detailed analysis a cca 5 km wide transect was selected in the lowermost third of the alluvial fan, in the environs of the village Győrújfalu. This transect demonstrates all the microforms typical of the

Fig. 1. Location of the Gabcikovo (Bős)-Nagymaros barrage system (by D. LÓCZY after F. SZŐLLŐSI, 1986). - 1= Dunakiliti-Hrušov reservoir; 2= Dunakiliti-Palkovičovo (Szap) diversion canal; 3= barrage; 4= channel regulation; 5= main Danube channel with reduced discharge

Szigetköz. A reduced version of the map of geomorphological units (facets) is presented here (Fig. 2).

MORPHOMETRIC ANALYSIS

The **negative forms** (in their majority infilled ox-bows) traceable and mappable occupy **one-third** of the area lying between the main Danube channel and the Moson-Danube.

The commonest type of infilled ox-bows has less than 1 m depth and is under arable farming. Today the detection of these features is hindered by the fact that large-farm agriculture is practised on fields of tens or hundreds of hectares using heavy machinery and, as a consequence, most of the minor forms have already been obliterated. The areal extension of deeper (1-2 m) one-time meander surfaces is rather limited, the most important one have been channelised and now have a double function of drainage and irrigation ditches.

The only living ox-bow of the mapped area (outside the dyke) is found between Dunaszeg and Győrladamér. This is the only landform which sinks more than 2 m below the general surface.

And now let us examine how microrelief is reflected in the satellite image. The 30 m resolution of LANDSAT TM images allows the recognition of microforms of these dimensions. For interpretation a false colour composite of April 4, 1984, had been chosen as it is rich in hues. The map of geomorphological units constructed from the interpretation of this image for the area under study is shown in Fig. 3.

As opposed to the map of Fig. 2, this map indicates infilled ox-bows for little more than **one-fifth** (Table 1). In order to explain this much lower proportion the factors influencing the recognition of infilled ox-bows in the image have to be studied.

The Szigetköz alluvial fan is mostly composed of coarse sediments (sandy gravel) and only the uppermost 1-2 m layer is of finer material (fine sand and silt). In the ox-bow fills, however, the thickness of the fine fraction may amount to 5-6 m. Capillary action is hardly able to supply water to the soils of the higher-lying point-bars from the gravel beds. The LANDSAT image was taken after a dry period and, therefore, shows these surfaces in pale

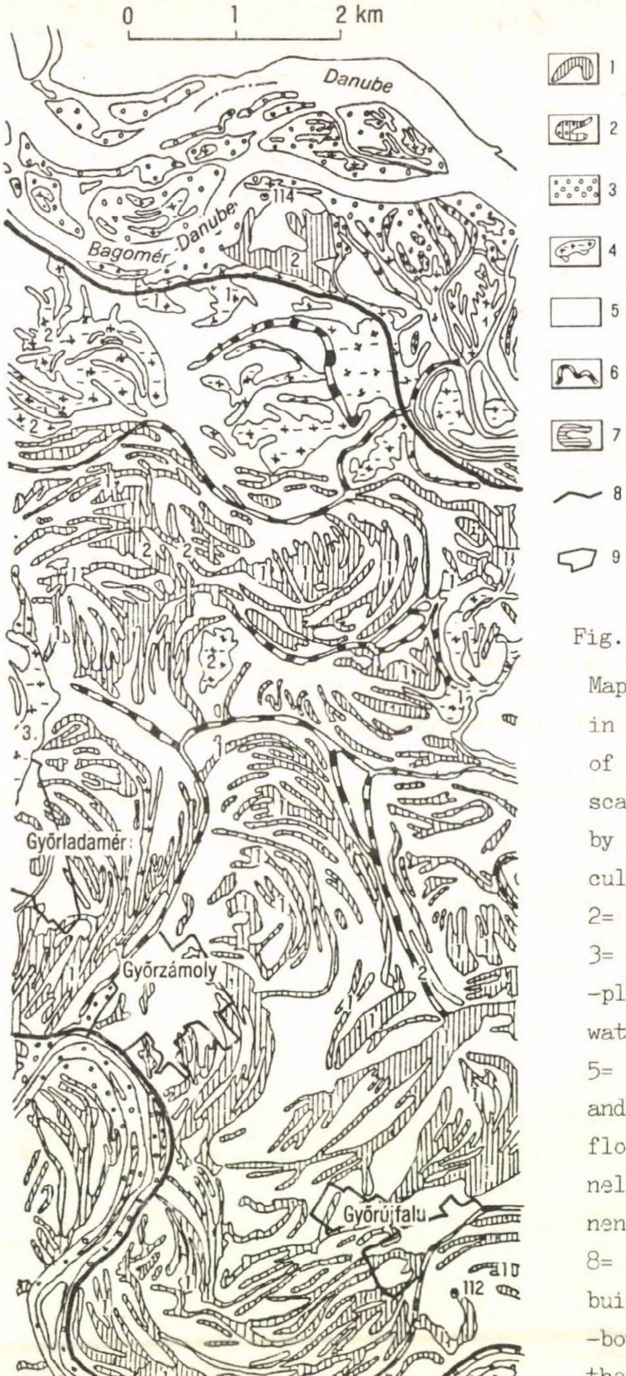

Fig. 2.

Map of geoecological units in the Győrújfalu transect of the Szigetköz (original scale: 1 : 10.000, surveyed by J. BALOGH in 1982). - 1= cultivated ox-bow remnant; 2= forested ox-bow remnant; 3= forest on lower flood--plain level; 4= seasonally waterlogged ox-bow remnant; 5= cultivated old point-bars and ridges of the higher flood-plain level; 6= channelised ox-bow; 7= permanently waterlogged ox-bow; 8= flood-control dyke; 9= built-up area. Depth of ox--bow remnants is shown in the following categories: 1=<1m; 2= 1-2 m; 3= >2 m

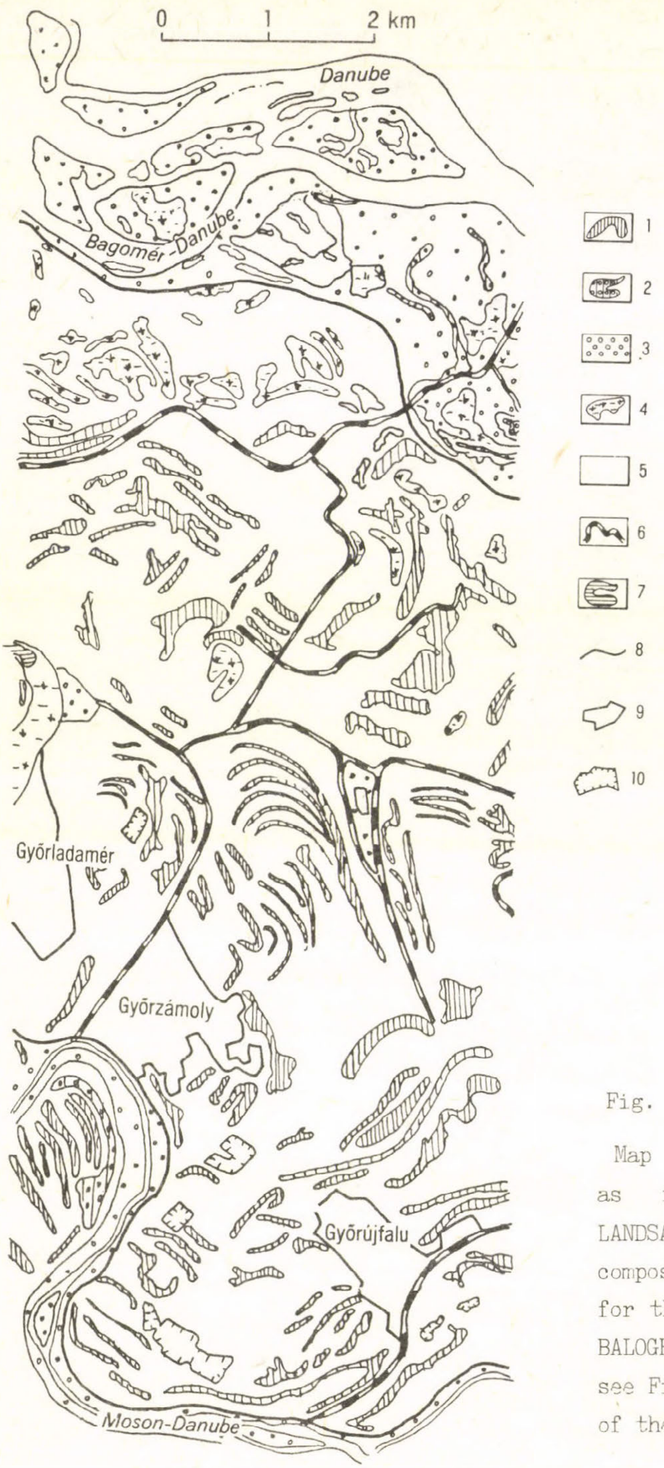

Fig. 3.

Map of geoecological units as interpreted from the LANDSAT TM false colour composite for April 4, 1984, for the same transect (by J. BALOGH in 1985). For legend see Fig. 2. with the addition of the symbol 10= gravel pits gray and white hues. In the area of the onetime ox-bow floors, however, capillary action is highly effective, water storage is considerable and soil moisture is satisfactory even under drought conditions. They are portrayed in the range of hues from light blue to bluish gray, being generally distinct from the adjoining, apparently homogeneous surfaces.

Table 1 Geoecological types in the Győrújfalu transect

Geoecological type	Area (km^2)	Percentage
1. cultivated ox-bow remnant	11.8	21.5
2. forested ox-bow remnant	0.5	0.9
3. forest on lower flood-plain level	2.1	3.8
4. seasonally waterlogged ox-bow remnant	3.8	6.9
5. cultivated old point-bars and ridges of the higher flood-plain level	35.2	64.1
6. channelised ox-bow	1.5	2.7
7. permanently waterlogged ox-bow	0.05	0.1
Total	54.95	100.0

Also crop phenophases can be regarded at the time of imaging. Unluckily the image was taken in April, when winter crops (wheat, barley and rye) have sprung. The satellite sensor observes them in the infra-red band and this means that they appear in purple hues in the false colour composite. The differences in hues are suitable for the delimitation of ow-bows, the habitats on the floor of channel remnants are better supplied with water and more vivid green vegetation will appear in deeper purple. The point--bars of poorer water household on the other hand are covered by less lively vegetation and a paler purple shade will mark them in the satellite image.

ECOLOGICAL ANALYSIS

The Szigetköz is an important agricultural area of Hungary. Long meteorological observation series indicate that its climate is more favourab-

Fig. 4. Land use map of the Szigetköz (by D. LÓCZY in 1987). - 1= arable land; 2= forest; 3= meadow and pasture; 4 = wetland (reed and sedge); 5= built-up area, gardens, orchards and vineyards

le for arable farming than that of the Great Hungarian Plain. The frequency of drought is lower and advantageous groundwater conditions also improve the availability of water for field crops. Consequently, most of the land is used as arable (Fig. 4).

The spatial pattern of microforms surveyed morphometrically and identified from satellite image reflects the ecological diversity of the region. The test area also well exemplifies the extent of human impact manifested in intensive farming and recently in the establishment of the Dunakiliti reservoir and its related facilities on the ecological units.

The microclimatic measurements in the Szigetköz (GÖCSEI, I. 1979) pointed out the daily range of temperature just above the soil surface is highest in the ploughed fields, while, with their temperate microclimate, the old ox-bow surfaces used as mown meadows are much closer in this respect to flood-plain forest microclimate. The observations showed that daily evaporation in the ox-bows was only one-third of the figure for arable fields.

The **land use** interpretation of the LANDSAT TM image for the transect area (Fig. 5) revealed that arable land or orchards occupy almost two--thirds of the area. For the study of these lands the colour composite of LANDSAT MSS for April 1. 1981, classified by field reference, and the relevant sheet of the agrotopographic map series of Hungary (at 1:100.000 scale) were used (GÓCZÁN, L. et al. 1983).

It is striking in the image that large-farm agriculture - increasing the size of plots for easier cultivation - has been totally neglecting the pattern of old ox-bows (by now mostly infilled). The natural habitats lying outside the flood-control dykes have almost completely been converted into agricultural habitats predominantly controlled by agrotechnology.

Moisture contrasts are evident from the image: the aquatic vegetation of channelised ox-bows and waterlogged ox-bow sections reflect in band 3 and, consequently, appear in bright red. The open water surfaces of inundated terrain are dark blue (including the living ox-bow and the gravel pits between Győrújfalu and Győrzámoly).

The belt of flood-plain forests is still almost contiguous, while arable fields have incorporated most of meadows along the S side of the dyke. Over a patch of cca 1 km^2 area, farming is practised even within the dyke, but of course it is possible only in flood-free years.

The remnants of the forests along the Moson-Danube are now restricted to some major infilled ox-bows.

PREDICTABLE IMPACT OF THE BŐS (GABČIKOVO) BARRAGE

Two elements of the Bős-Nagymaros Barrage System are expected to alter the present ecology of the Szigetköz: the Dunakiliti reservoir and the main channel of the Danube (with severely reduced water discharge).

The Dunakiliti reservoir will supply at least 50 m^3 per sec discharge at 0.4 - 0.5 m per sec velocity into the 'Old Danube'. The old channel will drain its banks and the groundwater table will drop. The by-channels of the river will be dammed in order to support the groundwater table and thus preserve the forests of the active flood-plain.

According to the official prognosis of planners groundwater levels 1-1.5 m below the maximum ever recorded are expected. For the central parts of the Szigetköz the plan has been modified for environmental considerations and, consequently, the maximum drop of groundwater level is not supposed to exceed 2 to 2.5 m. The damming effect of the Nagymaros barrage will ensure that in the lowermost portion of the Szigetköz, downstream the site where the diversion canal joins the main channel (Szap - Palkovičovo) no significant change compared with the present levels (113-114 m above mean sea level) occurs.

The projected Dunakiliti reservoir (NAGY, L. 1986) will occupy a larger area (68 km^2) than the test area studied in this paper. Maximum damming level will be at 131.3 metres above sea level, while the minimum one during operation 130.0 metres with two cycles of water level daily. Total volume will be 200 million cubic metres. The impact of the reservoir on mesoclimate will further reduce extremities and beneficially restricts water loss through evaporation.

Since almost the whole area of the Szigetköz lies downstream of the projected dam, the drop of groundwater levels and the reduced discharge of the Danube channel will lead to water deficit. A recharge system has to be constructed and it will use 30-32 m^3/sec water conducted from the Dunakiliti reservoir into a canal network. The canals, from which water will percolate into the sediments, are planned to follow by-channels on the active flood-plain and infilled ox-bows beyond the dykes.

For meander traces with depths less than 1 m, which are the widest-spread in both the test area and the Szigetköz, the projected percolation system, however, does **not** promise a satisfactory water recharge. In the fill of one-time meanders the percentage of fine fractions is high and in some of the existing canals, which are planned to be used for the recharge

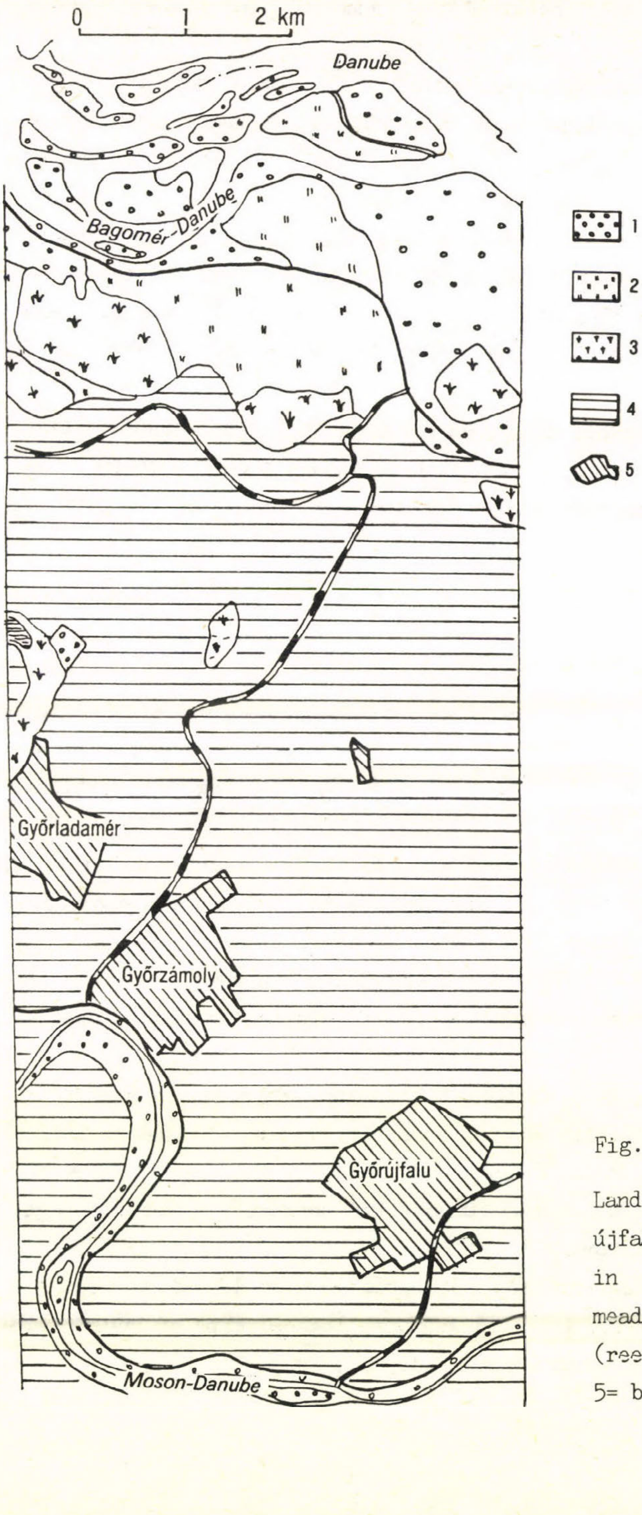

Fig. 5.

Land use map of the Győr-újfalu transect (by D. LÓCZY in 1987). - 1= forest; 2= meadow, pasture; 3= wetland (reed and sedge); 4=arable; 5= built-up area system, colmatation has begun, considerably reducing the horizontal permeability of sediment layers.

In knowledge of the geomorphological conditions, canals should cross as many old point-bars as possible and thus accelerate water percolation, reducing at the same time the danger of colmatation. This project, however, would need a higher level of investments.

Because of the various depth, lengths and fillings of old meanders, the Szigetköz has to be considered inhomogeneous in its material. Test pumpings indicated infiltration coefficients ranging from 0.14 to 1.2 cm/sec. Specific groundwater flow rates are 130-300 l/sec. km, while towards SE 10-20 l (UBELL, K. 1964).

It is undoubtedly desirable that simultaneous to the main canal a carefully designed system of secondary percolation canals should also be established and the various habitats should receive the minimum of required moisture.

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NEW CONCEPTS IN LANDSCAPE ASSESSMENT: A DYNAMIC LANDSCAPE ASSESSMENT

J. GALAMBOS

ABSTRACT

With the help of dynamic computer-based landscape assessment such a result can be achieved which reflects the changeability of landscape potential and is closer to reality than results given by previous methods. Thus the result numerically quantifies the probable suitability of the land from different aspects for any type of land use. Knowing the statistical regularities characterizing the changeability of suitability, the results of landscape assessment can be predicted as well. Consequently it can aid regional planning with land use choices to exploit the most efficiently prevailing landscape potentials in the given period of time.

As a result, we can obtain an answer in the possible suitability value-range for a freely chosen land use target like growing plants, developing resort places and nature conservation areas etc. We can also produce prognosis to estimate agricultural crops, recreational utilization and the future environmental.loading of the nature conservation sites. Since the latest data of the changeable factors of the data-base are continuously put into the system, it is suitable for monitoring the changes occurring in the environment, caused by either physical or technical effects. When applying it, we can actually monitor the dynamic changes in landscape potential. This information is very useful in local, regional or national decision-making to develop a reasonable spatial structure of land use pattern.

INTRODUCTION

Nowadays the socio - economic changes have entered a new phase. These changes occur in the very geographical space, causing its rapid alterations different from pervious ones. These alterations influence the tasks of geosciences too. The main tasks of today's geography are the quick revelation of the alterations having occurred in the total environment of society; exploring the cause and effect dependences; and the possible prognostics of future tendencies and changes (PÉCSI, M. 1979). Geography has to accomplish the above tasks so that its research work can serve the short and long range interests of the actual socio-economic development.

THE AIMS OF RESEARCH

The aim of dynamic landscape assessment is to produce a result, which reflects the changeability of landscape potential and is closer to reality than results given by previous methods. Thus the result numerically quantifies the probable suitability of the land, from different aspects, for any type of land use. Knowing the statistical regularities characterizing the changeability of suitability, future landscape assessment results can also be predicted. Consequently it can aid regional planning to make landuse choices for the most efficient exploitation of the prevailing landscape potentials in the given period of time.

The ever increasing intensity of land use results in an increase of human charging the environment. Therefore the governments of many countries all over the world try to reduce the technical charging of the environment. It is important to investigate the degree of charging concerning each branch of the economy and the efficiency of the measures taken in order to protect or improve the state of the physical environment. Another research task is to develop an evaluating method to define the overall environmental charging, emitted by agriculture, and to detect its temporal changes (GALAMBOS, J. 1987,1988).

METHOD AND RESULTS

Most of the landscape assessment methods are essentially static, resulting form the fact that only the average values of the changeable factors of landscape (e.g. temperature, precipitation, atmospheric humidity, groundwater level) are considered. Naturally, using mean values (e. g. mean annual temperature , mean temperature or rainfall of the growing season) the assessment results will be simplified. It is for this reason that we have to show that the use of mean values has drawbacks from several points of view:

a/ The statistical probability of the actual occurrence of any of the mean values is very low.

b/ Given mean values (even referring to a short period of time) may come from extreme actual values.

c/ From a given viewpoint (e.g. plant growing) the mean value (e.g. that of precipitation) is not efficient for assessment purposes because the actual value at a given time (e.g. germination) is the most important.

d/ The extremities (like minimum temperature) are not expressed by mean values, though these strongly influence the stability factor or plant growing.

e/ Landscape assessment based on mean values (land evaluation oriented towards growing sites) assigns the land a 'constant' value or rank score. Its static character is not suitable for predicting future changes in landscape potentials, e.g. in growing site conditions.

To eliminate the above disadvantages, the new type of landscape assessment has the following characteristics:

1/ Having been measured over decades, the actual values of the changeable factors of landscape form the basis of the method. Next the parameters of the most important factors are weighted from the point of view of the chosen exploitation (they are ranked into different quality categories). Then we compute and use the statistical likelihood of occurrence of the (changeable)actual parameters of factors ranked into different categories, instead of the average values. Thus the assessment result of one square grid unit of the investigated area will not be a static rank score, e.g. between 0 an 9. The result will be the statistical probability set of occurrence of different values (quality categories). The output of the former assessment method is a rank score assigned to the square grid units (e.g. 9.) from a given point of view and it represents a certain quality category (e.g. favourable). The assessment result of this method displays the same quality category e.g. as follows: 9 - 74 %, 8 - 23 %, 4 - 3 %.

The interpretation of this sequence: the area of a certain square grid unit has a 74 % probability of being classified into the favourable (9) category: a 23 % statistical probability of being in a less favourable (8) category; and a 3 % statistical probability of being in an unfavourable (4) category. In this way we have more detailed information about the real nature of the investigated area, represented in the form of square grid units. When assessing, e.g. growing site conditions, we can also obtain information about the estimated likelihood of a given crop yield (Fig. 1).

2/ As we use the data of several decades, we can compute the types and trends of the changes in the parameters. Thus we can calculate the future values of the parameters and can complete the prognosis of an investigated area for different land use purposes (Fig. 2).

When assessing the degree of environmental pollution emitted by agriculture, the following parameters are taken into consideration in the data bank of the information system.

a/ Types of land use,
intensity of land use,
amount of fertilizers used in agriculture.

b/ Type of animal husbandry,
intensity of animal husbandry,
manure management, storage.

c/ Horizontal dissection of relief,
steepness and exposure of slopes,
parent rock types.

d/ Yearly, monthly and weekly amount and
distribution of precipitation,
yearly, monthly and weekly distribution
of temperature.

e/ Depth of groundwater table,
reservoir of groundwater,
groundwater currents,
surface runoff on catchment areas.

f/ Genetic type of soil,
thickness of soil layer, erosion,
mechanical type of soil.

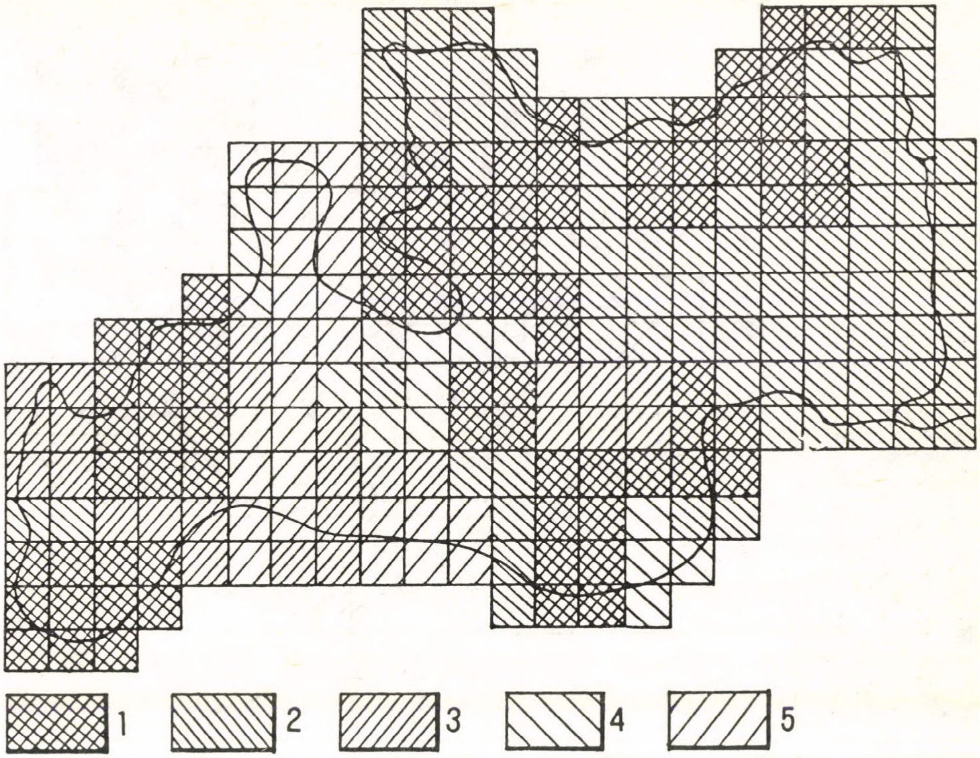

Fig. 1. Assessment result of a Hungarian test area from the viewpoint of growing grapes (Traminer) (by J. GALAMBOS 1986).

1= quality category - very favourable (The statistical likelihood of occurrence of the categories: 1. 82 %, 2. 16 %, 3. 2 %); 2= quality category - favourable (The statistical likelihood of occurrence of the categories: 1. 67 %, 2. 24 %, 3. 6 %, 4. 3 %); 3= quality category - less favourable (The statistical likelihood of occurrence of the categories: 1. 51 %, 2. 26 %, 3. 13 %, 4. 11 %); 4= quality category - moderately unfavourable (The statistical likelihood of occurrence of the categories: 1. 17 %, 2. 28 %, 3. 36 %, 4. 10 %, 5. 9 %); 5= quality category - favourable (The statistical likelihood of occurrence of the categories: 1. 0 %, 2. 8 %, 3. 29 %, 4. 14 %, 5. 49 %)

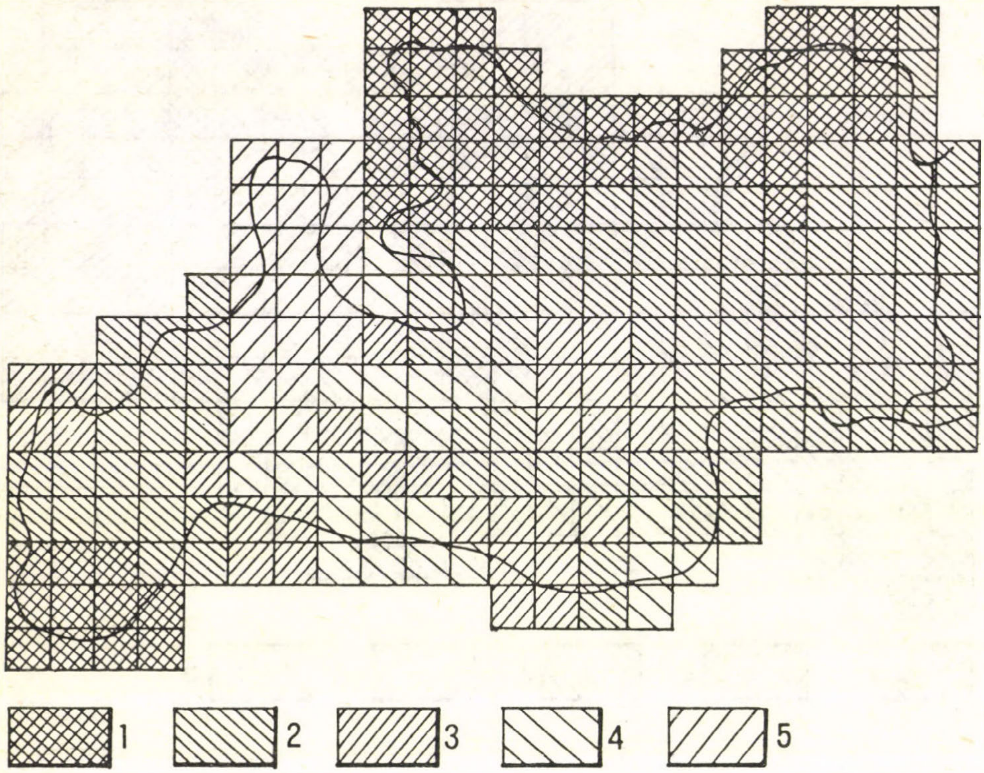

Fig. 2. Suitability prognosis of the test area for 1990 for growing grapes (Traminer) (by J. GALAMBOS 1986).

1= quality category - very favourable (The statistical probability of occurrence is above 75 %); 2= quality category - favourable (The statistical probability of occurrence is above 75 %); 3= quality category - less favourable (The statistical probability of occurrence is above 75 %); 4= quality category - moderately unfavourable (The statistical probability of occurrence is above 75 %); 5= quality category - unfavourable (The statistical probability of occurrence is above 75 %)

The agricultural charging or burdening of the environment is due to two basic conditions, like the quantity and quality of the polluting materials and the state and the specific dynamic features of the landscape.

These latter influence and control the possible charging and burdening of environment. Average data are not used when characterizing the changeable parameters of environment. The order and influence of environmental charging will be different in the different seasons, or in the cool-wet, cool-dry, warm-wet and warm-dry climatic year types, even though the amount of pollution is constant.

The differences in the interrelationship of the parameters are expressed by scores. The evaluation is run by a PC program and is carried on for three occasions with a county-size resolution in Hungary (Table 1). The resulting spatial and temporal distribution of the pollution emitted by agriculture reflects the areal differences and the improving porcesses due to social efforts (Figures 3, 4 and 5). Further checking evaluations are needed to make certain if these phenomena are momentary or stable, due to environmental protection activity of agriculture and land use.

APPLICATION

As a result, we can obtain an answer, the possible suitability value-range, for a freely chosen land use purpose such as growing plants, developing resort sites and nature conservation areas etc. We can also produce prognosis to estimate agricultural crops, recreational utilizations and the future environmental loading of the nature conservation sites. Since the latest data of the changeable factors of the data-base are continuously put into the system, it is suitable for monitoring the changes occurring in the environment, caused by either physical or technical effects. When applying it, we can actually monitor the dynamic changes in landscape potential. This information is very useful in local, regional or national decision making to develop a reasonable spatial structure of land use pattern.

As a result of the assessment of environmental burdening caused by economic branches (now agriculture), its specific spatial and temporal distribution can be detected.

The chronological performing of the assessment controls the efficiency of the measures applied in environmental protection and nature conservation. The method of the assessment is apt to detect the spatial and

Table 1 Environmental pollution caused by agriculture in Hungary (1975-1985) (by J. GALAMBOS 1989)

COUNTY	1975 SCORE	1975 QUALITY CAT.	1980 SCORE	1980 QUALITY CAT.	1985 SCORE	1985 QUALITY CAT.
1. Pest	278,1	3	304,3	4	251,6	3
2. Nógrád	49,9	1	64,5	1	57,8	1
3. Heves	131,6	2	124,0	2	129,9	2
4. Borsod-Abaúj	115,5	2	101,9	2	99,3	1
5. Szolnok	678,3	5	638,5	5	606,2	5
6. Hajdú-Bihar	1570,2	6	1220,9	6	1045,3	6
7. Szabolcs-Szatm.	293,4	3	250,5	3	237,6	3
8. Bács-Kiskun	364,4	4	304,7	4	258,3	3
9. Békés	3745,3!	6	3875,4!	6	2961,5!	6
10. Csongrád	645,1	5	636,1	5	632,8	5
11. Győr-Sopron	311,6	4	314,8	4	296,7	3
12. Komárom	201,1	3	164,1	2	212,6	3
13. Vas	141,9	2	152,7	2	168,9	2
14. Veszprém	284,9	3	293,6	3	282,4	3
15. Fejér	585,3	5	1032,2	6	950,8	6
16. Zala	104,6	2	59,9	1	71,5	1
17. Somogy	159,5	2	158,0	2	177,7	2
18. Baranya	288,7	3	252,7	3	269,9	3
19. Tolna	854,3	6	566,1	5	486,7	4
	563,7	6	552,5	5	482,7	4

CATEGORY

1 0 - 100: hardly polluting

2 101 - 200: slightly polluting

3 201 - 300: moderately polluting

4 301 - 500: strongly polluting

5 501 - 800: very strongly polluting

6 801 - - : seriously polluting

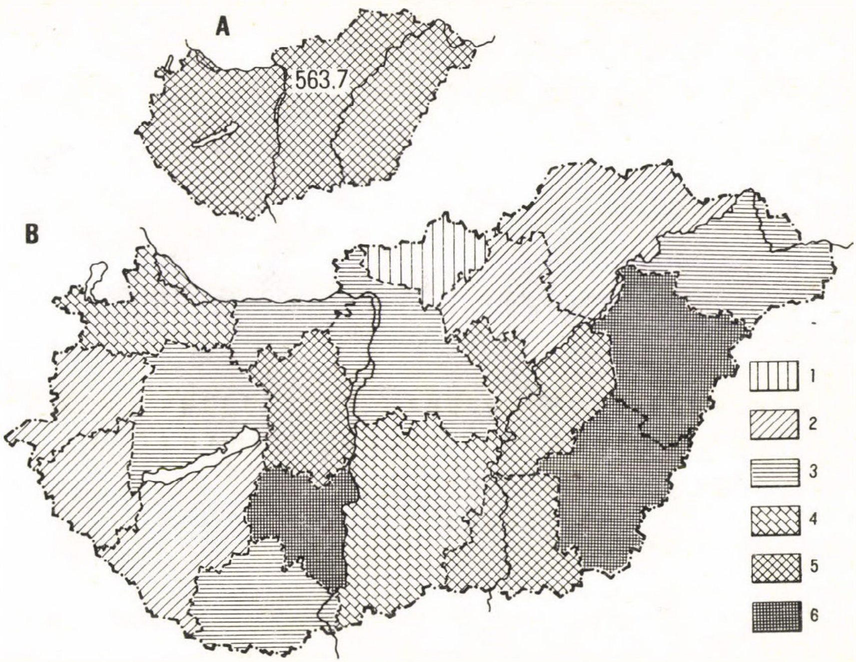

Fig. 3. Environmental pollution from agriculture in Hungary 1975 (by J. GALAMBOS 1989). - Map A: Average value in Hungary; Map B: Averages for the counties; Legend: 1= very weakly polluted; 2= weakly polluted; 3= moderately polluted; 4= strogly polluted; 5= very strongly polluted; 6= heavily polluted

temporal features of other environmental burdening caused by e.g. recreational or industrial activities. Therefore the general state of environment can also be assessed and observed or monitored.

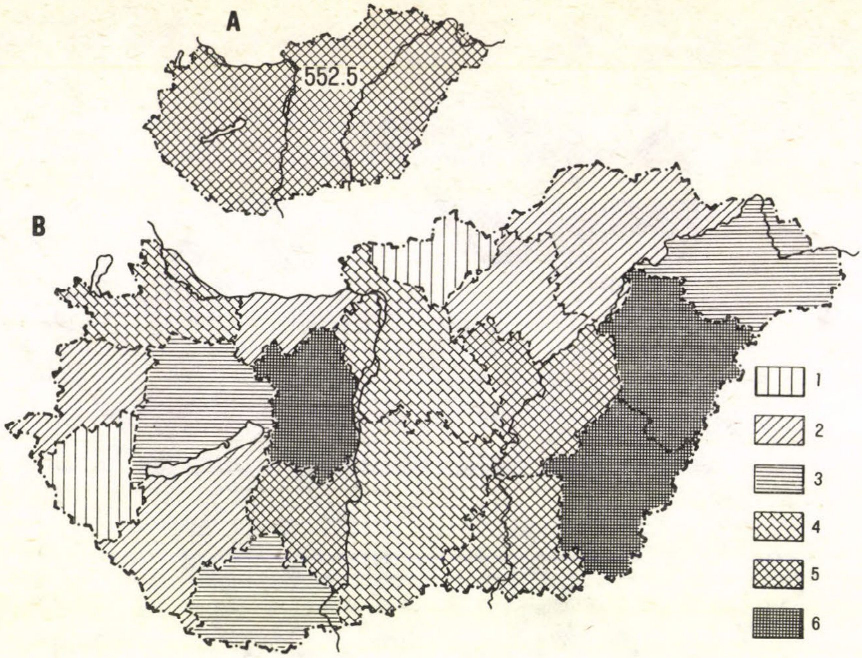

Fig. 4. Environmental pollution from agriculture in Hungary 1980 (by J. GALAMBOS 1989). - Map and legend: see Fig. 3.

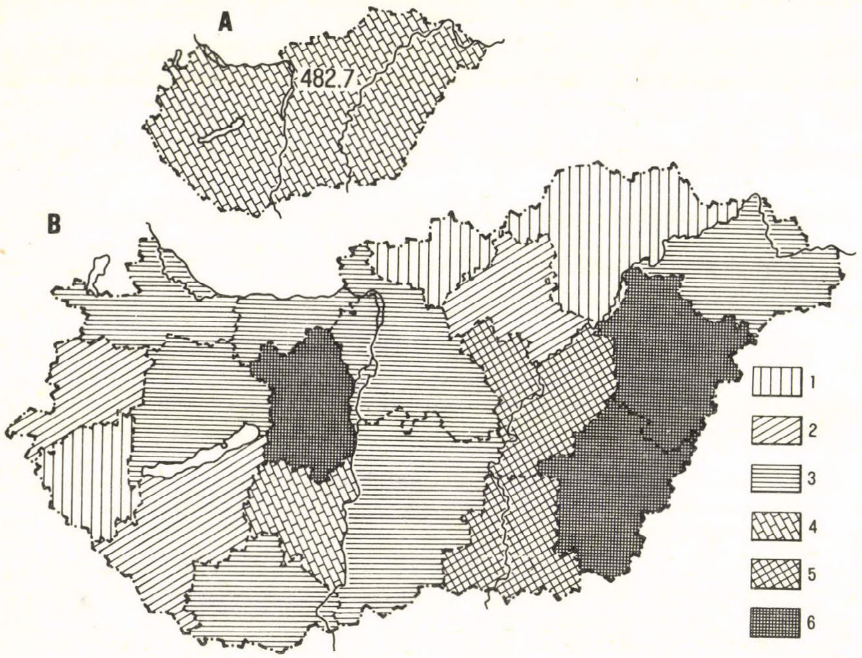

Fig. 5. Environmental pollution from agriculture in Hungary 1985 (by J. GALAMBOS 1989). - Map and legend: see Fig. 3.

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MICROCOMPUTER ASSISTED ECOLOGICAL FEASIBILITY STUDY OF LANDSCAPE TYPES

Á. KERTÉSZ - G. MEZŐSI

ABSTRACT

In our previous studies (MEZŐSI 1986, KERTÉSZ-MEZŐSI 1988) theoretical and methodological problems of a microcomputer assisted ecological feasibility study were examined in a hilly test area (Szuha valley, Borsod-Abaúj-Zemplén county, northern Hungary). In the present study a feasibility classification of the surface is given for the whole catchment area (Figure 1) from the point of view of maize production. Relationships between relief characteristics and land use types and between relief characteristics and crop rotation were evaluated as well. Maize was chosen since this is the most widespread crop in the area mostly because of economic, and not ecologic reasons. Our further objective was to investigate the interrelationships among landscape typological units, land use, the actual primary productivity and the feasibility scores gained in the course of the evaluation. Calculated potential and actual primary productivity of the typological landscape units were compared and the potential production corrected on the basis of soil characteristics was estimated. Suggestions for the best land use and crop rotation were elaborated based on the above mentioned calculations.

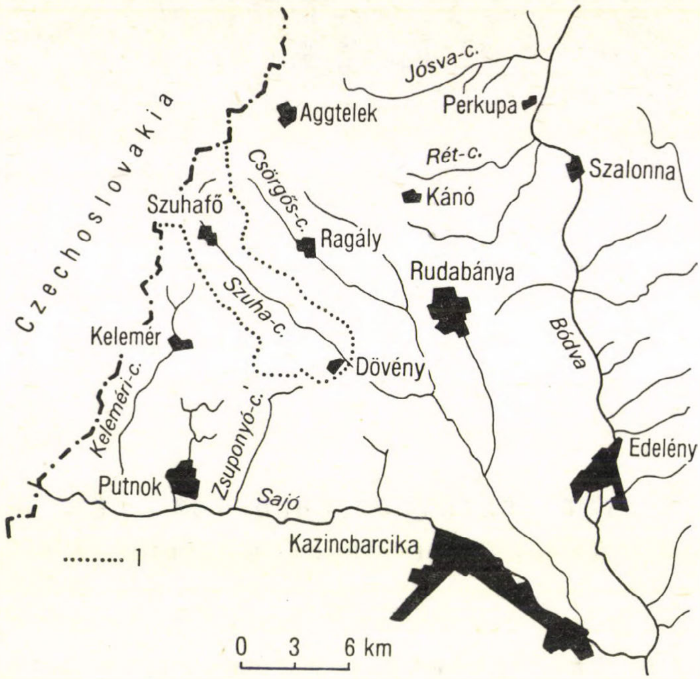

Fig. 1. Location of the test area. 1= catchment boundary (by G. MEZŐSI)

TEST AREA, DATA BASE

The test area of the Szuha valley catchment (5814 ha) stretches from NW to SE (see Figure 1). Our investigations concern only 2054 ha situated mainly in the central and southern part of the Szuha valley catchment, since we were interested in the evaluation of large scale farming agricultural areas ("agricultural land"). The most part of the remaining 3757 ha is forest.

Some private owned farmland belongs to the remaining 3757 ha as well ("non-agricultural land" in Figure 2). The latter category could not be included in our study due to lack of some of the necessary data (e.g. data on crop rotation, average crop production, etc.). Lands belonging to this latter category are of much better quality than the agricultural lands of the catchment.

The study area is built up from Tertiary sediments. The valley of the

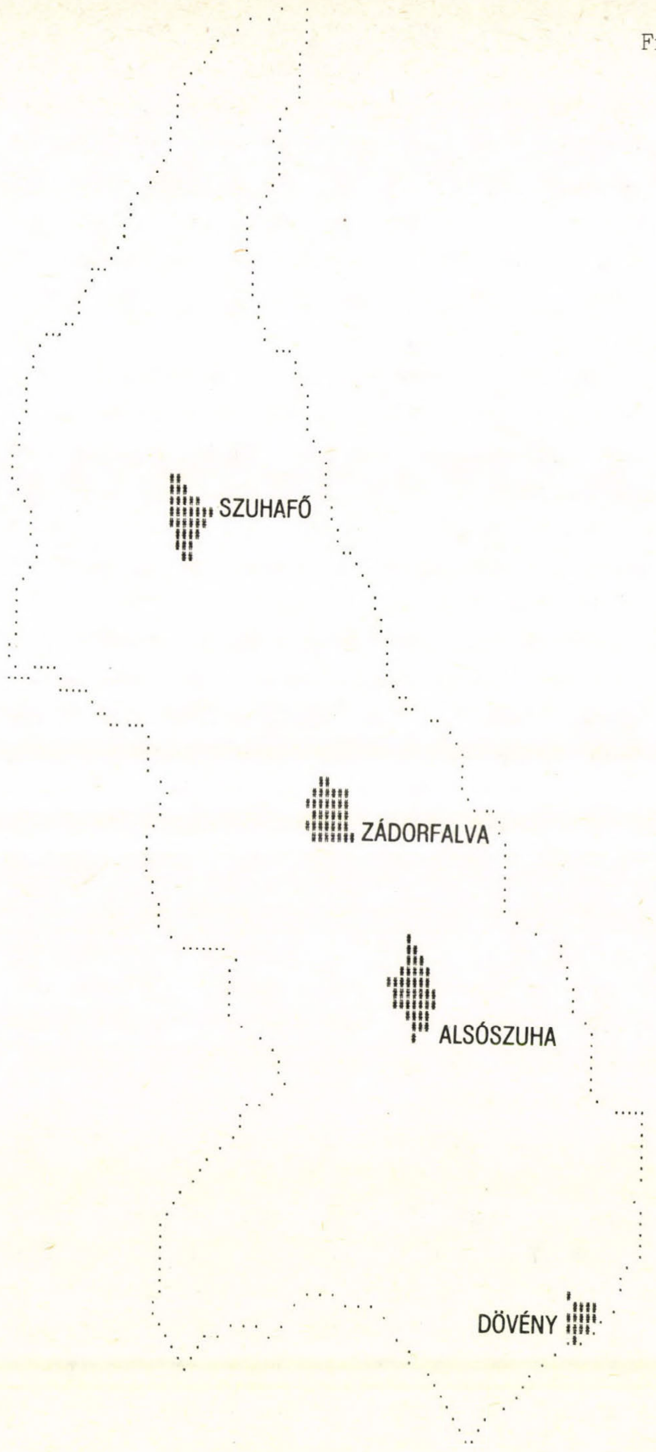

Fig. 2. The test area with its settlements (by G. MEZŐSI). ·····= boundary of the area; ıııı=settlements

Szuha-river is asymmetrical with several river terraces. The altitude varies between 180 m and 125 m a.s.l. (the higher values occur in N and SW of the catchment). Between SW and NE the divide runs on hilly plateaus. The valley side slopes in the NE parts are very steep with landslides or with the possibility of sliding. Slopes in SW are relatively long and gentle piedmont slopes with 2-3 cryoplanation terraces. The piedmont and terrace surfaces are dissected by erosional and derasional valleys and so they consist of several inter-valley ridges. More than 50 % of the catchment slopes are steeper than 18 % and about one third of the slopes have a gradient of only 0-4 % (Table 1 , 2). Most of the slopes (52 %) are exposed to N, NE and E. According to Figure 3 (Landscape types) slopes cover about 50 % of the catchment area whereas one sixth of it are piedmont surfaces, terraces and flood plains.

Figure 4 (Landuse map) was designed on the basis of 1986 data. Each grid cell of 1 ha was put into the category the precentage of which was the greatest in the grid cell. E.g. the real extention of outer zones of settlements comes to 73 ha, which is a bit more than the 70 ha taken into account in Figure 4. Infrastucture establishments (roads, railways, mines) are included in the category: "taken out from production". 35 % of the special category, "areas near water surfaces" are arable lands and 60 % of them are meadows and pastures.Half of the agr·cultural land is situated on floodplains, on terraces and on piedmont surfaces, whereas one third of them lies on hillslopes with a slope gradient of 12 %. Half of the agricultural land is arable land, one quarter are meadows and pastures. The soils are of low quality (with a land score of only 17,5), with a thin fertile horizon, slightly acidic (40 % of the soils have a pH value between 5,5-6,1), moderately cohesive (40 % of the soils have a saturation coefficient between 43-50). Brown forest soils are typical in the whole catchment, with a considerable loam and clay content.

Relief, climate and soil maps considered to be relevant and important were digitized and put in the database. Most of these data were directly available or could be taken from maps. In some cases, however, special programs must have been used. E.g. for the identification of regional differences in the values of monthly precipitation the application of an interpolation procedure was necessary based on the data of meteorological stations in the neighbourhood situated in different topographic positions, on the tendencies in horizontal precipitation changes and on short term

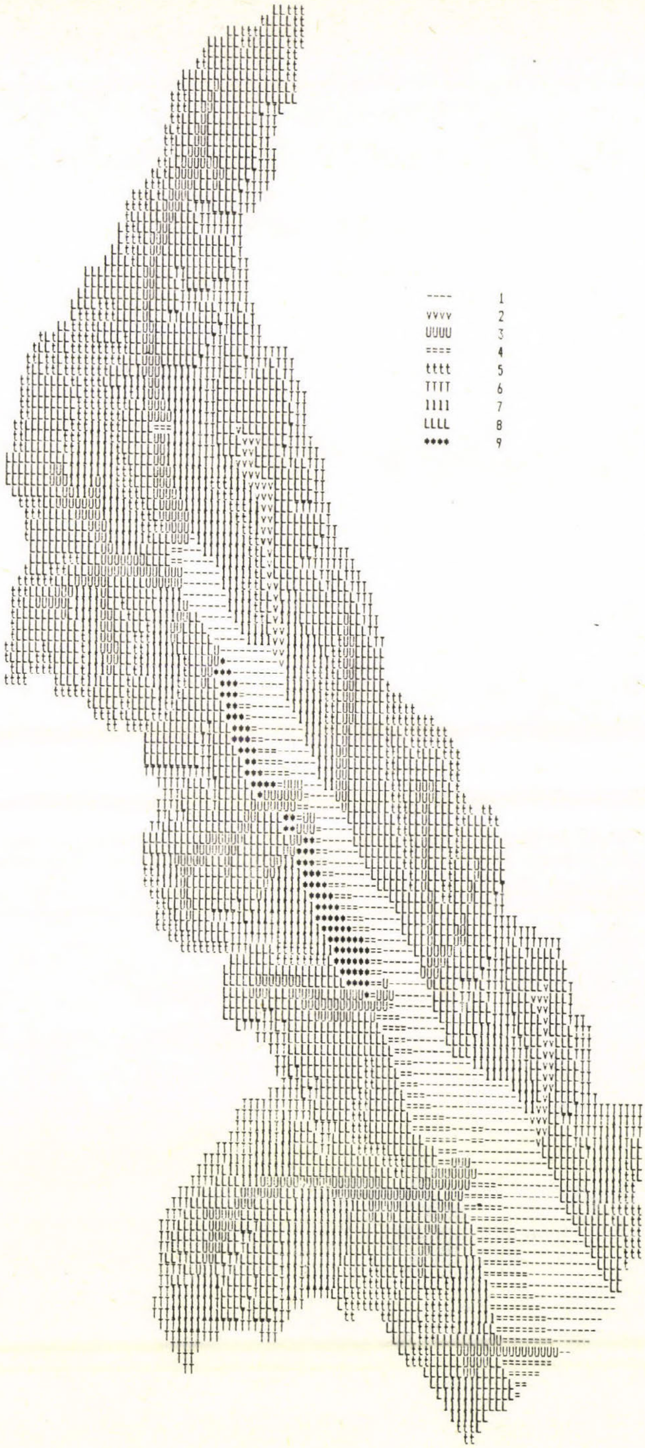

Fig. 3. Landscape typology map of the test area (by G. MEZŐSI).

1 = floodplains with meadow soils; 2 = floodplain valleys with grove and swamp vegetation; 3 = broad derasional and erosional-derasional valleys with meadow- and slope deposite soils, meadow and pasture; 4 = terraces with meadow and meadow chernozem soil type, oak and turkey oak forest; 5 = hilly plateaus and intervalley ridges on Tertiary sediments with lessivé brown forest soil and Ramann brown forest soil, originally covered with turkey-oak forest, today partly with agriculture; 6 = same as 5, only degraded; 7 = hillslopes (< 12 %) with brown forest soil, turkey-oak vegetation; 8 = loose deposits of sliding hillslopes and mountain slopes, with degraded turkey-oak vegetation, with eroded brown forest soils, dissected by erosional-derasional valleys; 9 = slightly dissected piedmont surfaces with meadow and slope deposit soils.

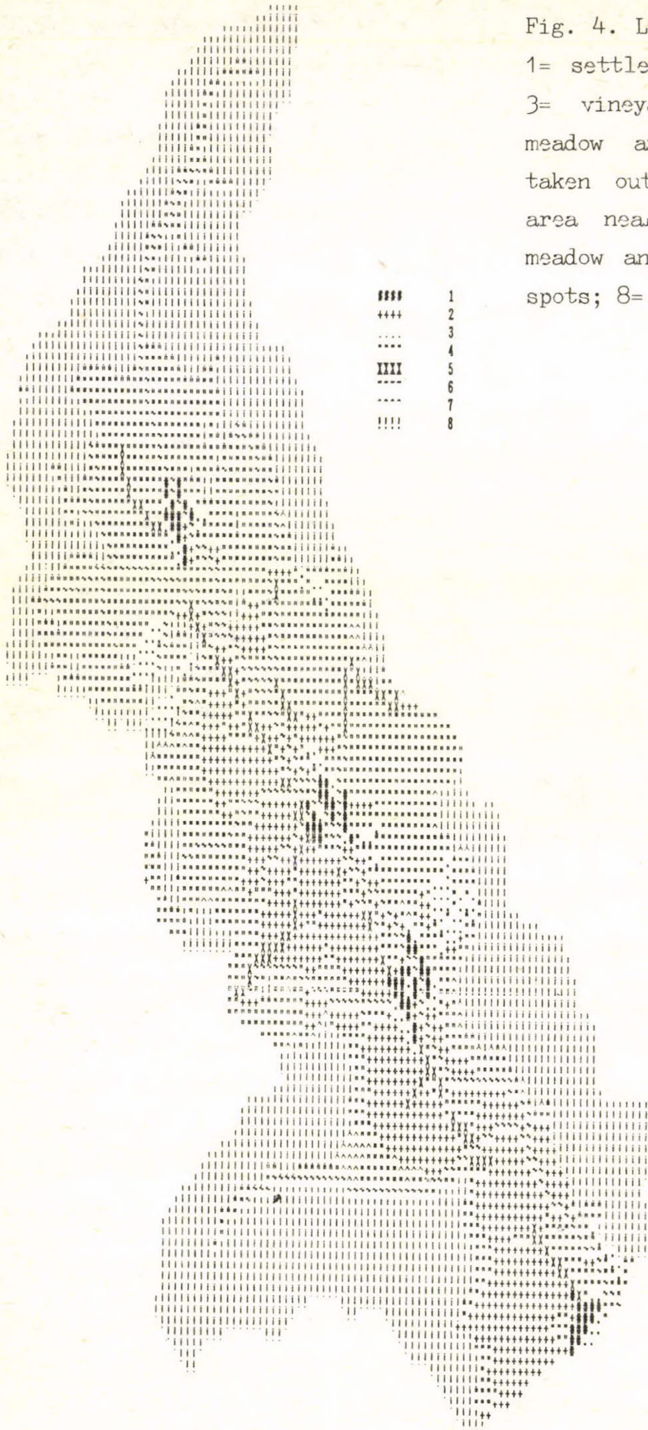

Fig. 4. Land use (by G. MEZŐSI). 1= settlement; 2= arable land; 3= vineyard and orchard; 4= meadow and pasture; 5= area taken out from production; 6= area near water surfaces; 7= meadow and pasture with forest spots; 8= forest

Table 1 Average slope angle and slope stability of agricultural lands (by G. MEZŐSI)

Land use	Area (ha)	Average slope angle (%)	Surfaces subjected to sliding (in % of the given land use type)	Surfaces with potential sliding hazard (in % of the given land use type)
1. settlements	50	12,49	-	-
2. arable land	799	12,26	0,8	1,3
3. gardens and vineyards	45	15,73	-	2,2
4. pasture and meadow	810	17,19	0,9	4,0
5. areas taken out from production	80	13,17	-	-
6. areas near water surfaces	197	12,12	-	0,5
7. pasture and meadow with forest spots	71	21,14	1,4	4,2

Table 2 Slope categories of different agricultural land use types (%)(by G. MEZŐSI)

Slope gradient category	arable land	areas near water surfaces	gardens and vineyards	pasture and meadow	pasture and meadow with forest spots
0–2	22,7	25,4	24,4	11,2	2,8
2–4	27,8	23,9	11,1	16,3	7,0
5–12	1,4	–	4,4	2,5	4,2
13–17	1,8	7,1	2,2	4,6	4,2
18–22	24,0	25,4	26,7	32,2	33,8
23–30	21,3	15,7	17,8	26,3	40,8
31<	1,1	2,5	13,3	6,9	7,0

microclimate measurements (Figure 5). The territorial distribution of monthly main temperatures was calculated in a similar way using the formula of PÉCZELY (1979) elaborated for the Carpatian basin and slightly modified for the area in question.

The county council of Borsod-Abauj-Zemplén county and the cooperatives owing farmland in the catchment gave us the 1:10 000 soil maps of the area. Land value scores (between 0-100) were calculated by the authors.

Some of the maps were generated by the applied programme itself, e.g. slope category, slope exposure maps, etc.. Land use, landscape typology and actual primary production maps, the latter based on the mean value calculated for the years 1983-86), complete the map series (Figure 6). Available data on fertilizers, amelioration and on income from agricultural production were also included in our investigations. Not all data were used for the above mentioned purposes, i.e. for the evaluation procedure. The rather broad data base enables us, however, to carry out quite a number of feasibility or natural hazard studies. Among others soil erosion hazard, the analysis of anthropogenic influences and the investigation of the recreation potential could easily be possible with the help of our data base.

METHODS

For the purposes of the ecological feasibility study of the area from the point of view of maize production 3 ecological factors, i.e relief, soils and climate, characterized by 14 parameters, were taken into account. In the course of our investigations ecological (site) requirements of maize were determined first followed by the elaboration of the weighted score system applied in the evaluation procedure. The evaluation procedure means the analysis of the ecological factors searching for an answer, why these factors and how well to approach the optimum. That is why the results, i.e the numbers on a scale between 1-100, do not only indicate the relative regional differences but they can be used as absolute values as well. Of course, this evaluation procedure contains a number of subjective elements too, but it enables the digital analysis and management of data, it is relatively quick and the registration of the parameter changes, for one parameter or for all together, is also possible.

Fig. 5. Mean precipitation in July (mm) (by G. MEZŐSI)

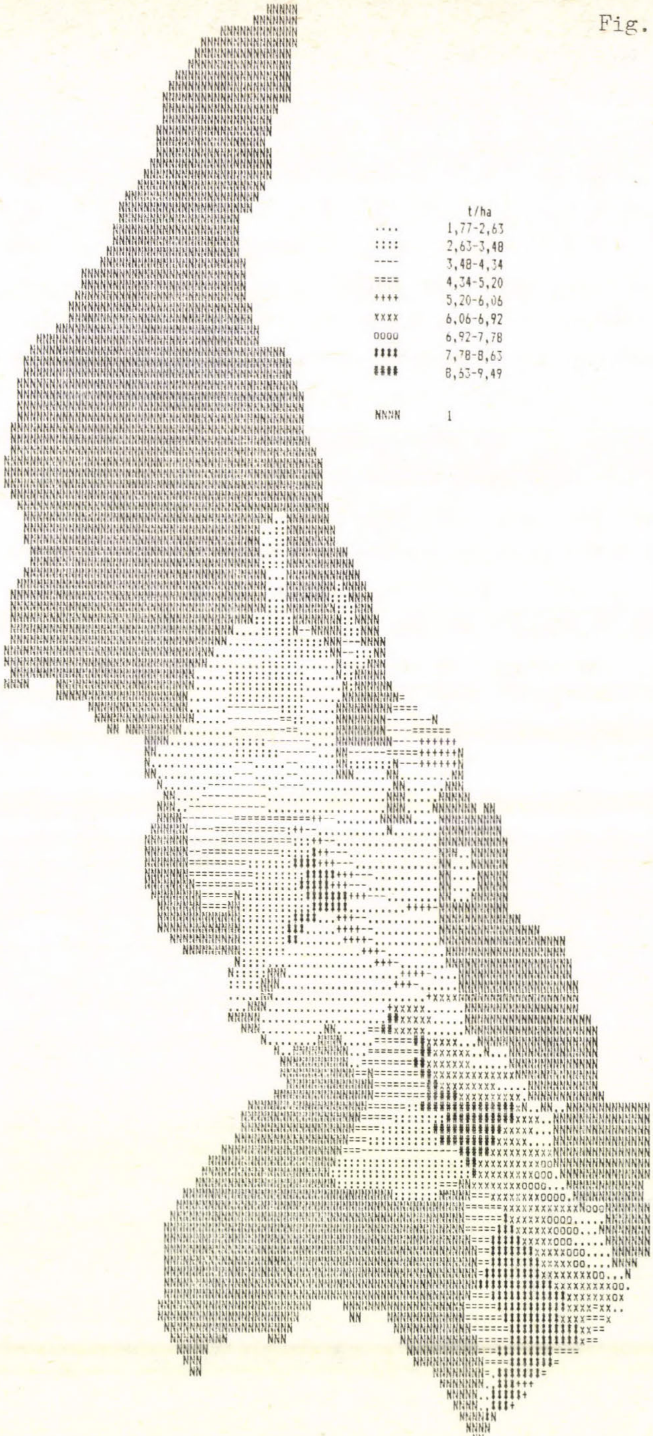

Fig. 6. Primary productivity (t/ha) (by G. MEZŐSI). - 1 = areas not used for agriculture

ECOLOGICAL CONDITIONS OF MAIZE PRODUCTION

The conditons of maize production and the territorial distribution of the amount of yield are controlled first of all by the climate. In Hungary the temperature influences the ripening of the crop and the precipitation controls its quantity. On the basis of correlation coefficients calculated between climatic factors and crop yield the following climatic requirements for maize production can be determined. Arid weather in April is favourable, especially in regions with high precipitation. The temperature does not play an important role in April, whilst in May both temperature and precipitation are very important. In June even more precipitation is wanted with a peak in July which decides the yield in Hungary. As far as temperature is concerned it can be said that in the case of a dry period a very warm weather can do considerable harm while it does not do any harm with enough precipitation. In August less precipitation is wanted if temperature is about the 50 years' average whereas much precipitation is necessary if the August is hot. The optimum values are summarized below (after BACSÓ 1963).

Temperature (^{0}C)

V	VI	VII	VIII	IX	Total quantity of heat
16.7	19.1	21.8	19.5	15.5	2880

Precipitation (mm)

V	VI	VII	VIII	IX	Total
80	75	86	96	54	391

To achieve a good yield the following series of weather conditions should be fulfilled:

1/ a lot of precipitation in July,
2/ high temperature in May,
3/ enough precipitation in August,
4/ enough precipitation in June preceeded by enough precipitation in May,
5/ not too high temperatures with a considerable amount of precipitation.

Soil requirements for maize production are as follows:

pH 5.5 - 7.0
saturation coefficent: 30- 50
Soil type: loamy soil.

EVALUATION PROCEDURE

In the course of the evaluation weighted scores (Table 3) and the land scores if fulfilled (Table 4) were multiplied and added for each grid cell of 1 ha. The MAP 2 GIS software, working with a grid system, was used, developed by the De Dorschkamp Institute (BERG, A. et al, 1985).

As we have already tried to use the MAP 2 software package (KERTÉSZ-MEZŐSI 1988) we attempted to answer the question to select the best land use type for a given area.

RESULTS

1. Site conditions of maize production in the Szuha valley catchment

Figure 7 shows the areal distribution of the feasibility land value numbers for agricultural land. The mean value of the land scores ranging between 35-72 is 56,6. Values above the average (63-72) are to be found on piedmont surfaces, terraces and on floodplains. More than 50 % of these areas are used today as arable lands, 25 % as meadow and pasture. Two thirds of the values near the average (51-62) can be detected on flood plains and on gentle slopes (with a gradient below 12 %), one sixth in the valleys. As for current land use, most of them (75 %) are arable land, meadow and pasture. Half of the slopes steeper than 12 % and a quarter of the slopes below 12 % have scores below the average (35-50). 75-80 % of the areas with low scores are meadows and pastures.

Table 5 shows the areal distribution of primary production and of the feasibility scores for different landscape typological units. Values of primary production above the average yield (4.29 t/ha) are due to the fact that both primary and secondary production were included in the calculation (FAZEKAS et al. 1983). The development of the most favourable crop stucture

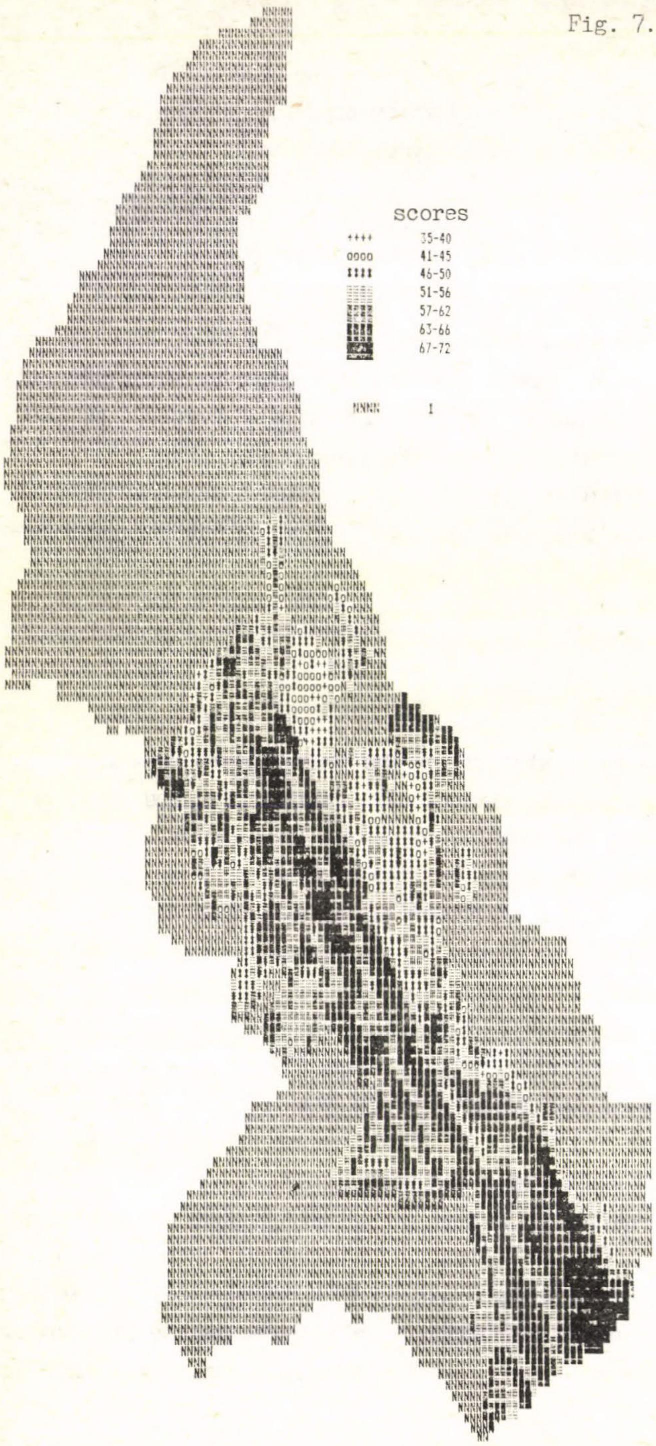

Fig. 7. Feasibility scores for maize production (by G. MEZŐSI). 1= areas not used for agriculture

Table 3 Weighted scores from the point of view of maize production (by Á. KERTÉSZ and G. MEZŐSI)

	Weighted scores
Climate:	55 scores
Precipitation:	35 "
1/ July	13 "
2/ August	9 "
3/ June	7 "
4/ May	6 "
Temperature:	20 "
5/ May	10 "
6/ August	5 "
7/ Total heat for the vegetation period	5 "
Soils:	30 scores
8/ cohesion	5 "
9/ thickness of fertile layer	9 "
10/ pH	4 "
11/ soil texture	7 "
12/ soil type	5 "
Relief:	15 scores
13/ slope category	9 "
14/ geomorphological processes	6 "

Table 4 Scores for different factors (by Á. KERTÉSZ and G. MEZŐSI)

1/ Precipitation in July	mm	scores
optimum: 86 mm- 13 scores	94–97	11
	90–93	12
	86–89	13
	82–85	12
	78–81	11
	74–77	10
	70–73	9
	66–69	8
2/ Precipitation in August		
optimum: 96 mm-9 scores	94–97	9
	90–93	8
	86–89	7
	82–85	6
	78–81	5
	74–77	4
	70–73	3
	66–69	2
	61–65	1
3/ Precipitation in June		
optimum: 75 mm-7 scores	89–92	3
	85–88	4
	81–84	5
	77–80	6
	73–76	7
	69–72	6
	65–68	5
4/ Precipitation in May		scores
optimum: 80 mm-6 points	78–81	6
	74–77	5
	70–73	4
	66–69	3
	62–65	2
5/ Mean temperature in May	°C	
optimum: 16.7 °C-10 points	16.2–17.1	10
	15.2–16.1	9
	14.2–15.1	8
	13.2–14.1	7
	12.2–13.1	6
6/ Mean temperature in August		
optimum: 19.5 °C-5 points	19.0–19.9	5
	18.0–18.9	4
	17.0–17.9	3
	16.0–16.9	2
	15.0–15.9	1

Table 4 (cont.)

		scores
7/ Total heat for the vegetation period		
optimum: 2880-5 points	2870-2939	5
	2800-2869	4
	2730-2799	3
	2650-2729	2
	2580-2649	1
8/ Saturation coefficient		
optimum: 30-50 - 5 points	38-42	4
	43-50	5
	51-58	3
	59-66	2
	67	1
9/ Thickness of the fertile layer	thickness of fertile layer (cm) humus content (%)	
maximum: 9 points	50 cm, 3 %	7
	40-50 cm, 3 %	6
	40-50 cm, 1,5-3 %	5
	40-50 cm, 0.5-1.5 %	5
	30-40 cm, 1.5 %	4
	20-30 cm, 3 %	3
	20-30 cm, 1.5-3 %	2
	20-30 cm, 0.5-1.5 %	2
	10-20 cm, 1,5 %	1

Table 5 Primary productivity and potential scores of landscape ecological units (by Á. KERTÉSZ and G. MEZŐSI)

Landscape ecological units [x]	Area (ha)	Contribution %	Actual primary productivity	Feasibility scores
1	507	24.7	5.31	59.2
2	25	1.2	2.65	52.3
3	192	9.3	3.45	57.5
4	227	11.0	6.30	60.9
5 + 6	162	7.9	3.15	55.7
7	175	8.5	3.59	51.7
8	670	32.6	3.28	53.6
9	99	4.8	5.03	61.6

[x] see Figure 3

and the most favourable agriculturaal utilization of an area does not absolutely mean a maximum primary production far above the potential productivity in spite of a preference system advantageous for crops with high primary productivity. It seems to be much more important, especially in regions with poor ecological conditions like the test area, to develop a crop structure better adjusted to the ecological conditions and based e.g. on industrial plants assuring the biggest net income. The results of our investigations can be considered authentic since they inform about the productivity of a landscape typological unit. The authenticity is guaranteed by relatively homogenous crop structure during the investigation period and by the significant correlation between plant production referred to fields and net income.

The question of the convertibility and confidence of the results should be asked as well. To answer this question and to test the method we started control investigations in the Bódva-valley (SZENDRŐ basin) and in the Sajó-valley (in the vicinity of Putnok and Serényfalva). The following conclusions can be drawn from the first results of these investigations.

a/ Landscape typological units controlling the functioning of the landscape should be exactly defined with leading parameters (MEZŐSI, G. 1986).

b/ Difference between actual and calculated primary productivity is less than 20 % in the control area except on floodplains and on slopes steeper than 12 %.

c/ The production capacity of landscape typological units for different plants can be given considerably well in the case of bigger landscape units.

Table 6 gives a good evidence on the good correlation between calculated potential scores and primary productivity. The correlation is somewhat looser on piedmont surfaces and on floodplains. The high values of potential scores do not bring high primary productivity with them.

Feasibility and primary productivity values of agricultural lands are shown in Table 7 for each land use type. Areas near water surfaces are to be considered the best reserves offering a more intensive utilization of the areas after water regulation. Areas taken out from production have a relatively high production value. This can be explained as follows. In the course of data input each grid cell was put into this category if one third of its area was occupied by roads, railways, etc..

Table 6 Primary productivity of areas with different potential scores (by Á. KERTÉSZ and G. MEZŐSI)

Potential score	Area (ha)	Primary productivity (± 0.43 t/ha)
35–40	33	2.54
41–45	93	2.92
46–50	306	3.02
51–56	636	4.02
57–62	407	4.42
63–66	458	5.10
67–72	121	5.22

Table 7 Feasibility and primary productivity scores for different landuse types (by Á. KERTÉSZ and G. MEZŐSI)

	Area (ha)	Area (%)	Feasibility scores	Primary productivity (t/ha)
Settlements	55	2.7	58.4	4.38
arable land	799	38.8	59.1	4.98
gardens and vineyards	45	2.2	55.9	3.69
pasture and meadow	810	39.4	53.8	3.53
areas taken out from production[x]	80	4.9	58.2	4.91
areas near water surfaces	197	8.6	58.2	3.81
pasture and meadow with forest spots	71	3.4	53.4	2.99
not used by large-scale farming (mainly forest)	3757	–	–	–

[x] e.g. public road, mining area

2. Defining areas with critical ecological conditions for maize production

In the course of the investigations the question was asked whether in the case of any ecological factor (relief, climate, soil) maize production would be impossible. Figure 8 shows those agricultural lands where relief (see e.g. sliding slopes > 18 %). Half of the arable land is situated on slopes > 12 % (Figure 9) where approx. on 12 ha no tillage would be possible

Fig. 8. Agricultural areas where relief characteristics exclude maize production (by G. MEZŐSI). 1= excluded areas; 2= boundary of the area

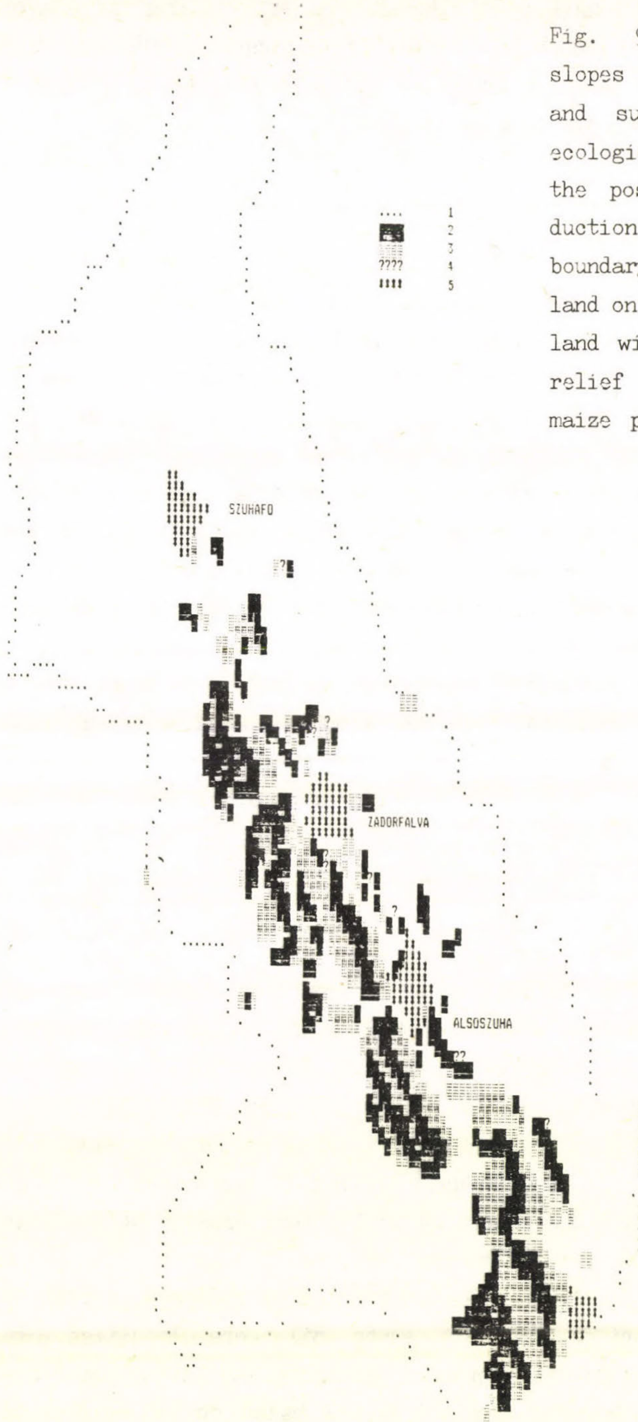

Fig. 9. Arable lands with slopes > 12 % and < 12 % and such arable lands where ecologic conditions exclude the possibility of maize production (by G. MEZŐSI). 1= boundary of the area; 2= arable land on slopes 12 %; 3= arable land with slopes 12 %; 4= relief characteristics exclude maize production; 5= settlement

due to unfavourable relief conditions. These areas are utilized as arable lands in spite of the bad ecological conditions because of the economic preference system. Figure 10 shows areas not suitable for plant production on arable lands because of poor soil conditions.

3. Assessment of primary productivity

In the course of our investigations we attempted to assess the production capacity of different soil types as well. It is a rather delicate problem since differences between ANPP and $ANPP^x$ are not only the consequences of the not perfect methods but they indicate also agrotechnical, technological, agrochemical differences. The rather unimportant agrotechnical differences enabled the application of the Moss-Davis method (1982).

The investigation of the net primary production (NPP) is one of the most important tasks of ecology since the material and the energy potentially available for heterotrophs are concerned here. It is much easier to assess NPP than GPP as the latter requires data on the intensity of photosynthesis and on active radiation. Assessments of NPP go on since over 2 decades. Most of them are empirical formulae using the measurable relationship between climate parameters and ANPP. The "Miami model" (Lieth-Box 1972-' Thornthwaite Memorial Model') is applied for regional investigations:

$$p= 3000\ (1-e^{-0,0009695\ CE-20}),$$

where p= NPP (g/m^2/year, or t/100 ha/year),
E= actual evapotranspiration. It must be emphasized that the model is suitable for only bigger regions with an actual evapotranspiration ranging between 200 and 700 mm. The exact determination of actual evapotranspiration depending on the moisture content of the air, on temperature, soil moisture, vegetation cover etc. requires a network of measurement stations. For quite a number of localities in Hungary these data are available (VARGA-HASZONITS 1977). Actual evapotranspiration in the test area is 346 mm/year and the average value of NPP is 8,13 t/ha.

Regional differences in NPP can be concluded from different fertility characteristics of the surface. For this reason soils were classified into 7 classes taking into account the degree of hindering the agricultural activity. It follows the Canadian classification based on relief (slope

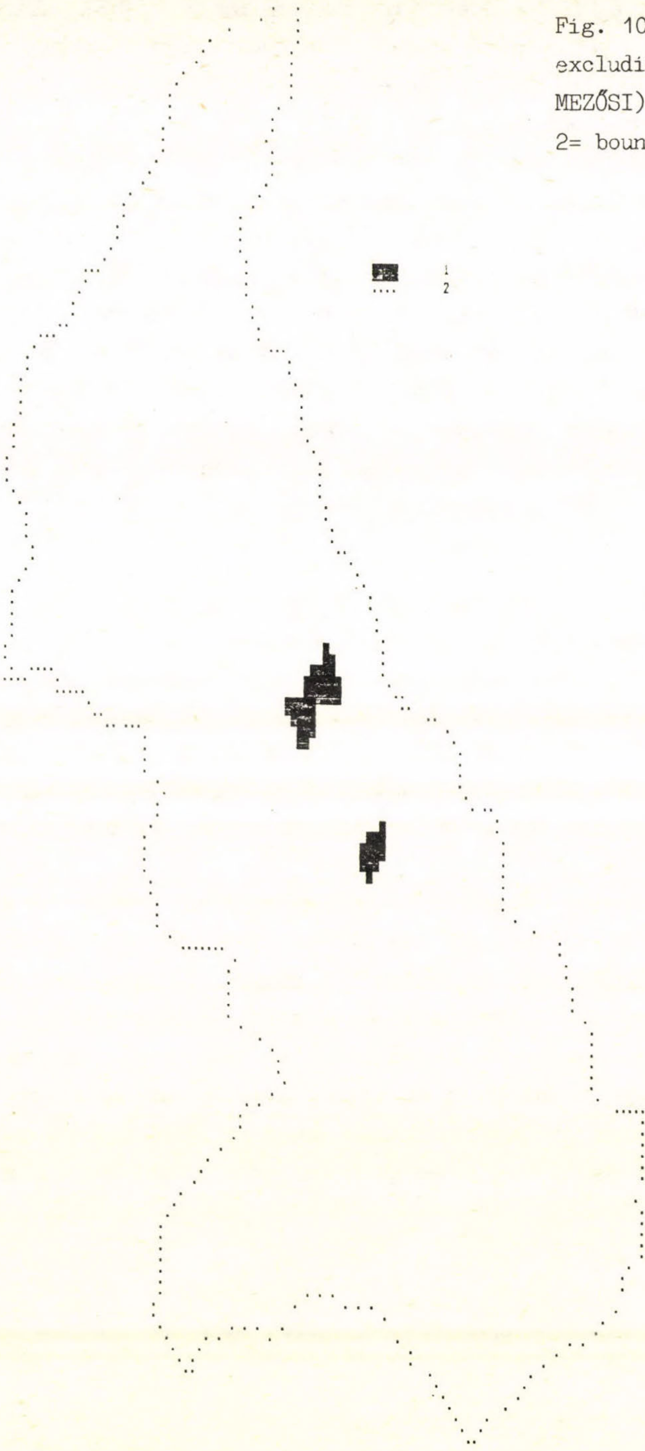

Fig. 10. Very low quality soils excluding crop production (by G. MEZŐSI). - 1= areas in question; 2= boundary of the area

angle) and on climatic factors. The system is very similar to the FAO site classification system (LQ_5). Category I includes areas with optimal ecologic conditions without any hindering factors whereas category VII includes areas not suitable for agricultural activity.

The categories were characterized by the constant of Anderson-Hoffmann (in: Moss-Davis 1982), the values of which for each category are as follows: I-1,00; II-0,80; III-0,66; IV-0,58; V-0,49; VI-0,48; VII-0,48. The cartogram shown in Figure 11 ($ANPP^x$) was constructed by multiplying these constants and the value of NPP for each grid cell. Table 8 contains the comparison of the actual (ANPP) and the estimated ($ANPP^x$) values of primary production. Applying the results for landscape typological units it can be condluded that the floodplains, terraces and piedmont planes have values above the average (4,5 t/ha) whilst the values calculated for slopes and erosional valleys are below the average (3,8 t/ha).

4. Suggestions for the alternative utilization of the area

It is not enough to consider only ecological data and aspects when suggesting the best utilization of an area. Therefore we make suggestions only for those areas where instead of the actual utilizations another kind of utilization could be advised but we do not analyse wether the best crop structure is applied.

Figure 12 shows the areal distribution of agricultural areas where forestry could be suggested instead of the recent land use type. These territories with steep slopes have low potential scores. In the case of arable lands with poor ecological conditions an alternative land use, i.e. pasture and meadow could be suggested. In a similar way, pasture and meadow with good conditions should be utilized as arable land (Figure 13). Performing the feasibility study on the territories where no large-scale farming is introduced at the moment some sites with very good conditions could be found (Figure 14).

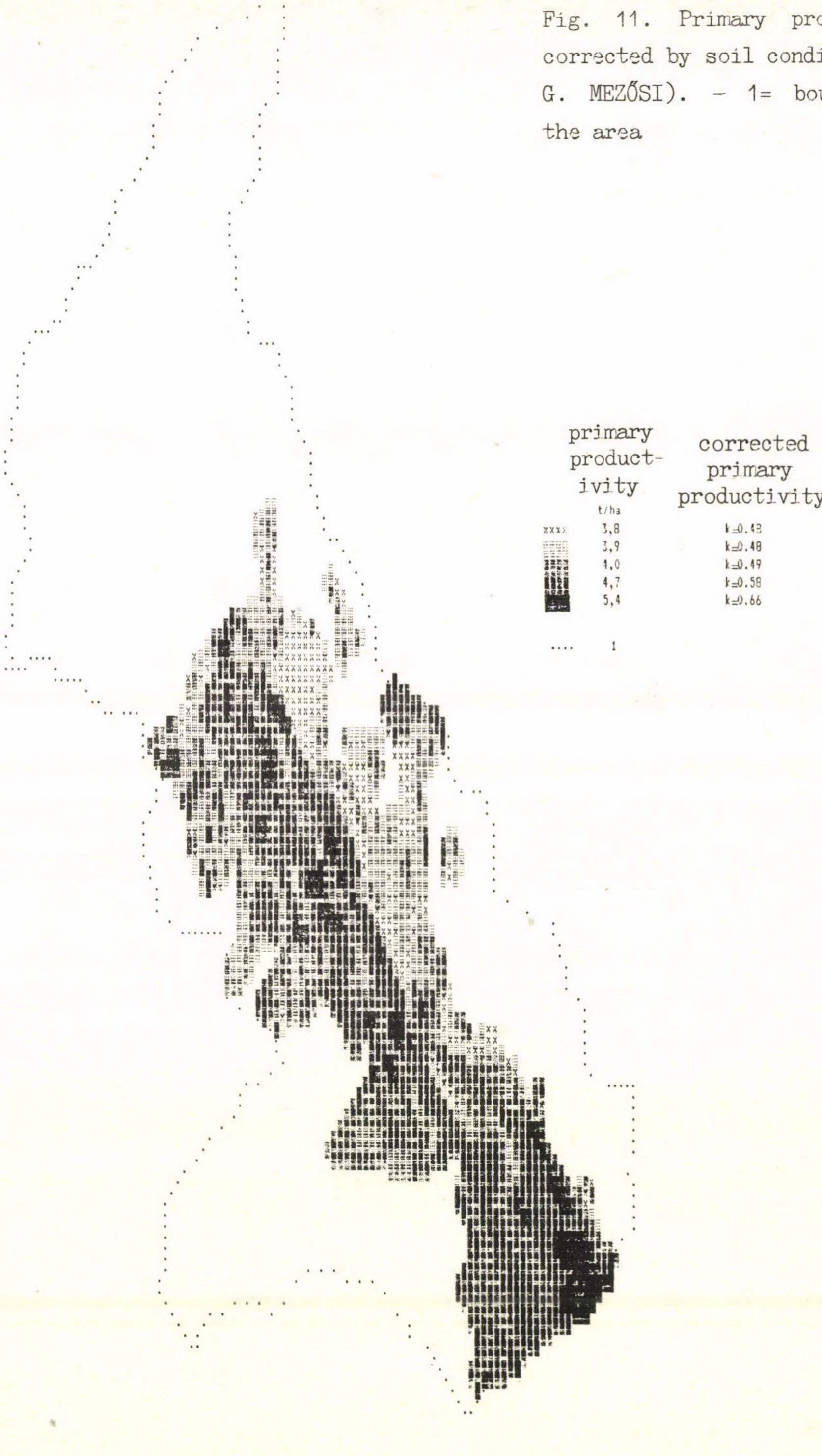

Fig. 11. Primary productivity corrected by soil conditions (by G. MEZŐSI). – 1= boundary of the area

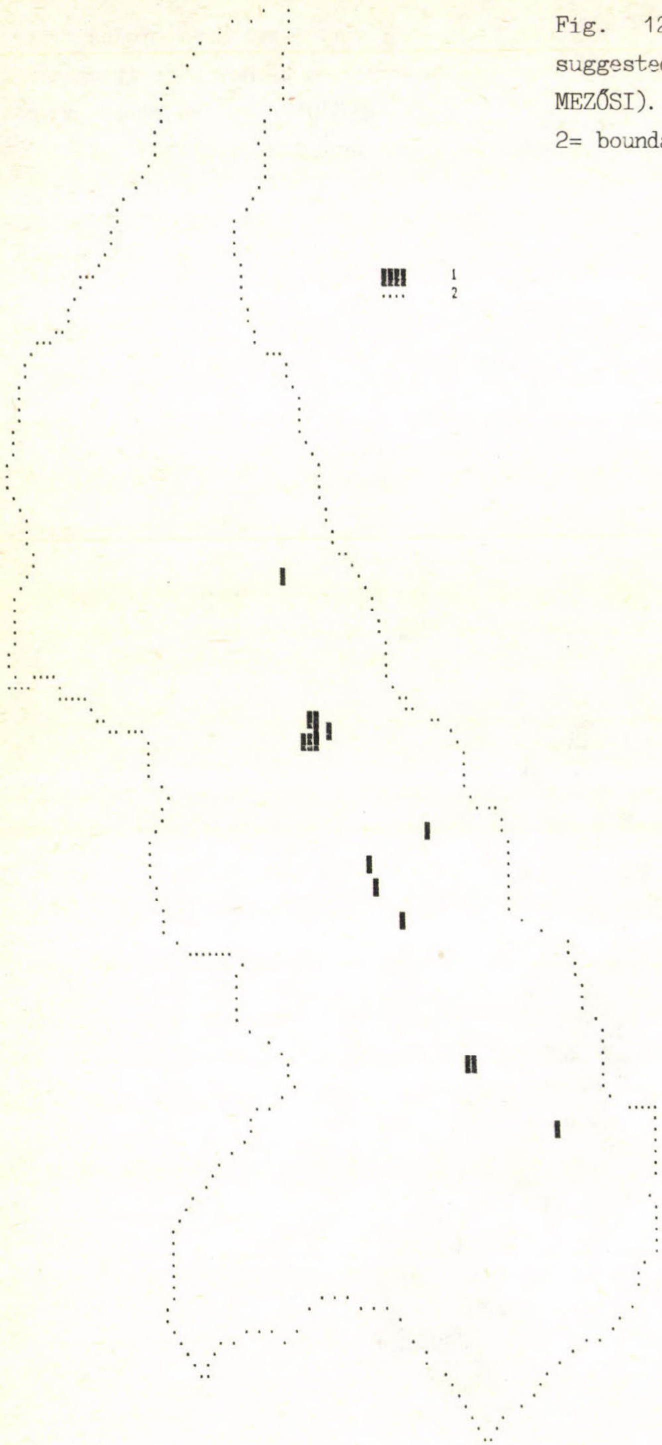

Fig. 12. Agricultural lands suggested for forestry (by G. MEZŐSI). - 1= suggested areas; 2= boundary of the area

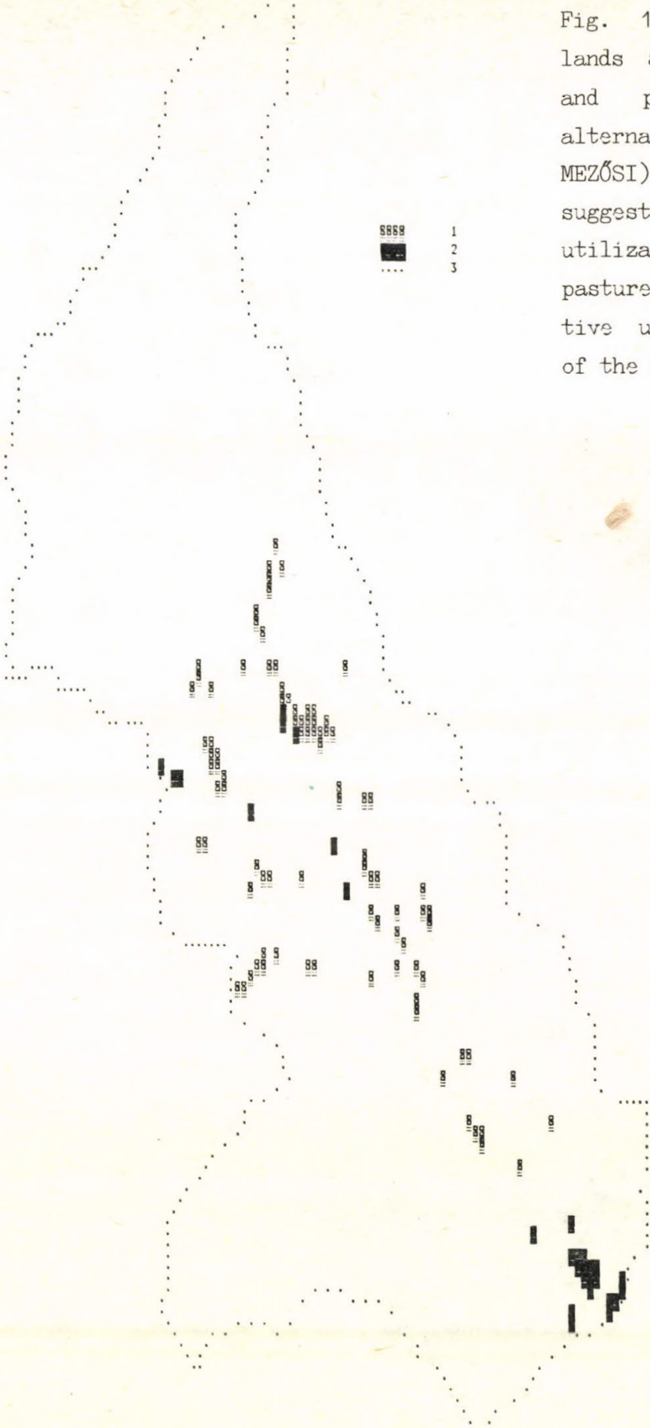

Fig. 13. Low quality arable lands and good quality meadow and pasture suggested for alternative utilization (by. G. MEZŐSI). – 1= arable land suggested for alternative utilization; 2= meadow and pasture suggested for alternative utilization; 3= boundary of the area

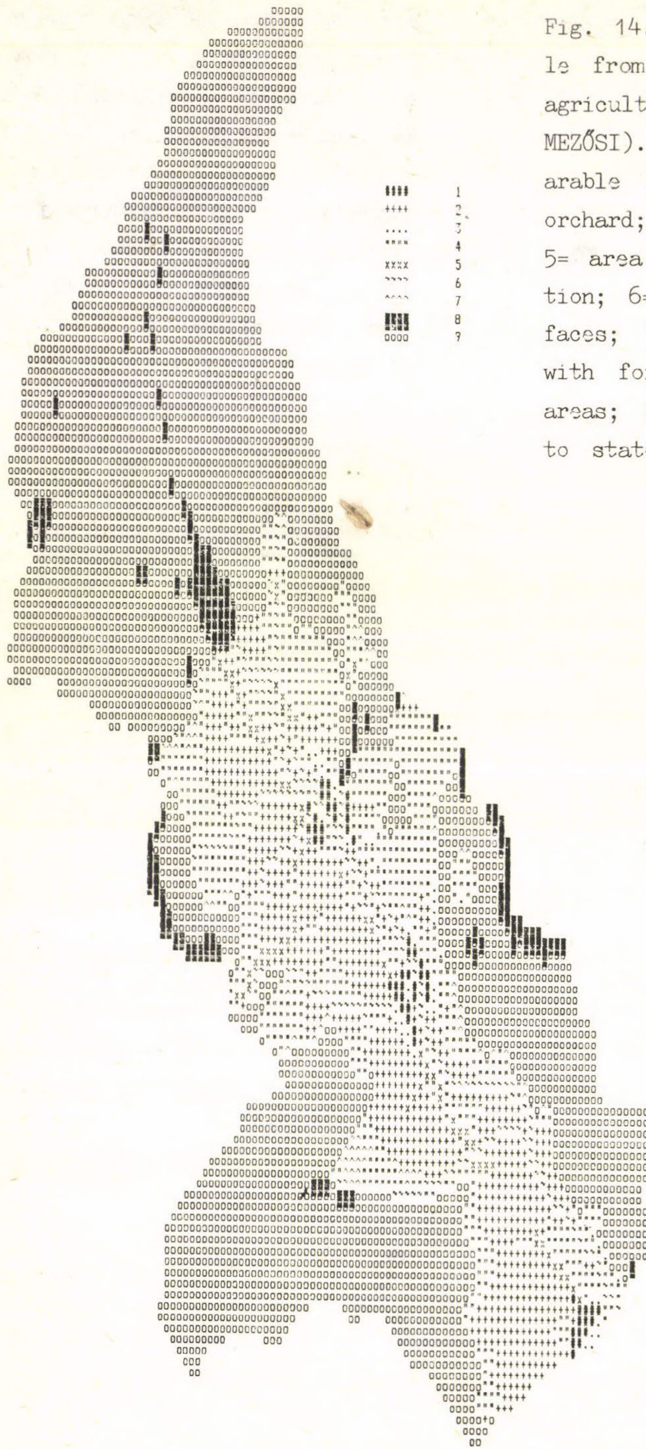

Fig. 14. Reserve areas suitable from ecological aspect for agricultural utilization (by G. MEZŐSI). - 1= settlement; 2= arable land; 3= vineyard and orchard; 4= meadow and pasture; 5= area taken out from prduction; 6= area near water surfaces; 7= meadow and pasture with forest spots; 8= reserve areas; 9= area not belonging to state farms, mostly forest

Table 8 Potential scores, primary productivity (ANPP) and corrected primary productivity (ANPP^x) for different soil types (by G. MEZŐSI)

	Area (ha)	Potential scores	ANPP (t/ha)	ANPP^x (t/ha)
acidic non podzolic brown forest soil	1085	54,84	4,91^x	4,16
lessivé brown forest soil	202	57,89	3,42	4,30
Ramann's brown forest soil	168	61,62	4,36	4,49
slope deposit soil	602	57,71	4,56	4,28

^{x} with high standard deviation

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MICROCLIMATIC MEASUREMENTS IN THE COMPLEX LANDSCAPE RESEARCH

S. MAROSI

ABSTRACT

The author emphasizes the importance of topo- and microclimatic measurements in complex landscape-typological investigations and in defining the ecological units. The test area selected for landscape typological investigations is situated S of Lake Balaton. The definition of the agroecological units reflecting various natural ecological and anthropogenic influences is based on data on temperature, evaporation and wind, collected every hour at seven measurement stations, on four levels along the cross-section of a N-S directed valley. After defining surfaces covered and not covered with vegetation a further differentiation was carried out based on slope exposure, lithology, morphology, soils and on ground water level, especially in low lying geotopes with cooler and wetter microclimatic conditions. The definition of agroecotops with different conditions enabled us to propose different land use types for different conditions.

INTRODUCTION

More than a quarter of a century ago, when elaborating principles and methods of landscape assessment (MAROSI, S. - SZILÁRD, J. 1963, p. 412), concrete measurements on local and microclimate were suggested. Micro- and topoclimatologic investigations jointly with complex geotopologic research were applied in representative test fields over different landscape types. This microclimatologic approach was aimed at making landscape research and landscape typology a more exact discipline and, at the same time, was considered as a contribution to applied landscape research. Each evaluation as a result of the investigations ended with a summary of land use proposals (JAKUCS, P. - MAROSI, S. - SZILÁRD, J. 1963, 1964, 1967, 1968, 1971; MAROSI, S. - PAPP, S. - SZILÁRD, J. 1973; MAROSI, S. 1980).

Goals to be accomplished in the course of these investigations were to reveal interrelationships of several physico-geographical factors reflected in microclimate, to identify and compare microspaces (microclimatopes) with different relief, exposure, lithology (parent rock), soils, thermal balance and moisture regime, vegetation and regularities of microclimatic conditions. The regularities related to various reprezentative sites can be extended to area of the same type by analogy (PÉCSI, M. - SOMOGYI, S. - JAKUCS, P. 1972, MAROSI, S. - SZILÁRD, J. 1975).

The contribution presented below is associated with the agroecological investigations carried out in the area of the Enying largescale farm situated southwards from the Lake Balaton in the west stripe of the Mezőföld and summarized on a series of thematic maps which contain 14 sheets at a scale of 1:10 000 (GÓCZÁN, L. - MAROSI, S. - SZILÁRD, J. 1972).

The area investigated is crossed by a stream (Kabóka- or Csíkgát-patak) running in NNW-SSE direction. Stations for microclimatic measurements were set along its cross-section. In addition to those mentioned above, note of thanks are due to KAJUCS, P., HAHN, GY. and PAPP, S. who were also participating in the measurements. The tasks of the analysis and evaluation of results within this work of a wider content, scale and complexity were undertaken by the author.

GEOGRAPHICAL ENVIRONMENT OF THE TEST FIELD

As a result of subsidence of Berhida Basin situated between Transdanubian Mid-Mountains and the Mezőföld, in the Kabóka Valley - which used to be longer than nowadays - a divide was formed at village Küngös during the Late Pleistocene. Presently, there is only a short section of valley towards Berhida Basin to the north while the stream Kabóka still flows to the south as a remnant of the initial valley of NW-SE direction (Figure 1). However this unit was also affected by the subsidence of the Tikacs flat; the stream can only hardly flow even in regulated channel on its surface:

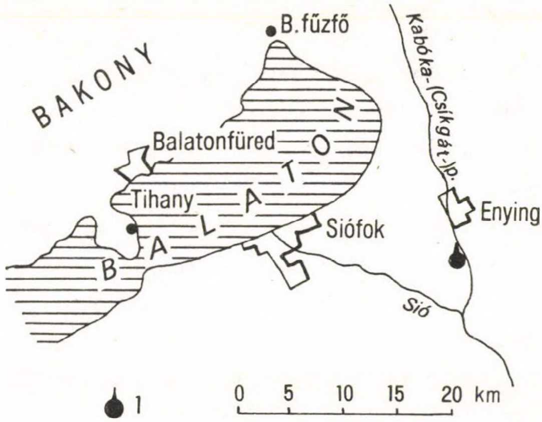

Fig. 1. Location of the test field for microclimatic measurements (1) and its wider surroundings (by S. MAROSI)

before water regulation a swamp was formed here and simultaneously an intensive filling up occurred (SZILÁRD, J. 1967).

After leaving the Tikacs flat the Kabóka Valley proceeds in the direction of the test field cutting relatively deep (from Enying the stream is called Csíkgát-patak) and reaches the Sió Valley southwards from the area investigated. The Sió Valley as drainage of Lake Balaton in its present, deeply cut configuration of a wide alluvial valley was formed in the Late Pleistocene, as a result of tectonic movements and erosion processes.

1. In the vicinity of the test field and the lowland-plain **surface** of the West Mezőföld fluvial processes and alluvial fan formation played an outstanding role. During the Quaternary, fluvial sediments: fine grained sandy material and flood-plain alluvium, depending on discharge and topography, were deposited; of them, under dry periglacial climatic conditons wind-blown sand accumulated in several places.

The fluvial material, exposed Pannonian sand and dust of remote origin in arid and cold periglacial climatic circumstances partly underwent loess formation. This, however, was hindered by fluvial and sheet wash processes and became possible only by the Late Pleistocene, after development of present-day drainage network and deepening the valleys. This explains why the loess mantle of the West Mezőföld and that of the test field is thin and scanty. Formation of a thick loess cover was also hindered by periglacial derasion and deflation processes responsible for surface denudation of this relatively elevated area.

2. **Relief and slope conditions.** The test area is a poorly dissected flat surface situated between 135 and 160 m a.s.l. (in the microclimatic section the aluvial plain of Kabóka lies at an altitude of 106 m a.s.l.). Moderate dissection is a result of recent processes of derasion and deflation. The hollows and flats of the surroundings can partly be attributed to man-made impact, primarily land cultivation.

3. Although apart from Kabóka no permanent watercourse can be found in the area **drainage** as a factor of soil formation has played an important role. Unconfined ground water makes both a direct and indirect impact, early spring waterlogging in hollows of poor drainage has a minor influence on soils.

4. From a **climatic** viewpoint the test area is considered as a part of the Great Plain (Alföld) with a moderately warm and dry weather and mild winter.

The annual total of sunshine hours is 2000-2100 hours. The sunshine hours of the growing season (April-September) amount to 1450-1500 hours. The annual number of clear days (cloud cover $<$20 per cent) is 70-90, and that of cloudy days (cloud cover $>$80 per cent) is 80-100, there are 20-30 foggy days on the average. Annual mean temperature is 10.0-10.5 ^{0}C; main air temperature during the growing season of spring cereals (March-June) 12.5-13.0 ^{0}C and that for root crops (April-September) 17.0-17.5 ^{0}C. The mean date of first air frost is between 25 and 31 October and that of last frost between 10 and 15 April. The frost-free period lasts usually 190-200 days.

Annual precipitation amounts to 550-600 mm (at Enying: 561 mm); main rainfall during the growing season of spring cereals is 200-225 mm, and that for root crops 300-350 mm. Annual potential evapotranspiration totals 680-700 mm. Annual number of days with snowfall amounts to 15-20, that of with snow cover 30-35. Average thickness of snow cover is 7-8 cm. Northwesterly winds are prevailing.

Apart from a relatively low amount of precipitation its uneven distribution motivates irrigation.

5. The climatic conditions under which genetic types of **soils** were formed, basically differed from the present-day situation. Although under na-

tural conditions the Mezőföld as a whole belonged to the **forest-steppe zone**, the westernmost margin studied here - prior to land cultivation - neighboured with steppe, and there was a strong impact of the latter. A clear evidence for this are steppe-like brown forest soils, chernozems with forest remnants, and chernozem brown forest soils. As a consequence of land cultivation after forest clearance an aridization of soil climate started and former brown forest soils acquired chernozem features.

6. Under **man-made impact** also the semihydromorphic soils have shifted towards chernozem dynamics. Other anthropogenic features are soil erosion from slightly dissected but seasonally bare lands and accumulation of this material on flats.

Among man-made transformations and accelerated geomorphic processes can be mentioned, apart from general planation, that the earlier long and gentle slopes are being reshaped - as a result of denudation-accumulation interactions - into horizons of flat marginal steps.

GENERAL CHARACTERISTICS OF THE MICROCLIMATIC SECTION AND EVALUATION OF THE RESULTS OF MEASUREMENTS

A microclimatic section was set in the Kabóka (Csíkgát) Valley, across the most dissected part of the complex test field. Block diagram (Figure 2a) shows relief dissection and slope configuration; vegetation is reflected on Figure 2b.

Station 1. 10 per cent gentle slope segment of eastern aspect, arable land. Altitude: 121 m a.s.l. Soil: pseudomyceliar chernozem with thin humous horizon, developed on loess (see: Soil profile 1, Station 2). No ground water was detected in the profile.

Station 2. 10 per cent gentle slope segments of eastern aspect, maize. Altitude: 121 m a.s.l. Soil: pseudomyceliar chernozem with thin humous horizon, developed on loess (Soil profile 1). No ground water observed through the profile. Vegetation: corn maize of 1.20 m height, 30 per cent coverage.

Station 3. 15 per cent slope of east-southern aspect, elder shrub with acacia. Altitude: 108 m a.s.l. Soil: meadow chernozem covered by slope sediments. Vegetation: 25 per cent canopy coverage of acacia and 100 per cent by shrub horizon. Grass coverage amounts to 15-20 per cent. Main species

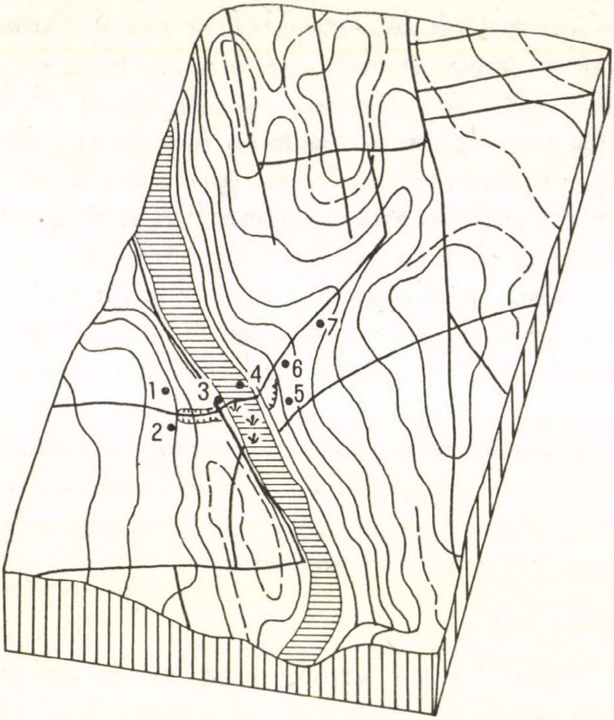

Fig. 2a. Block-diagram of the test field located across the Kabóka (Csík-gát)-patak (stream)(by S. MAROSI). Valley with the location of stations of measurements. For the explanation of stations 1-7 see Figure 3.

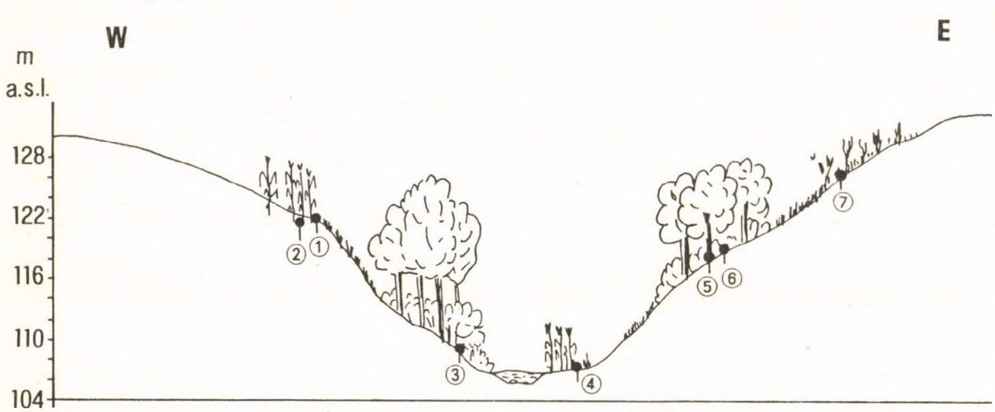

Fig. 2b. Cross-section of the test field located across the Kabóka Valley with the location of stations and vegetation cover (by S. MAROSI). For the explanation of stations 1-7 see Figure 3.

occurring in the complex: Robinia pseudo-acacia, Sambucus nigra, Galium aparine, Torilis japonica, Prunus spinosa, Crataegus monogyna, Chaerophyllum bulbosum, Euphorbia cyparissias.

Station 4. Valley bottom swamp meadow. Altitude: 106 m a.s.l. Depth of ground water level: 0,5 m. Vegetation: narrow margin of high sedged swamp meadow along the lakeside reed. Grass is cut down, 20 cm high. Coverage: 100 per cent for the grass horizon and 80 per cent for the cut high sedged meadow horizon. Identified species: Carex acutiformis, Agrostis alba, Alopecurus pratensis, Symphytum officinale, Caltha palustris.

Station 5. 20 per cent slope of western aspect, arable land. Altitude: 117 m a.s.l. Soil: anthropogenic soil (artificial filling on an eroded surface) of embrionic chernozem dynamics developed on loess (see Soil profile 2). No ground water detected in the profile.

Station 6. 30 per cent slope of west-southwestern aspect, acacia forest. Altitude: 117 m a.s.l. Soil: pseudomyceliar chernozem developed on loess, covered by slope sediment. Vegetation: forest of 20-25 years. Canopy coverage amounts to 70 per cent, shrub horizon - 35-40 per cent, grass horizon - 20 per cent. Species: Robinia pseudo-acacia, Cheliodonium majus, Euphorbia cyparissias, Gallium aparine, Chaerophyllum bulbosum.

Station 7. 40 per cent slope of west-northwestern aspect, abandoned vineyard. Altitude: 125 m a.s.l. Soil: heavily eroded cultivated chernozem developed on loess. Vegetation: weeds. Species: Melilotus officinalis, Daucus carota, Ononis spinosa, Lavatera thuringiaca, Andropogon ischaemum.

*

Soil profile 1

Description

Location: 8-10 per cent valley slope segment of eastern aspect

Vegetation: corn-maize

Depth of profile: 115 cm

Thickness of humous horizon: 45 cm

Soil type: pseudomyceliar chernozem with thin humous horizon, developed on loess

Genetic horizon	Depth cm	
A_{sz1}	0–15	10 Yr 3/2, loam. In dry state blocky, when wet polyhedral, crumbling due to cultivation impact. $CaCO_3$ ++
A_{sz2}	15–32	More compact loam 10 YR 3/2. Crumbling into polyhedra, in nests small crumbs. Humous veneer over the surface of structural elements. Dense rooting. $CaCO_3$ ++—+++
(B)	32–45	Lighter, slightly variegated loam (krotovinas filled with C horizon material). Loose small crumbs, slightly pseudomyceliar. $CaCO_3$++++
(B) C_1	45–70	Variegated, spotted, pseudomyceliar loessy loam lighter to bottom. Crumbling into small aggregates. Vertical animal burrows of the thickness of a finger. Lower level of fine root zones $CaCO_3$++++
C	100–(115)	Pale yellow loess with lime veins. Krotovinas. $CaCO_3$++++

General analyses (analysed in the Laboratory of Geogr. Res. Inst.)

Depth, cm	pH H_2O	pH KCL	$CaCO_3$ per cent	hy_1 per cent	Saturation coeff.	Humus content per cent
0–15	7,6	7,6	6,0	2,18	54	3,23
15–32	7,6	7,6	9,4	1,77	51	3,23
32–45	7,9	7,7	17,6	1,72	52	1,72
45–70	8,0	7,8	21,0	1,77	53	1,29
70–100						
100–115	8,2	8,0	24,4	1,10	39	0,22

Grain size composition (analysed in the Laboratory of Geogr. Res. Inst.)

Depth cm	<0,002	0,002–0,005	0,005–0,01	0,01–0,02	0,02–0,05	0,05–0,25	0,25–0,5	>0,5
0–15	13,7	11,9	4,3	12,4	31,4	25,3	0,3	0,7
15–32	18,9	8,9	5,8	12,5	30,7	22,5	–	–
32–45	19,3	10,2	5,1	8,4	33,0	22,9	0,2	–
45–70	20,77	10,6	4,2	7,6	30,9	26,2	0,5	–
100–115	17,29	6,14	5,99	5,45	37,16	28,05	–	–

Soil profile 2

Description

Location: 20 per cent valley slope of western aspect, 5 m above the alluvium of Kabóka stream and 6 m lower than the top level. There is a 10-20 per cent slope in northwestern direction, towards a dell (side-valley of Kabóka). In the very neighbourhood 20-25 cm deeply ploughed land frequently contains material of C horizon (loess) on the soil surface.

Vegetation: ploughed land

Depth of profile: 100 cm

Thickness of the humous layer: 70 cm

Soil type: artificial filling on an eroded surface, today soil of embrionic chernozem dynamics developed on loess

Genetic horizon	Depth cm	
A_{sz}	0-30	10 YR 3/2 loam. Blocky, crumbling in aggregates reflecting the impact of cultivation when pressed, ploughed in maize roots and stalks. $CaCO_3$+++
A_{k1}	30-50	Greyish brown, loose sandy loam without structure. Remnants of bricks and charcoal. Very light A horizon material, evenly slightly humic C horizon material in small spots, the impact of cultivation. $CaCO_3$ ++-+++
A_{k2}	50-70	Same colour, C horizon material in spots of egg or nut size, very loose, light, crumbling sandy loam. Brick and charcoal remnants. The former are oriented horizontally mostly in the same direction in C horizon material. The lower boundary is distinct. $CaCO_3$++++
C	70-(100)	Pale yellow very fine-grained loess. Some vertical humous-filled animal burrows of human finger thickness. Some lime veins. Undisturbed horizon $CaCO_3$++++

Horizon C shows analogies with parent rock D as a sign of denudation which had affected the initial genetic soil type, even in its C horizon.

*

Measurements lasted one day in August (started on 25th at 19.00 and finished on 26th at 18.00) and were carried out in each hour. The microclimatic features of a calm, late summer day were registered. Irradiation and emission were not affected by cloudiness, development of microclimate was not perturbed by the breeze that arose during daytime. Clouds only appeared in the last hour and data related to this time interval were not taken into consideration. This by no means affects the reliability and completeness of measurement series, which can be used in comparing values for various horizons of several microclimatopes and determining similarities and differences among them.

Measurements were carried out at four levels (in soil at a 5 cm depth; on the surface; at 20 cm and 1 metre height above surface) as for temperature; at two levels (20 cm, 1 metre) for evapotranspiration and at one level (1 m) for wind measurements.

Evaluation of data presented by figures 3-8 is found below.

Temperature

In soil at a 5 cm depth (Figure 3a). The most balanced temperature regime was registered in the shrub (Station 3): between 15.2 ^{o}C and 16.3 ^{o}C, i.e. 1.1 ^{o}C oscillation, but the fluctuation also showed low values for the swamp meadow (Station 4) and acacia forest (Station 6): 2 to 4 ^{o}C with relatively low absolute values (16.2 to 20.2 ^{o}C). Comparing these two stations, despite a more moisted surrounding, extreme maximum and minimum values were registered for Station 4; in this respect acacia with a closer stand was more moderate.

Both maximum and minimum values in this horizon were registered at Station 7 with a steep angle of slope loosely covered by domesticated plants. Stations 1 and 5 with bare surface testify on a relatively extreme daily regime; high values of fluctuation can be attributed to an intensive irradiance and emission.

Variations between the corresponding values for these two stations were caused by the difference in aspect and slope angle.

A transitional type from balanced microtopes to those with extreme values is represented by the climate of the corn-maize field.

It follows that in the upper soil layers temperature regime is primarily determined by the vegetation cover and modified by other factors.

Soil surface (Figure 3b) is a horizon with most extreme temperature regime. Daily fluctuations for the two arable fields (Stations 1 and 5) show similar features (25 to 26 ^{o}C) but both the maxima and minima are lower for Station 5 (Station 5: 6.9 ^{o}C--32.9 ^{o}C; Station 1: 9.9 ^{o}C--33.6 ^{o}C) which is explained by the aspect and slope angle.

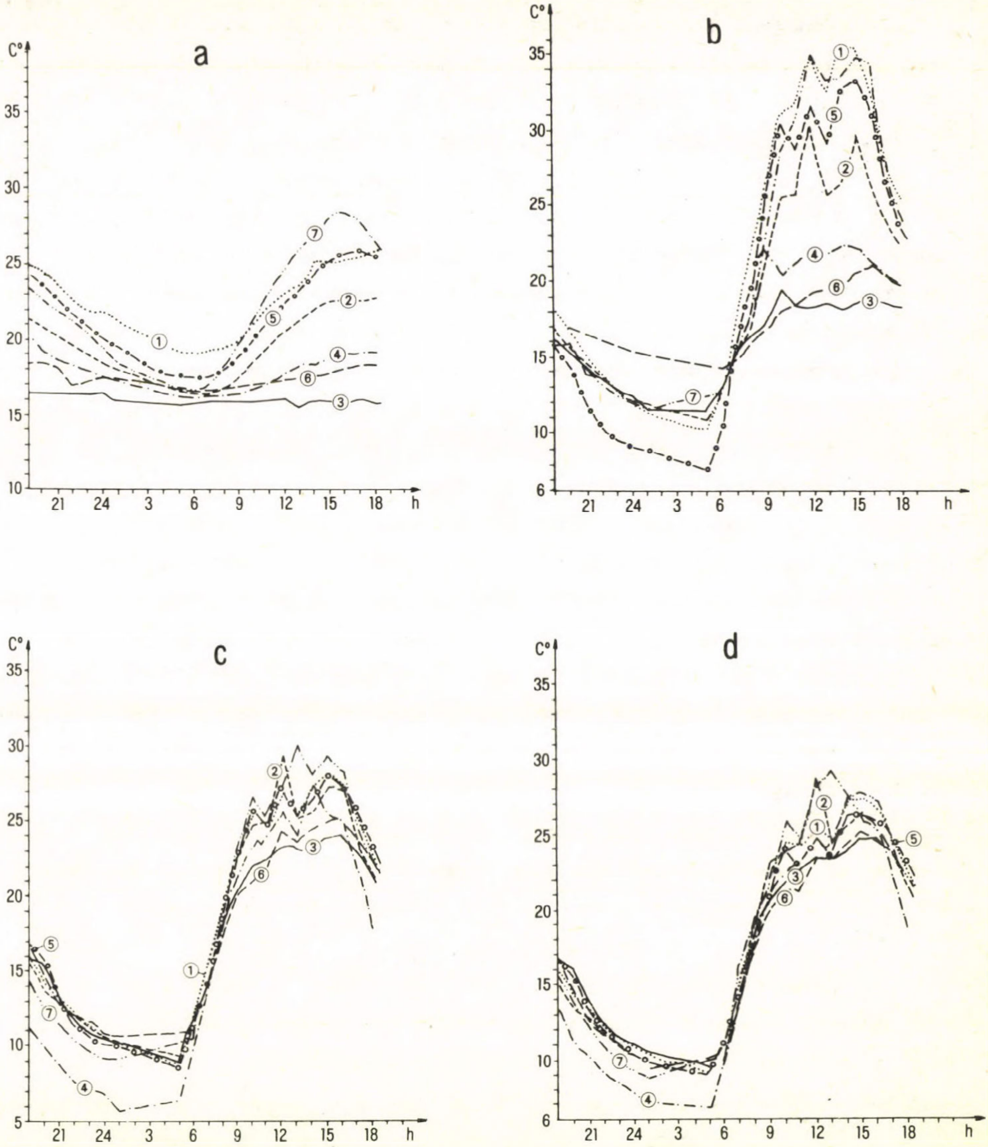

Fig. 3. Temperature regime in soil at 0–5 cm depth (a), on the surface (b), at 20 cm height (c) and at 1 m height (d) from 25 August 19.00 till 26 August 18.00 (by S. MAROSI). Stations: 1= arable land (slope of eastern aspect); 2= corn maize; 3= shrub; 4= swamp meadow; 5= arable land (slope of western aspect); 6= acacia forest; 7= abandoned vineyard

The most balanced temperature regime for the soil surface was registered for the two forest stands but with substantially higher minimum and lower maximum values (Station 3: 11.2 ^{o}C--19.2 ^{o}C; Station 6: 13.8 ^{o}C--21.7 ^{o}C) which is associated with the vegetation coverage.

The absolute maximum during the whole series of measurements was observed at Station 1 (35.1 ^{o}C) but Station 7 is represented by a similar maximum (34,7 ^{o}C). Within this horizon, to the extreme type belongs the sparse stand of the corn-maize field while the swamp meadow shows a more balanced regime.

20 cm above surface (Figure 3c). The absolute minimum during the series was registered in this horizon, for the swamp meadow (4.3 ^{o}C) as a result of the stream of cool air descending from the valley sides. Also the daily fluctuation showed here the highest value (21.6 ^{o}C) which is explained by an intensive warming-up in this active layer. The highest warming-up in this layer was registered for Station 7 (29.8 ^{o}C). Even for the forest-shrub (Stations 3 and 6) with the most balanced temperature household daily fluctuation value reached 14.6 ^{o}C. Of these, Station 3 represented the lower values as both minimum and maximum are concerned (with 1.1 ^{o}C). Conspicuously, in this layer the corn-maize - owing to its sparse stand - showed similarities with bare surfaces whereas the swamp meadow with forest and shrub stations.

It is very typical that average temperatures measured at different stations show convergency within this layer (Figure 4) while e.g. on the soil surface daily average differed by 7 ^{o}C between Stations 3 and 7 (15.7 ^{o}C--22.7 ^{o}C), at the 20 cm height it decreased to 1.8 ^{o}C (17.4 ^{o}C--19.2 ^{o}C).

1 m above surface (Figure 3d). The variations of thermal regime among all stations showed a tendency towards further levelling out although Station 4 - owing to morphologic features (valley bottom) - had a very low minimum value (6.9 ^{o}C) as a result of cool air streaming down the valley slopes. It is conspicuous, however, that while in the 20 cm horizon minimum occurred as early as at 1.00 hour, maximum cooling reached the 1 m level only by 5.00 (Figure 5). The reason is that in the beginning cool air filled up the lower space of the valley bottom and gradually extended upwards. The difference between these two layers in tenth of centigrades at 5.00 however, indicates a rise in temperature starting from below. Intensive warming is evidenced by the steep rise of the thermal curves. (Naturally, temperature values measured in soil follow those of soil surface and air).

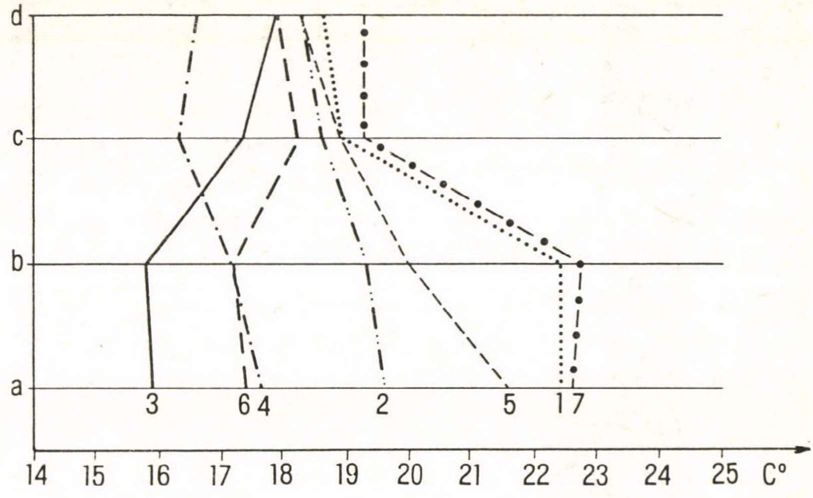

Fig. 4. Average temperature values (for the 23-hour period) at the different stations for various levels (by S. MAROSI). - For the explanation of stations 1—7 and indications a—d see Figure 3.

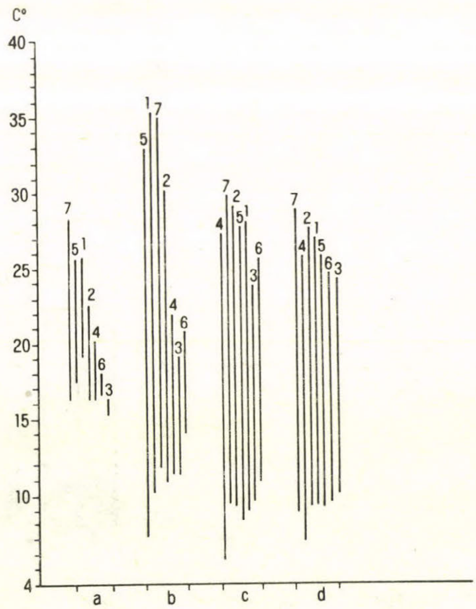

Fig. 5. Rating of maximum and minimum values at the different stations for various levels (by S. MAROSI). - For the explanations of stations 1—7 and indications a—d see Figure 3.

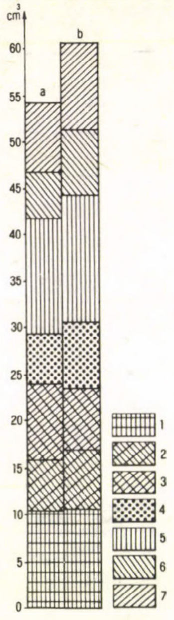

Fig. 6. Amounts of evaporated moisture in cubic cm, summarized by station and levels, from 25 August 19.00 till 26 August 18.00 (for 23-hour period) (by S. MAROSI). - a= at 20 cm height; b= at 1 m height; for the explanation of stations 1—7 see Figure 3.

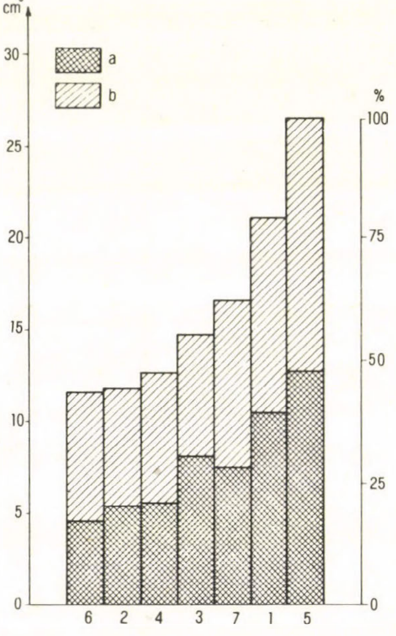

Fig. 7. Amounts of evaporated moisture in cubic cm, by station, from 25 August 19.00 till 26 August 18.00 (for 23-hour period) (by S. MAROSI). - a= at 20 cm height; b= at 1 m height; for the explanation of stations 1—7 see Figure 3.

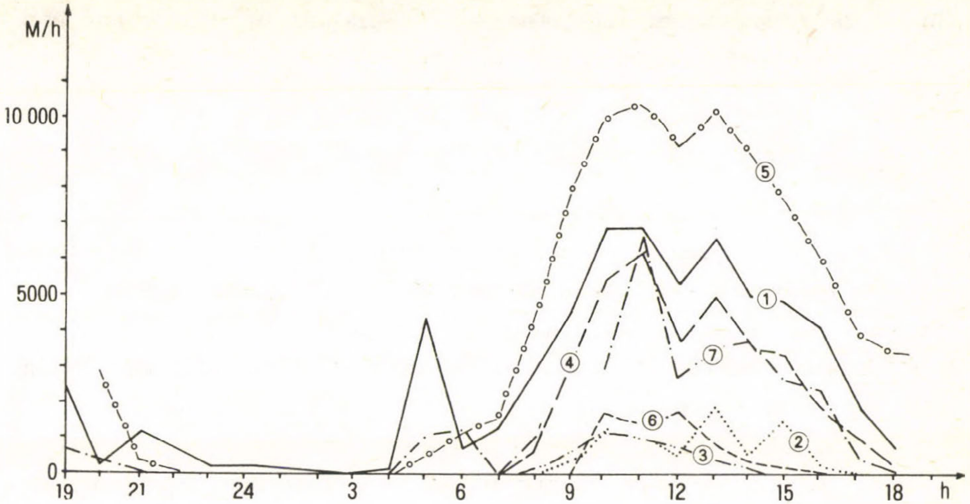

Fig. 8. Wind velocity regime from 25 August 19.00 till 26 August 18.00 at 1 m height (by. S. MAROSI). - For the explanation of stations 1—7 see Figure 3.

Maximum values for the 1 m level were lower than those for the 20 cm horizon; among them the highest was valid for Station 7 with 40 per cent slope angle and north-western aspect. The lowest maximum was measured (24.5 ^{0}C) and the highest minimum was registered also here (9.5 ^{0}C).

At 1 m level a transition is observed from micro- towards meso- and macroclimatic conditions in every respect. So there was only a slight oscillation in daily average in values for 6 stations (between 17.8 ^{0}C to 19.2 ^{0}C). An exception was Station 4, at which - due to very cool night thermal conditions - a daily average of only 16.6 ^{0}C was reached at this level.

Evapotranspiration

The highest values represented by Stations 5, 1 and 7, both at the 20 cm and 1 m level, were associated with the thermal balance and circulation regime. The moist swamp meadow and stations with closer vegetation cover belong to another type (Figures 6 and 7).

For each station were valid somewhat higher amounts of the evaporated water at the 1 m level than for that of 20 cm. An exception is the shrub which presented an opposite phenomenon explained by the breeze being stronger near surface under the shrub horizon.

Air current

During the measurement series in the evening of the first day there was a breeze which had fallen by 22.00 hour at Stations 5 and 7 and by 1.00 at Station 1. At the same stations wind started again at 4.00; the highest velocities were measured at Station 4. At the rest of the stations air current was first registered at 7.00 and in the acacia forest from 9.00.

The highest velocities belonged to the open stations ranked as follows: 5, 1, 4, 7. In this respect swamp meadow (4) should have been considered open and behaved as a wind channel (Figure 8).

CONCLUSIONS

Summarizing the results of measurement series it can be stated that it revealed microclimatic regularities of different agroecologic units which reflect varied ecological conditions and human impact, and helped to identify these units as a product of natural and anthropogenic factors.

Surfaces with vegetation cover and those without belong to distinct types.

Within the former (eastern and western) aspects served as basis for the further differentiation. Western slopes proved to be of more favourable ecologic conditions owing to various effects of irradiance.

Also this secondary notion served for separating localities on the open slopes of eastern and western aspects.

On the eastern slope, two agroecotopes: open arable land (Station 1) and corn-maize (Station 2), in similar lithologic-morphologic-pedologic situation are differentiated by coverage. Due to a loose and low stand of maize, however, this deviation is not so striking.

The biotope of the swamp meadow shows a double-faced character. This is expressed at different levels i.e. vegetation as an active surface divides it into lower and upper levels of measurements. The former show similarities to units with closed stands whereas the latter are analogous with open agroecotopes.

This locality is strongly influenced by the high ground water table inducing a cool and humid microclimate thus limiting the opportunities of land use. At the same time these are sites with frost hazard.

As units identified on the slopes reflect differences primarily caused by varied vegetation cover they offer more or less similar possibilities of economic utilization. Neverheless, certain specifications are necessary. On the slope segments of 8--10 per cent category (of eastern aspect) cereal farming in closer stand is possible and that of root crops to a lesser extent; in this latter case contour line ploughing as shallow tilth induces erosion.

Slopes of western aspect are steep and impose erosion hazard (Soil profile 2) thus need crops combined with soil protective measures (fruit farming on terraced and grassed plots). Drier and warmer micro- and topoclimate of these sites gives ground for these plantations.

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AN APPLICATION OF GIS FOR SITE SELECTION IN ENVIRONMENTAL MANAGEMENT

I. TÓZSA

ABSTRACT

A land assessment type of GIS was developed in the Geographical Research Institute in 1986. It operates in square grid units of any scale depending on the nature of the data fed in. The assessment function, through qualification, can select the most and the least suitable sites alike for certain proposed economic activities in the investigated area. An example of its operation is presented here; where the GIS is applied for the territory along a narrow-gauge forest railway in the northern part of Hungary.

On the one hand the economic pressure and the presently cheaper road transportation force the Hungarian State Railway Company and the State Forestry to close down the still operating narrow-gauge, unprofitable forest railway lines.

On the other hand in the highly developed countries there is an increasing demand for narrow-gauge forest railroads with reconstructed steam engines to transport tourists.

The question arises 'how should we render circumstances for the still existing forest railway in the northern part of Hungary to survive the period of economic recession?'

This study aims to give information of the environmental potential

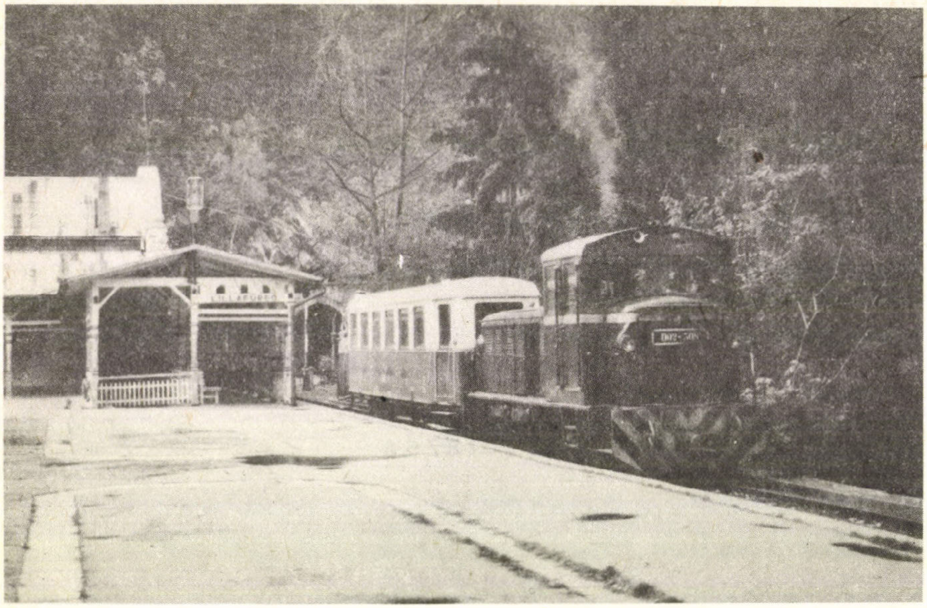

Photo 1. The Lillafüred State Forest Railway was built in 1920 (by I. TÓZSA) (See Fig. 1)

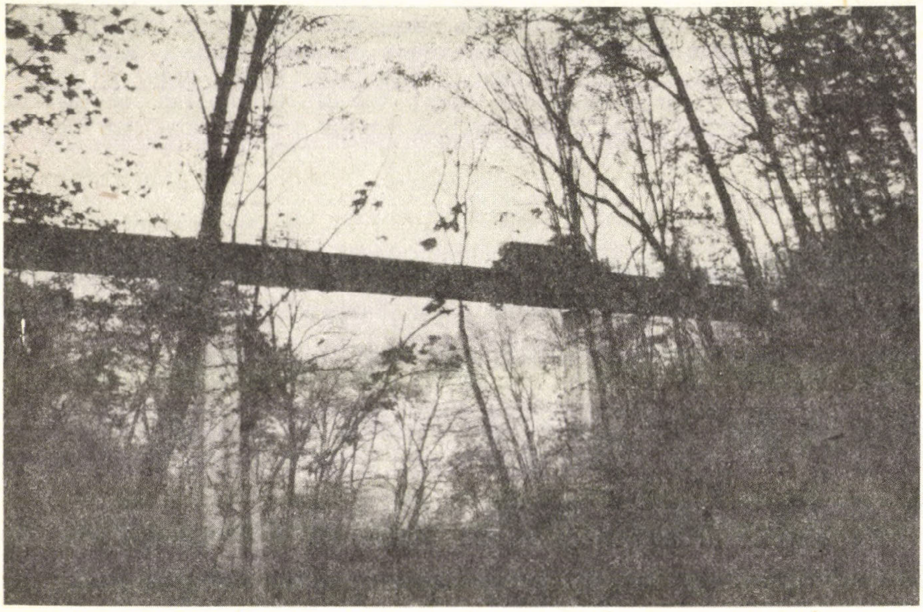

Photo 2. A viaduct with a freight train passing on (by I. TÓZSA)

Photo 3. The Sleeping Beauty of the Hungarian hotel industry (by I. TÓZSA). The Palace 'Hotel' at Lillafüred has never been used as a hotel but as a resort of the aristocracy before 1945 then later as that of the National Trade Union. Being in a beautiful environment, this palace could house a hotel, a thermal bath and a casino

Photo 4. The valley of Garadna Brook where the railway also passes (by I. TÓZSA)

Fig. 1. The Lillafüred State Forest Railway can be found in the Bükk Mountains in the neighbourhood of Miskolc (by I. TÓZSA)

along the railway. In doing so the application of a land assessment type of geographical information system is presented. This type of GIS based on microprocessor has been elaborated in the Geographical Research Institute in 1986 (TÓZSA, I. 1988). The solution of the survival of the railway may lie in the privatization of operating it, e.g. making it within a corporation of private share-holders. For making the operation of the forest rail line profitable, a number of infrastructural investments of similar (private) nature would be unavoidable. Motels with restaurants, a scout camp, a camping site, horse riding schools should be built along the line. Reconstruction of the ski runs in the neighbourhood of the line would also be useful. And lots of advertisements home and abroad alike would be needed to attract tourists. A motel chain based on the railway should be built. These motels of the railway should have special programmes for foreign tourists first, later for Hungarians as well, exploiting the endowments and resources of the environment of the railway. As for the possible choice of programmes, see Fig. 2.

According to the above proposition to save the forest railway for the future demands, and making its operation profitable, foreign capital should also be welcome in the suggested investments. The present application of the land assessment type of GIS serves to set an example how to select the most suitable sites along the rail for investments like building a forest motel chain and a scout camp for children. According to PÉCSI,M.(1988) a new aspect of geography in Hungary is to seek an answer

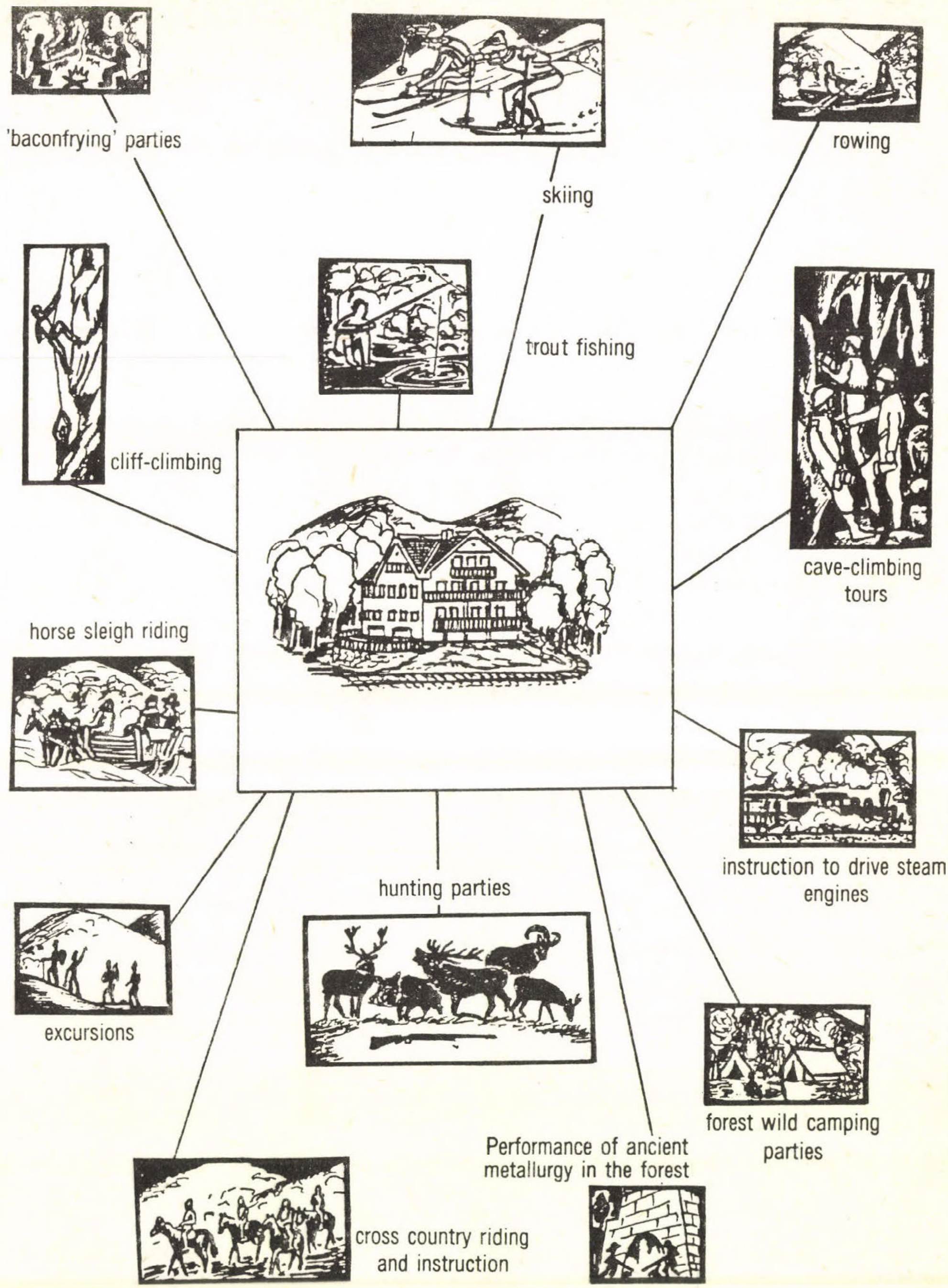

Fig. 2. Suggested programme choice for the guests of the forest railway motel company (by I. TÓZSA)

to the question what the present or potential future role of a region or some geographical environment in the life and welfare of the population is.

Figure 3 shows the square grid system applied along the forest railway line.

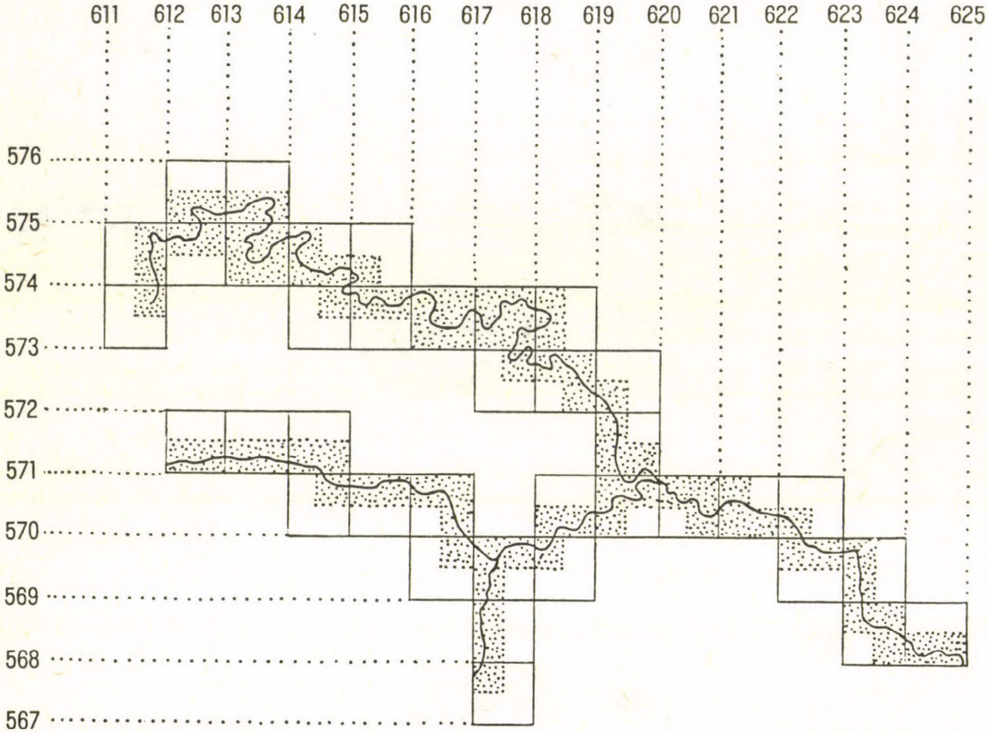

Fig. 3. The forest railway information system and its cells in the stereographic map projection km network (by I. TÓZSA)

The resolution of the system is 25 ha. But in principle, as it is a regular hierarchical model (see PEUQUET D.J. 1988), it can be further divided depending on the detail of data. See Fig. 4.

The data base contains the following input factors: the distance of **springs** from the railway in m and similarly that of **streams, sites with**

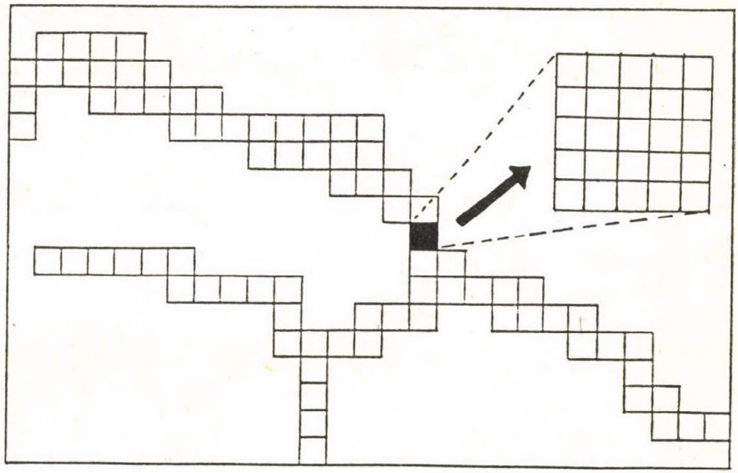

Fig. 4. The frame of the data base of the forest railway GIS with a resolution of 500x500 m, indicating the possibility of further division (by I. TÓZSA)

winter sport suitability, lakes, accommodation, food shops or restaurants, caves, looking out places. Other data are the **forested area** in hectares, the **local industrial plants,** the **average elevation** of the unit **above sea level** in m, the **length of railway ,** the **road accessibility,** the **footpath accessibility** and the data of **other attractive factors** like famous buildings, ruins, waterfalls, museums and memorials. On the basis of these 15 environmental factors the program of our GIS performed the assessment function that resulted in the site selection for two purposes.

The first was to detect the most suitable places for planting the forest railway motel chain along the rail (see Figure 5). The 25 ha units with the most favourable environmental endowments are enlarged.

The second site selecting output was meant to detect the units having the most suitable environmental endowments for building a scout camp for children (see Figure 6). The most favourable 25 ha units are enlarged from the map.

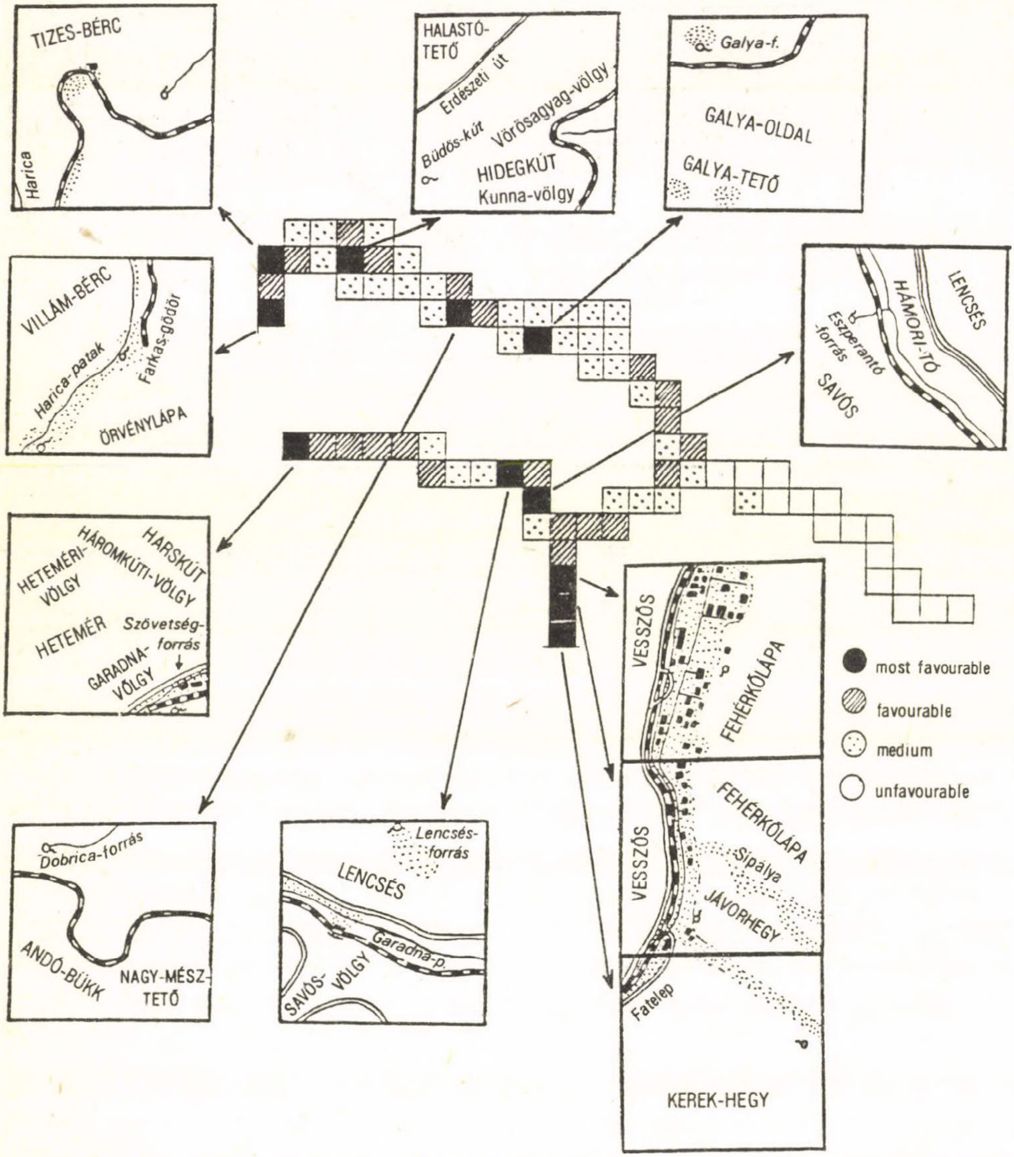

Fig. 5. The suitability for planting the forest railway motel chain along the rail (by I. TÓZSA)

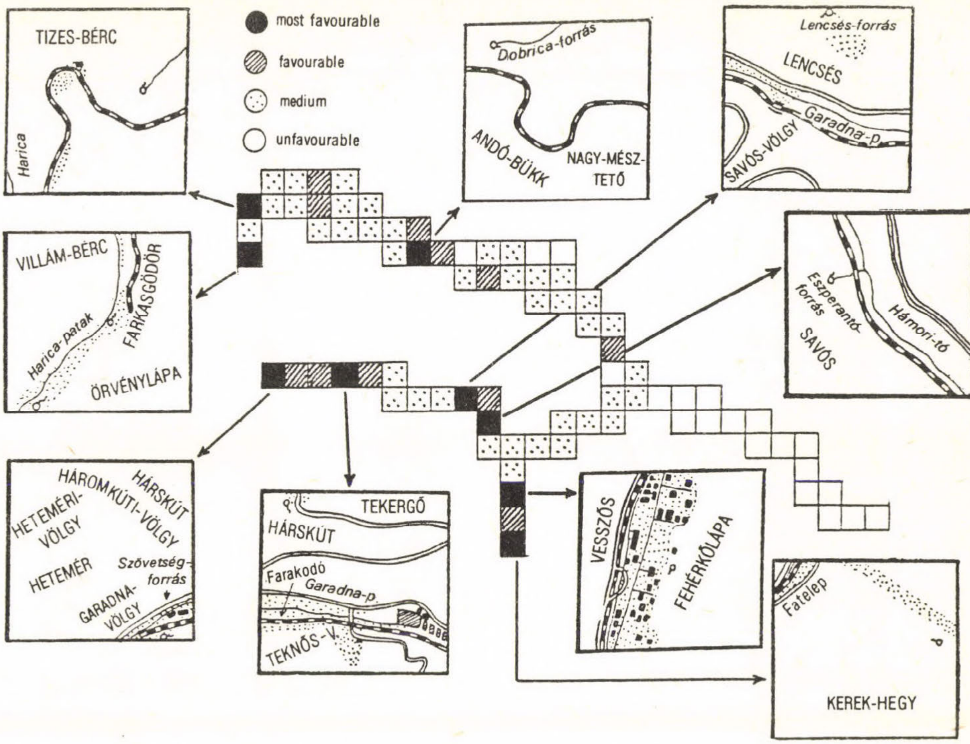

Fig. 6. The suitability for planting a scout camp along the rail (by I. TÓZSA)

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