GEOGRAPHICAL RESEARCH INSTITUTE
HUNGARIAN ACADEMY OF SCIENCES

HILLSLOPE EXPERIMENTS AND GEOMORPHOLOGICAL PROBLEMS OF BIG RIVERS

30 August – 6 September, 1987, Hungary

GUIDE

BUDAPEST
1987

INTERNATIONAL SYMPOSIUM
ON HILLSLOPE EXPERIMENTS AND
ON GEOMORPHOLOGICAL PROBLEMS
OF BIG RIVERS

THEORY – METODOLOGY – PRACTICE
ELMÉLET – MÓDSZER – GYAKORLAT

43

Geographical Research Institute
Hungarian Academy of Sciences

INTERNATIONAL SYMPOSIUM ON HILLSLOPE EXPERIMENTS AND ON GEOMORPHOLOGICAL PROBLEMS OF BIG RIVERS

IGU COMMISSION ON MEASUREMENT,
THEORY AND APPLICATION IN GEOMORPHOLOGY and
INQUA COMMISSION ON LOESS

30 August – 6 September, 1987, Hungary

GUIDE

Edited by
DÉNES LÓCZY

BUDAPEST – HUNGARY, 1987

Compilation advised by
M. PÉCSI
Á. KERTÉSZ

Technical board:
J. FÜLÖP, Mrs. Zs. KERESZTESI, M. MOLNÁR,
J. NÉMETH, I. POÓR, Mrs. E. TARPAY, Mrs. L. VARGA

ISSN 0139-2875
ISBN 963 7322 663

Published, printed and copyright by
GEOGRAPHICAL RESEARCH INSTITUTE
HUNGARIAN ACADEMY OF SCIENCES

LIST OF CONTRIBUTORS

BORSY, Zoltán

Department of Physical Geography Kossuth Lajos University, Debrecen

GÓCZÁN, László

Geographical Research Institute Hungarian Academy of Sciences, Budapest

HAHN, György

Geographical Research Institute Hungarian Academy of Sciences, Budapest

KÁDÁR, László

retired from Department of Physical Geography Kossuth Lajos University, Debrecen

KERÉNYI, Attila

Department of Regional Geography Kossuth Lajos University, Debrecen

KERTÉSZ, Ádám

Geographical Research Institute Hungarian Academy of Sciences, Budapest

LÓCZY, Dénes

Geographical Research Institute Hungarian Academy of Sciences, Budapest

MAROSI, Sándor

Geographical Research Institute Hungarian Academy of Sciences, Budapest

MEZÖSI, Gábor

Department of Physical Geography József Attila University, Szeged

NAGY, László

National Water Authority, Budapest

PÉCSI, Márton

Geographical Research Institute Hungarian Academy of Sciences, Budapest

PINCZÉS, Zoltán

Department of Regional Geography Kossuth Lajos University, Debrecen

SCHWEITZER, Ferenc
Geographical Research Institute Hungarian Academy of Sciences, Budapest
SCHEUER, Gyula
Institute for Geodesy and Geotechnics, Budapest
SOMOGYI, Sándor
Geographical Research Institute Hungarian Academy of Sciences, Budapest
STELCZER, Károly
retired from Research Centre for Water Resources Development, Budapest
SZALAI, László
Geographical Research Institute Hungarian Academy of Sciences, Budapest
SZILÁRD, Jenö
retired from Geographical Research Institute Hungarian Academy of Sciences, Budapest

CONTENTS

PREFACE

The International Geographical Union Commission on Measurement, Theory and Application in Geomorphology and the International Union for Quaternary Research Commission on Loess have decided to organize a symposium with field trip in Hungary to promote the exchange of experience in theory and methodology. Organization was undertaken by the Geographical Research Institute, Hungarian Academy of Sciences, with the participation of experts from the National Water Authority, the Research Centre for Water Resources Development and the Institute of Geography, Kossuth Lajos University, Debrecen.

The present guide is meant to inform about the conference, presents geomorphological and hydrogeographical sketches of the regions visited, and outlines the activities of organizing institutions.

The Geographical Research Institute of the Hungarian Academy of Sciences was founded in 1951 to survey the physical-geographical, economic and social-geographical factors and resources of Hungary. A general information booklet on the Institute was published in 1986. International relations are advanced between the Institute and the geomorphological commissions of IGU and INQUA. For this reason, too, the request of Prof.A.SCHICK, president of COMTAG, to organize the 1987 meeting in Hungary was accepted with great pleasure. The other motivation is that flood-control and other hydroengineering measures have a long tradition in Hungary.

The papers presented at the COMTAG sessions are to be published in a Proceedings volume.

On behalf of organizers acknowledgements are made to the contributors and editor of this guide and also to managers and researchers in the mentioned institutions who participated in the arrangements for the field trip and will provide information at localities.

Budapest, June,1987

Prof.Márton Pécsi
ordinary member
Hungarian Academy of Sciences

RESEARCH CENTRE FOR WATER RESOURCES DEVELOPMENT

KÁROLY STELCZER*

Following the integrated organization of state water administration after World War II, the need arose for establishing its scientific research basis. In June, 1952 the Research Institute for Water Resources Development (VITUKI) was founded. Under the guidance of the National Water Authority (OVH) and supported effectively by the Hungarian Academy of Sciences (MTA), integrated research for water management (incorporating hydrographic survey) has developed steadily. The tasks of the Institute, as outlined in the founding decree of the Council of Ministers, are:

a, the survey of surface water resources;

b, the survey of subsurface water resources, the exploration of further reserves, professional counselling and guidance in the planning and implementation of exploration;

c, research into the regularities of water regime, compilation of water budget and water supply studies, engineering preparation of water resources allocation, continuous filing and registering their development and exploitation;

d, keeping continuous quantity and quality files on all water resources, preparing studies and proposals for their conservation and more effective utilization;

e, compilating water management master plans;

f, cooperating in defining standard consumption rates;

---

* retired from VITUKI (Research Centre for Water Resources Development, Budapest)

g, improving methods and techniques of measurement, observation, forecasting and research;

h, theoretical and experimental research on the hydraulics of streams, structures and vessels;

i, consulting in the planning of major water resources projects, regularly collecting and evaluating experience on existing projects, dissemination of data to operators and engineering institutes;

j, continuously maintaining the operation of the hydrographic service;

k, editing publications on research and the hydrographic service;

Rapid expansion was characteristic of the first decade of activity. The three main groups of tasks were

a, surveying and exploring the amounts and quality of water resources on and under the surface;

b, exploring storage prospects;

c, irrigation research.

Tremendous amounts of data were obtained from the measurement network and test areas established in the 1950's. Parallelly, fundamental research required a large scientific and personnel capacity. A growing number of increasingly complex technological research problems related to constructions were presented to the VITUKI. All these necessitated changes in the organization of the Institute. New interdisciplinary tasks such as environmental protection and technical development were undertaken under the new name and the present system of organization *(Fig. 1)*.

Today major fields of research include

1. Hydrologic and water management research

   Surface waters (hydrometeorological observations, river and lake gauges)

   Groundwater (groundwater table and soil moisture observations, karst water and artesian water observations)

   Basic hydrological phenomena (runoff models, water, ice, and sediment regimes)

   Subsurface aquifers (storage and recharge)

Experiments on instrumented catchments (runoff conditions, excess water, groundwater hydrograph, hydrological modelling)

Regional exploration of water resources (artesian, karst and thermal water, water supply of towns)

Water resources management (cooperation in water management planning, definition of water management balance, water demand forecasts)

Land reclamation, drainage studies

Flood control, river and lake regulation studies

2. Hydraulic engineering research

Hydraulic model testing (river barrages, valley dams, thermal power stations, river regulation and flood control, seepage in soil and around structures, lakes and theoretical studies)

Checking of structures (stability checks, monitoring systems)

Field hydraulic machinery and fittings (wells, pumps, pipes, cooling water systems)

3. Water quality and water technology research

Data collection (automatic water quality monitoring system)

Lake water quality (lake Balaton and Velence eutrophication, sedimentation, impacts of vegetation)

Micro-pollutants in surface waters

Waste water treatment technology (biological treatment, industrial procedures, tertiary treatment, sludge treatment)

Pollution control (pilot zones, administrative aspects)

4. Research of technical development in hydraulic engineering

Hydrotechnical construction (soil mechanics, flood control by earth structures, hydraulic excavation, soil transport, use of plastics, quality control, licensing new products and construction methods)

Agricultural engineering (irrigation, sewage disposal, liquid manure use)

Instrument development and automation (electronic instruments, nuclear methods)

Scientific Council

Scientific Adviser

DIRECTOR

DEPUTY DIRECTOR
CF FINANCES AND
MANAGEMENT

V. Department of
Personnel and Training

VI. Section for
Administration and
Legal Affairs

VII. Department for
International Relations
and Information

DEPUTY
DIRECTOR

VIII. Accountancy

Finances and
Accounting
Labour, Salaries,
Wages and Social
Policy
Group for Material
Management

IX. Section for
Machinery and
Technical Services

X. Group for
Investment and
Construction

I. INSTITUTE FOR
HYDROLOGY

1. Dept. for Hydro-
graphical Coordination
(quantity and quality)
2. Dept. for Hydro-
graphic Network
(quantity and quality)
3. Dept. for Data
Processing
(quantity and quality)
4. Dept. for River
and Lake Hydrology
5. Dept. for Shallow
Groundwater and
Regional Hydrology
6. Dept. for Hydrology
of Subsurface Waters
7. National
Hydrometeorological
Forecasting

II. INSTITUTE FOR
HYDRAULIC
ENGINEERING

1. Jenö Kvassay
Hydraulic
Laboratory
2. Laboratory
for Machinery and
Hydrotechnics
3. Dept. for
Controlling
Hydraulic
Structures

III. INSTITUTE
FOR WATER
POLLUTION
CONTROL

1. Dept. for Aquatic
Environment
Protection
2. Dept. for Water
Chemistry and
Biology
3. Dept. for Water
and Wastewater
Technology
4. Section for
Standardization
of Technology

IV. INSTITUTE
FOR TECHNICAL
DEVELOPMENT

1. Dept.for Sec-
torial Research
Development
2. Dept.for
Development
of Operation
Technology
3. Dept.for
Hydraulic
Engineering
Development
4. Dept.for
Testing and
Supervision
5. Dept.for
Instrumentation
and Automation
Development

Fig. 1 Organization of the Research Centre for Water Resources Development (Director: Dr.László ALFÖLDI, Deputy Director: Dr.András SZÖLLÖSI-NAGY) - (from VITUKI Proceedings, Report, 1976)

THE TRANSDANUBIAN MOUNTAINS

MÁRTON PÉCSI *

The individual block-faulted horst units of the Transdanubian Mountains are separated by small *basins* and *grabens* of northwest-southeast strike, perpendicular to the main strike of the mountains. The largest single unit is the Bakony, situated north of the lake Balaton and delimited against the Vértes by the Mór graben. Farther east and north there are fault blocks and intercalated basins of the Buda-Pilis-Gerecse group. To this latter group the volcanic range of the Dunazug Mountains ("Danube nook") joins, although in forms and structure it differs from them. The conspicuous valley gorge of the Danube divides the Dunazug unit more sharply from the Intra-Carpathian volcanic girdle than they are connected by morphological similarities.

The Transdanubian Mountains between the Little and Great Hungarian Plain basins has a crystalline basement. The long marine trough of northeast-southwest trend that developed late in the Palaeozoic was mainly filled with a sequence of Triassic limestones and dolomites, of more or less pronounced South Alpine affinities. Most of this trough dried at the end of the Triassic, but its northern side was inundated by the Jurassic and Cretaceous and then also by the Tertiary seas. Along the mountain axis, the individual tectonic units performed intricate movements, subsidence and uplift irregular in space and time.

---

*

Geographical Research Institute Hungarian Academy of Sciences, Budapest

In the *Cretaceous*, however, the surface of the mountains was still rather uniform. Under a tropical climate it was planated to a low but extensive *peneplain*. This is proved by the bauxites and laterites widespread in the mountains. From the Upper Cretaceous onwards, in the phases of orogeny that resulted in the folding up of the Carpathians, the Transdanubian Mountains underwent block-faulting with the development of grabens and horst-type karstic hills. In the *Tertiary*, the blocks uplifted to various altitudes were worn down and partly turned into marginal platforms, *foothill surfaces* while the graben-type intramontane basins were being filled with waste. The surface elements in threshold position were covered with gravel sheets derived from the north and south, from the crystalline regions which at that time were still higher than the Transdanubian Mountains region. This prolonged up to the Lower Miocene. It was at the end of the Miocene, and even more in the Pliocene, that the Transdanubian Mountains rose above their surroundings. Their present-day mean altitude of 500 m, however, is the result of late Pliocene and Pleistocene uplifting.

Two members of the Transdanubian Mountains, notably the *Bakony* and *Vértes*, possess highly similar structures composed of several more or less isolated blocks. The rocks constituting them, largely Triassic limestone and dolomites, have a general northwesterly dip. In the southern forelands of these mountains, Palaeozoic rocks are exposed. In the Bakony, the Lower Triassic overlies a Permian sandstone which in turn overlies a Carboniferous phyllite *(Fig. 1)*. Indeed, south of the Balaton even the granitic basement is at a quite small depth below the surface. South of the Vértes, on the other hand, the basement granite constitutes a batholith rising above the surface in the form of the Velence Hills. The Vértes and the Velence Hills are separated from one another by a shallow graben. One particular difference between the Bakony and Vértes is that in the southwestern part of the Bakony and in the so-called *Balaton Uplands*, a large-scale basalt volcanism took place during and after the Upper Pannonian crustal movements.

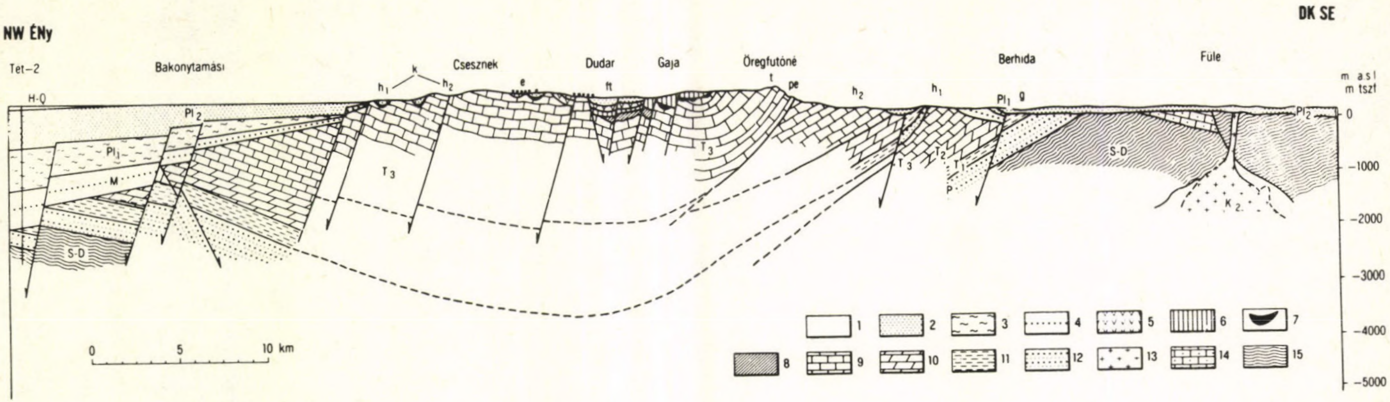


Fig. 1 Profile across the Bakony Mountains (after Gy.WEIN-M.PÉCSI, 1969)

1 = Holocene-Pleistocene river-laid sand and gravel and alluvial soils; 2 = Upper Pannonian sand and clay; 3 = Lower Pannonian (Pliocene) clay marls; 4 = Miocene gravels and sand (in the Dudar basin, including the Upper Oligocene); 5 = Eocene coal seams and carbonatic rocks; 6 = Lower Cretaceous (Aptian-Albian-Cenomanian) limestones and calcareous marls; 7 = bauxite and related formations; 8 = Jurassic limestones; 9 = Upper Triassic dolomites and limestones; 10 = Middle Triassic limestone; 11 = Lower Triassic aleurolite, marl and limestone; 12 = Permian sandstones and conglomerates; 13 = Upper Carboniferous granite porphyry; 14 = Lower Carboniferous conglomerate and clay shales; 15 = Silurian-Devonian phyllite and crystalline limestone; t = uplifted remnant of tropical peneplain; ft = cryptoplane; e = exhumed peneplain, locally covered with a Miocene gravel sheet; pe = mountain-border bench; h_2 = Pannonian bench of abrasion; h_1 = piedmont surface (pediment); g = Pleistocene piedmont surface modelled in little consolidated sediment (glacis); k = remodelled tropical peneplain in threshold position; Tét-2 = prospect wells

The extensive basalt capped surfaces were subsequently worn down to buttes.

The blocks and intercalated graben basins of the Gerecse Mountains are arranged in a north-south pattern. In the Eastern Gerecse, however, and in the Buda-Pilis Mountains, the relief-controlling structural lines strike northwest-southeast, i.e. perpendicularly to the main trend of the Transdanubian Mountains. From the Upper Cretaceous onwards, graben subsidence took place along these structural lines, with horst blocks left standing between them. In the grabens, Eocene-Oligocene and Miocene sea-shore deposits accumulated.

Despite the intense structural dissection, the summit levels of the horst blocks of various altitude of the Transdanubian Mountains turned out to be due to a process of planation. Besides the summit levels of planation, on the flanks narrow marginal benches formed and the block mountains as a whole are surrounded by broad foothill surfaces. These latter are partly pediments sculptured in dolomite and partly glacis of erosion modelled in little consolidated Tertiary deposits.

The continuous tropical planation of the Transdanubian Mountains went on only up to the beginning of the Eocene, and the surfaces of planation themselves are polygenetic in origin, because the remnants of a Tertiary terrestrial gravel sheet, encountered even on the summit levels of these mountains, suggest that the gravels had been transported by streams coming from the neighbouring crystalline mountains onto the Transdanubian Mountains region which by that time had already undergone tropical planation. Hence, the Mesozoic regions were in the Miocene the forelands, pediments and indeed the pediplains of the Palaeozoic crystalline mountains. In the *Pliocene*, when these crystalline mountains had foundered, the Transdanubian Mountains emerged as an *archipelago* from the Pannonian Sea. Along the shores of this latter, benches of abrasion came to exist, which today constitute mountain-border benches or steps.

There is no evidence for a continued tropical planation beyond the early Eocene. The tropical climates of the Jurassic and Cretaceous gave rise to tower karst forms and laterite and bauxite deposits widely distributed over the mountain blocks (Bakony, Vértes, Gerecse, Buda Mountains). Today, these forms are encountered at the graben bottoms, covered with Eocene limestones and also other sediments. An analysis of the structure of the Transdanubian Mountains, the correlate deposits indicative of the modes of planation (laterites and bauxites) and their redeposited varieties, including also the deposition in space of these correlate deposits, has revealed tropical planation to have extended in the Cretaceous most probably over the entire Transdanubian Mountains region. This vast low tropical peneplain was uplifted to various altitudes by the differentiated structural movements - block upliftings and subsidences - that took place from the Upper Cretaceous onward. The individual blocks can, on the basis of their distinctive present-day morphological positions be subdivided into five groups *(Fig. 2)*.

Elements of planated surface remained unworn only on those blocks which in the Eocene had subsided to be covered by a complex of limestones. This cover then protected them from further wear. Some blocks sank deeper during the Tertiary, giving rise to small intramontane basins or foreland basins. It is these forms that are included in the group of *cryptoplanes*. In the karst hollows of the Eocene-covered tower-karsted cryptoplanes there are substantial bauxite deposits especially on the margins of the Bakony and Vértes. The types of cryptoplane were established and documented as a result of the exposures occurring in the bauxite mines.

Some blocks carrying remnants of the Cretaceous planated surfaces now occupy the *piedmont* position or low rises in the Bakony, Vértes and Gerecse. This group includes further the low-lying fault blocks of the Southern Bakony and Balaton Upland, too. The tropical forms and weathering products have mostly been worn down, but there are traces of them in spots. Locally the tropical laterite and red residual clay is restricted to joint fissure fillings. Elsewhere there are on the surface small spots or scattered pebbles of a Tertiary gravel, usually consisting of red-tinted quartz. This suggests

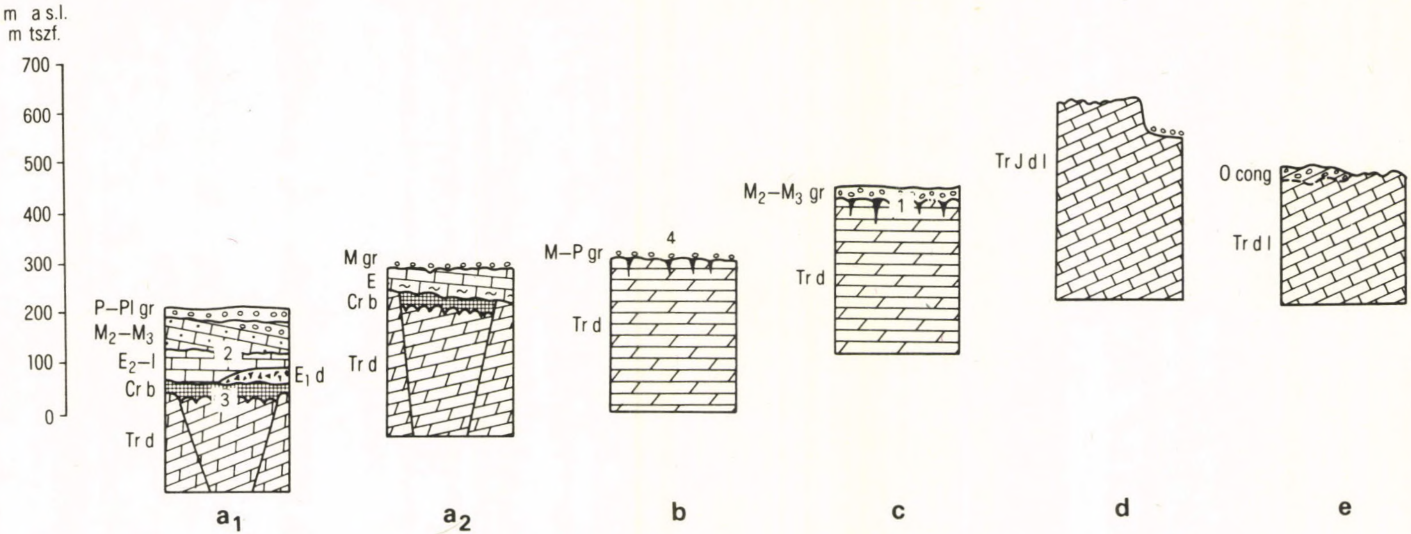


Fig. 2 Schematic position of the tropical planated surfaces in the Transdanubian fault blocks(after M. PÉCSI)

a_1-a_2 = buried tropical surface remnant on the mountain border or in an intermontane graben; b = low threshold surface with traces of tropical weathering, truncated by subsequent pedimentation; c = uplifted but still covered tropical surface, pedimented when the Tertiary gravel cover was being deposited on it; d = uplifted tropical surface remnant, fully truncated in the Tertiary; e = semiexhumed, uplifted surface remnants, pediplanated in the Tertiary (e.g. Oligocene) in the forelands of the crystalline massifs; their subsiding portions wear a conglomerate cover; P-Pl gr = Pliocene-Pleistocene gravel; M_2-M_3 = Middle Miocene marl, limestone and gravel; E-E_2l = Middle Eocene limestone; E_1 = Lower Eocene dolomite detritus; Cr b = Upper Cretaceous bauxite; Tr d = Triassic dolomite; M gr = Miocene gravel; M_2- M_3 gr = Middle and Upper Miocene conglomerate; O cong. = Oligocene sandstone and conglomerate; Tr-J d,l = Triassic-Jurassic dolomite, limestone; M-P gr = Miocene-pliocene gravel; 1 = Remains of a tropical weathering, with kaolinite and red clays; 2 = unconformity; 3 = needle-karsted remnant of a tropical surface; 4 = gravel rags on the surface the ancient tropical surface to have undergone a pedimentation in subsequent times.

This group includes those highest blocks of the Bakony and Gerecse whose surfaces bear no trace of tropical forms or correlate deposits (Köris Hill, Papod, Tés Plateau, Nagygerecse etc.). However, on the lower levels surrounding them (400 to 500 and 200 to 250 m) there are in the mouths of dry valleys remnants of redeposited red tropical clays. The planated summit-levels, presumably modelled in the Upper Cretaceous by tropical planation, were considerably worn down in the Tertiary. However, data on the depth and modes of erosion are not yet sufficient.

The uplifted remnants of a tropical surface of planation within this group are buried under a more or less thick sequence of sediments or a sheet of gravel. They are consequently covered despite their elevated position (semiexhumed surfaces). The gravel sheet up to the Upper Miocene was dumped from the surrounding crystalline mountains onto the lower-lying portions of the tropical surface, presumably in the course of a process of pedimentation. These elements of the relief were then uplifted to their present altitudes by the Pliocene and Pleistocene tectonic phases (e.g. Farkasgyepü in the Bakony, some blocks of the Buda-Pilis Mountains, the Romhány block in the Cserhát etc.).

In the Buda and Pilis Mountains and in the Cserhát Hills east of the Danube bend there are Mesozoic blocks uplifted above their surroundings which were once covered by Oligocene sandstones and conglomerates. Some of them have been completely *exhumed* since, however.

The conglomerate locally directly overlies the tropical tower karst, contributing to its destruction. The lithologic composition of the gravelly deposit suggests a derivation from a nearby crystalline mountain.

The presence of gravelly correlate deposits in the Transdanubian Mountains and its borders reveals that tropical planation could not have been continuous throughout the Tertiary. The Lower Oligocene conglomerate, the Upper Oligocene gravelly sand, the Lower to Middle Miocene (Eggenburgian to Badenian) gravels represent clear indications of the processes of pedimentation that took place in the foreland of the Palaeozoic crystalline mountains then still rather high and undergoing repeated vertical movements. True correlate deposits indicative of a tropical or subtropical weathering - kaolinite-bearing varicoloured and red clays - did come to exist in other periods of the Tertiary. Still, in certain stages of the Eocene, Middle Oligocene and Miocene, planation on the tectonically displaced, sinking or rising relief by tropical planation must have been restricted to brief episodes. The relief features and correlate deposits suggest surface evolution to have been a polygenetic one, with repeated pedimentation dominating the episodes of tropical planation.

In the Miocene, the main agency of relief modelling on the borders of the mountains rising above the Pannonian sea was abrasion resulting in mountain-border platforms. After the retreat of the Pannonian sea, pedimentation and glacis formation resumed their dominant role on the margins of the continuously rising blocks. These forms of planation were, however, dissected into interfluvial ridges by processes of valley sculpture in the warmer climatic phases of the Quaternary. Another episode with a climate suitable for *pedimentation* and *glacis formation* set in the Upper Pliocene, when under a warm semiarid climate pedimentation was dominant, whereas in the cold and dry periglacial climate phases of the Pleistocene, relief modelling by *cryoplanation* was the most extensive process. This is why, on the gentle slopes of the foothill areas, terraces, pediments and glacis of cryoplanation are fairly widespread *(Fig. 3)*.

In the fault blocks, largely consisting of limestone and dolomite, of the Transdanubian Mountains, fault-controlled *karst valleys* are rather frequent. Most of them are dry over most of the year, and their flanks are as steep as those of the canyon in some sections. On the flanks of almost every block there are *lapies slopes* and *dry caverns* hanging above the valley bottom. On the mountain borders, hot karst springs

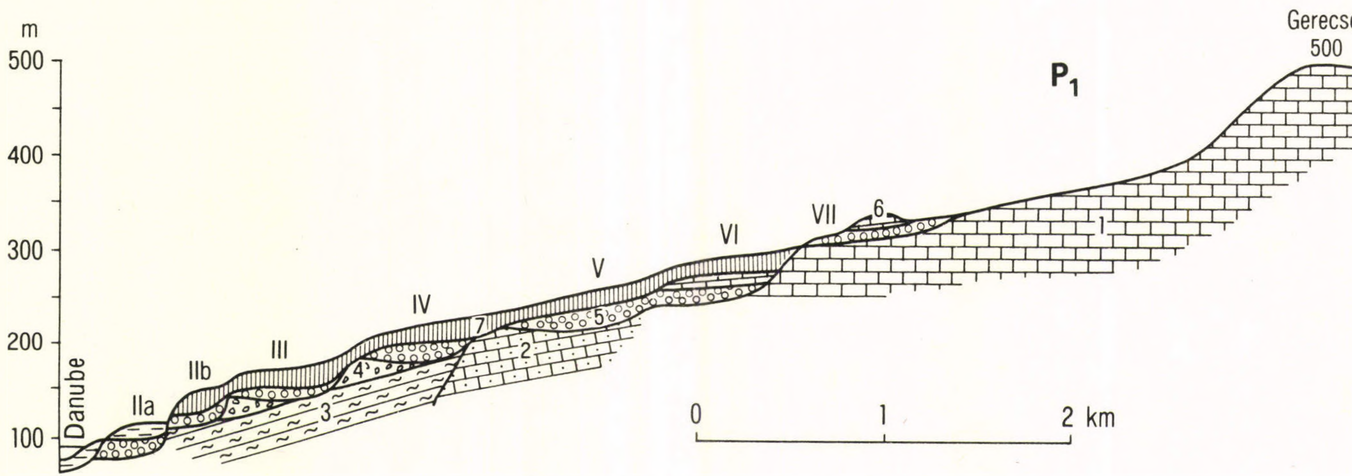


Fig. 3 Danube terraces on the northern border of the Gerecse Mountains (after M.PÉCSI)

P_1 = Upper Pliocene pediment; IIa-IIb = Würm and Riss-Würm terraces; III = Riss terrace; IV = Mindel terrace; V = Günz terrace; VI = Pre-Günz terrace, travertine-covered (coeval with Danube glacial phase); VII = Upper Pliocene terrace, travertine-covered; 1 = Mesozoic undivided; 2 = Cretaceous sandstone; 3 = Eocene marl; 4 = Oligocene conglomerate; 5 = terrace gravel; 6 = travertine; 7 = slope loess of high yields tend to occur, particularly in the Buda Mountains. Active since the end of the Tertiary, these springs have given rise to travertine-covered levels of one-time floodplains in the foreland. There are instances of up to five *travertine levels* at various altitudes on top of terrace deposits.

The absence of extended connected cave systems has been attributed to the tectonic jointing of the rocks constituting these mountains. Thus in the limestone basement of the intramontane basins there are huge waterbearing cavities. Inrushes of water from these cavities are a constant menace to coal and bauxite mining in these basins. The slopes and basin topographies of these mountains are smoothed by mountain-type slope *loess mantles* of varied thickness. This type of loess has the peculiar lithologic feature that the fine-grained stratified loess packets constituting it are separated by rhythmic intercalations of sand or rock debris. The relief covered with loess or loess-like deposits bears typical derasional valleys. Deep loess gullies modelied by erosion, due to anthropogenic influences, are quite numerous locally. Microforms due to Pleistocene ground frost, deflation, cryoturbation and solifluction are classified as accessory elements of the landscape.

REFERENCES

PÉCSI, M. 1970: Geomorphological regions in Hungary. Budapest, Akadémiai Kiadó. 45 p. (Studies in Geography in Hungary. 6.)

PÉCSI, M. 1970: Surfaces of planation in the Hungarian mountains and their relevance to pedimentation. Budapest, Akadémiai Kiadó. pp. 29-40. (Studies in Geography in Hungary. 8.)

PÉCSI, M. - SCHEUER, Gy. - SCHWEITZER, F. HAHN, Gy. - PEVZNER, M.A. 1985: Neogene-Quaternary geomorphological surfaces in the Hungarian mountains. Budapest, Akadémiai Kiadó. pp. 51-63. (Studies in Geography in Hungary. 19)

September 2

LAKE BALATON AND THE BALATON 'RIVIERA'

SÁNDOR MAROSI* and JENÖ SZILÁRD*

Lake Balaton is the largest and one of the most studied lakes in Central Europe (77 km long and 14 km wide with a surface area of 600 km^2 - *Fig. 1)*. Considering its size it is exceedingly shallow, with an average depth of 3-4 metres and a maximum of 10.5 m at Tihany.

The northern margin of the lake is fault defined and drops rather abruptly from a narrow, pebbly shore with reed-beds to the average depth of 3-4 metres. The southern shore presents a strong contrast because the lake bottom actually begins to rise 500 to 1,000 metres off shore to form a wide, flat, sandy beach, the longest lacustrine beach in Europe. Its fine velvety sand and warm, shallow water make it a bather's paradise *(Fig.2)*.

First, Lake Balaton was assumed to proceed from the joining of several flat tectonic depressions and deepened by deflation in the Early Pleistocene. Later it was described as a uniform tectonic graben. The geomorphological analyses carried out in the 1940s put the time of origin of the lake back to the Riss-Würm interglacial. The botanical studies in the 1950s fixed the date at the end of the Würm; while geological studies showed Early Holocene age.

Authors, on the basis of their recent geomorphological studies, consider Lake Balaton to be a *polygenetic depression* formed by sinking periodical both in space and time. Its slow sinking started in the Riss, became more active in the Würm, mainly in its later stages; this evolution goes on, though at a restricted rate, even nowadays.

---

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

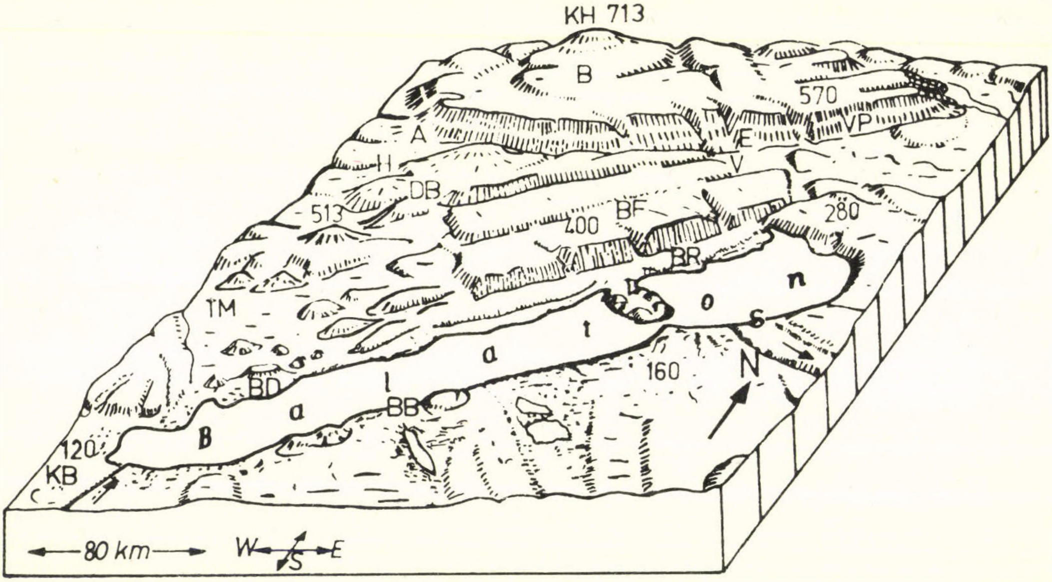


Fig. 1 Block diagram of the Bakony Mountains and Lake Balaton (after Gy.PEJA), height in metres

A = Ajka; B = Northern Bakony; BB = Balatonboglár; BD = Badacsony; BH = the Balaton Highlands; DR = Balaton Riviera; DB = Southern Bakony; E = Eplény; H = Halimba; KB = Little Balaton; KH = Mount Köris; S = Siófok; T = Tihany peninsula;TM = Tapolca Basin; V = Veszprém; VP = Várpalota

In depressions of the lake basin situated in N to S axis, alluvia reach the thickness of 30 to 50 m, while underwater ridges in the axis of meridional ridges of hills are covered with deposits of negligible thicknesses; denudation is characteristic here.

The temporary periodicity of subsidence can be traced by relict basin features and detrital fans superimposed now on piedmont steps, on the northern fringes of hills south of the lake as well as on valley shoulders.

The part of the basin occupied by the lake at the present level (the terrain around 104 m a.s.l. *(Fig. 3)* was formed in the (late) Würm.

This statement is supported by

1. the dry valley systems running towards the basin control-

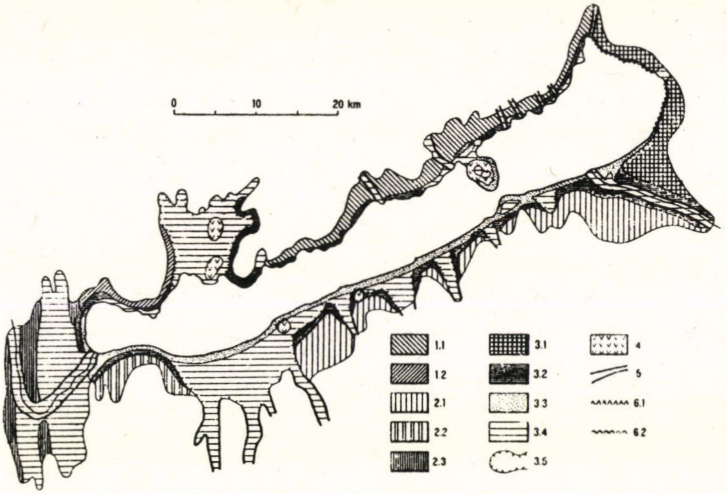


Fig. 2 Relief and landform types of the Balaton region (after S.MAROSI-J.SZILÁRD)

1 = mountainous relief types; 1.1 = pediment of the Balaton "Riviera"; 1.2 = pediment of the foreground of the Keszthely Mountains; 2 = hilly pseudotypes relief; 2.1 = foothill sloping flat in Outer-Somogy; 2.2 = foothill sloping flat in the foreground of the Marcali ridge; 2.3 = Little Balaton hilly ridges; 3 = lowland relief types; 3.1 = Mezöföld loess tableland; 3.2 = lacustrine abrasional platforms (raised beaches); 3.3 = lacustrine bars; 3.4 = alluvial and lacustrine valley floors; 3.5 = bights ('berek' in Hungarian); 4 = mountains; 5 = valleys; 6 = shore types; 6.1 = steep cliffs; 6.2 = steep low beaches

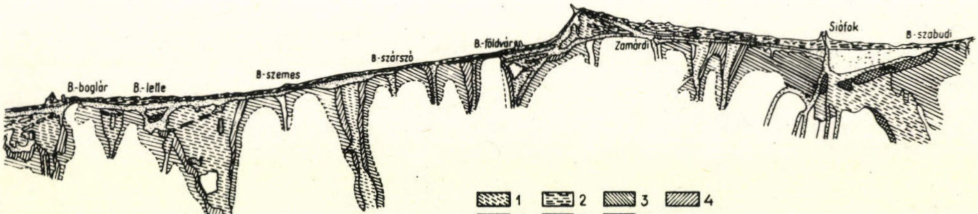


Fig. 3 Sketch of abrasional platforms and bars along the Outer Somogy shore of Lake Balaton (after S.MAROSI - J.SZILÁRD)

1 = alluvium, marshy pasture; 2 = younger, low-situated system of bars and intermediate abrasional platforms; 3 = older, higher abrasional platforms; 4 = younger abrasional platforms; 5 = fish ponds; 6 = older, higher-lying bar; 7 = system of 2 to 3.5 m long bars

led by a base level lower than the present; these are filled with periglacial deposits showing cryoturbation phenomena and enclosing fossil soils.

2. The development of lacustrine abrasional surfaces and offshore bars *(Fig. 3)* located 6 to 8 m above the present 0 level, below similar deposits.

3. The hypothesis of the pre-Würm subsidence of the lake basin in question is contradicted by the river system which existed from the Early Pleistocene to the Würm, coming from the Bakony Mountains, crossing the present Lake Balaton and southern hills, stretching as far as the Kapos depression' On the other hand, the break of this system, probably connected to the intensive subsidence in the Early Würm, is clearly confirmed by the loess covering the fluviatile (correlative) deposits in the Bakony. These deposits lie in the base of the plain along the Kapos river and have the thickness of 100 m.

On the basis of absolute C^{14} dating of charcoal remnants (21,725 ± 660 years) recovered from the humified base of thick (15-20 m) slope sediments deposited conformably over the lowest sand bars of lake Balaton, it can be concluded that the present-day water-filled lake bottom was formed about 30,000 years ago.

The 130.2 km² 'Riviera' (the S-sloping north shore zone of Lake Balaton) is a moderately dissected *piedmont* surface with rendzinas and locally various zonal soils and with a deep ground-water table.

Regarding *lithology,* the Riviera presents a rather variable picture. The Palaeozoic rocks of the basement commonly form outcrops. Most frequently Permian red sandstone occurs (covering an area of 16 km²). Mesozoic formations extend over substantially larger surfaces. Triassic dolomite has the largest extension (30 km²). In addition, various marls, Sarmatian and other limestones represent calcareous rocks.

The youngest deposits of marine origin are Tertiary sandy -clayey sediments. Older rocks are locally overlain by Quaternary, mainly proluvial, foothill talus material, deluvial loess-like deposits. Their mantles of various depth are parent materials for soil formation.

Lithological differences, tectonic movements and the effect of planation and selective erosion produced varied relief. Two basic surfaces are identified at 120-150 m and at 160-180 m a.s.l. They are structurally preformed as evidenced by the dips of strata in many places. The surfaces slope towards Lake Balaton and rise above the lake in a wave-cut margin, the abrasional platform at 112-116 m *(Fig. 4)* which is succeeded by a system of lacustrine elevated beaches of three-fold division. A primary feature of the multifaced slope conditions is southerly exposure involving radiation and thermal surplus favouring intensive farming (vineyards and orchards). Gentle stable slopes are generally predominant. To the west, in Tapolca basin, however, where basalt caps locally preserve the pre-Pliocene surface of sandy and clayey sediments, in the form of buttes, landslips frequently occur.

Among the forms of *microrelief*, flat derasional valleys are to be mentioned. Several forms of various width are associated with erosional valleys: tali and alluvial fans as well as terrace-like 'valley shoulders'. Typical microforms are the cryoplanation steps, the small, conical or frustrum-cone-shaped forms resulting from selective erosion; they are outcrops of porphyroid sills. Man-made forms are some terraces, deep-cut tracks in loess, stone quarries, sand and clay pits. The karst springs of the adjacent Balaton uplands take a leading role in the water-supply of the Riviera as well as that of the lake shore zone.

It is characteristic of the *climate* in the Riviera that from SW to NE there is an 100 hour increase in the number of hours of sunshine and, at the same time, it is the western part which receives an extra 100 mm precipitation. The number of days with precipitation is remarkably higher in the west, but this part is also windier and cooler. In the vicinity of Lake Balaton it is the Riviera which enjoys the best shelter from the wind and the warmer character due to slope exposure has its ecological impact. As a function of relief dissection, vegetation cover and soils, various micro- and topoclimates have emerged.

The Balaton receives more than two million visitors each year, attracted by its warm, oxygen-rich, slightly alkaline waters which also contain some $CaCO_3$. The water of the lake is slightly therapeutic, but in this respect is greatly surpassed by the sulphurous spa of Balatonfüred and the sulphurous radium-bearing thermal water of Héviz on the northern shore.

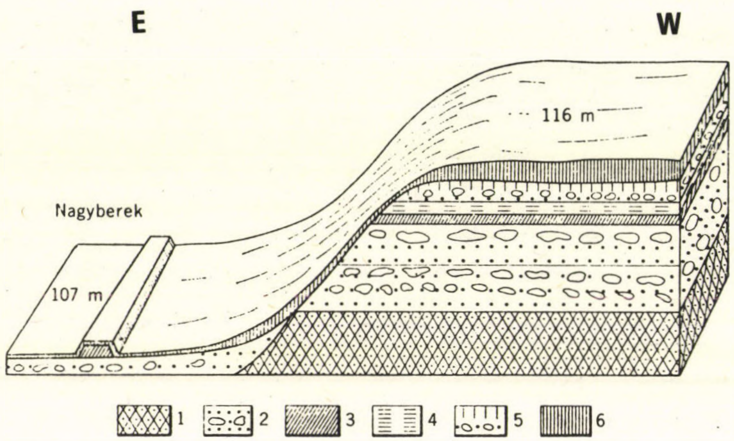


Fig. 4 Section of a Pleistocene raised beach of Lake Balaton at Balatonkeresztúr (after S.MAROSI - J.SZILÁRD)
1 = Late Pliocene cross-bedded sand; 2 = sand with dolomitic debris; 3 = lacustrine sand, silt; 4 = bog clay; 5 = sandy loess with dolomitic debris; 6 = soil

REFERENCE

MAROSI, S. - SZILÁRD, J. 1981: A Balaton kialakulása. (The origin of Lake Balaton). Földrajzi Közlemények. 29. (85), pp. 1-30.

September 2

L o c a l i t y 1

TIHANY PENINSULA

SÁNDOR MAROSI* and JENÖ SZILÁRD*

One of the most spectacular landscapes in the Balaton region. The peninsula has 5 km length, 2-3 km width, ca 15 km² area, connected to the Balaton 'Riviera' by the Aszófö isthmus, a 1.5 km wide alluvial zone. In the south it is divided from the south shore by the Szántód strait of 1.5 km width and 11 km water depth.

The peninsula is composed *lithologically* of Upper Miocene-Pliocene sands, sandstones and clays deposited upon the Mesozoic red sandstones, aleurite, limestones and dolomites of the Balaton Uplands at 200-300 m depth from the surface. The sedimentary layers are overlain in various thicknesses by basalt tuff, agglomerate, breccia and tufite around the two main centres of eruption, the Outer and the Inner Lakes. In groups *post-volcanic* formations, mostly hydroquartzite and travertine cones occur. Earlier interpreted as geyserites, now the opinion is held that the base and middle parts resemble to geyser deposits, while the top part accumulated from gravity springs.

Volcanic activity is now placed into the period from latest Pliocene to Upper Pleistocene. The present-day *landforms (Fig. 1)* are of secondary shape. Locally resistent vents survived with groovings of flowing thermal water. Parasitic cones surround the Outer Lake. The basaltic dykes of former eruption centres arise 6-8 m from the terrain. Most of the geyserite cones are found in the south (ca 50 cones). The

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

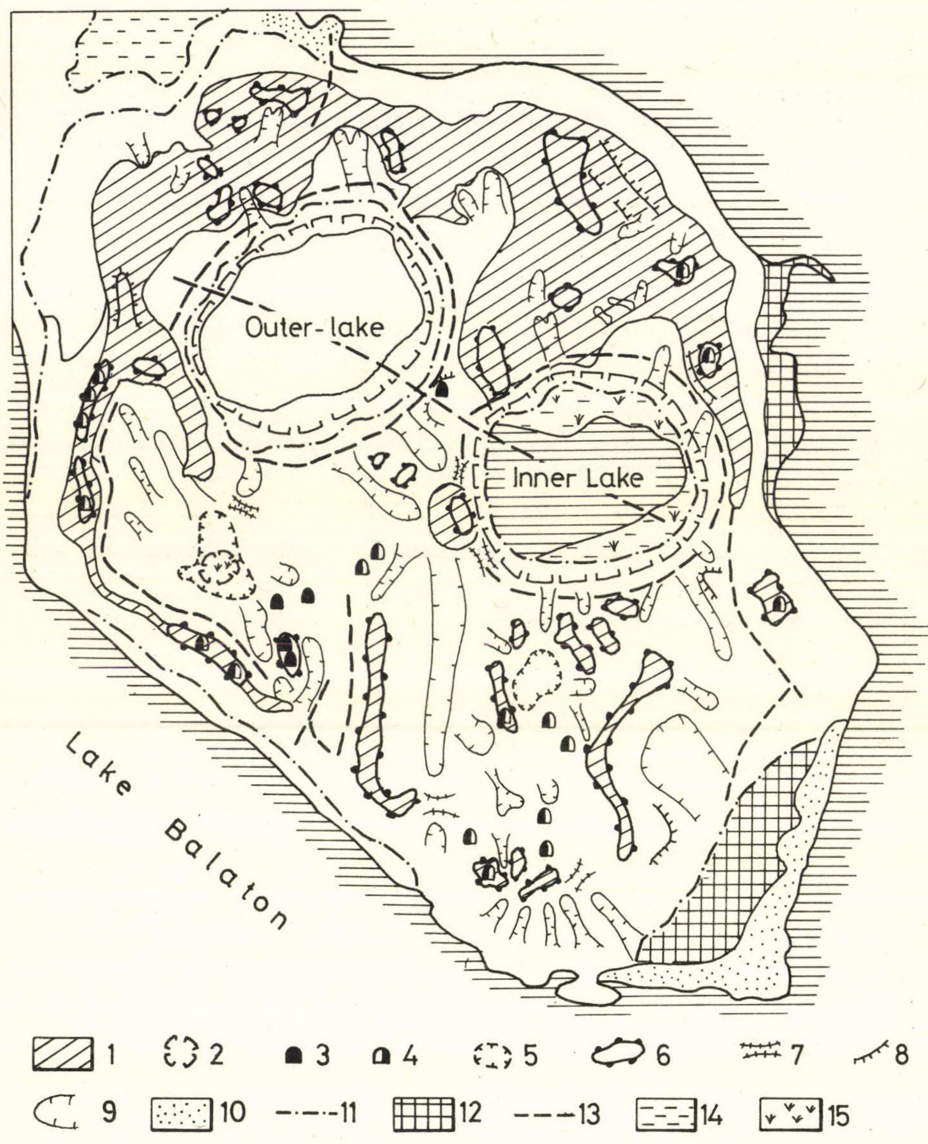


Fig. 1 Geomorphological map of the Tihany peninsula (simplified and drawn by Á.KERTÉSZ after E.LÁNG-BUCZKÓ 1968)

Fig. 1 (cont.) 1 = summit level of mountains of volcanic origin; 2 = caldera; 3 = parasitic cone; 4 = remnants of geyser cone; 5 = small basin; 6 = derasional residual hill; 7 = derasional col; 8 = scarp; 9 = negative derasional features (valley, dell, niche, cirque); 10 = bar; 11 = rise of abrasional platform; 12 = artificial fill; 13 = tectonic lines; 14 = seasonally waterlogged area; 15 = swamp

largest is called Aranyház (golden house), it has steep slopes and a major vent of 3-4 m diameter. An important post-volcanic landform is the Forrás-barlang (spring cave) near the Tihany Abbey, explored in 1951. It has 8 m length, 5 m width and 3 m height. The cave was formed in the travertine body of the Kálvária-domb (Calvary hill).

Three major fault systems can be traced in northwest to southeast and rectangular directions. The depressions of lake basins are probably connected with collapsing volcanic calderas. Quaternary tectonic movements control some valley courses. Tectonic activity is manifest in steep *slopes* above 50%. Slope stability varies with slope materials: the erosion of slopes of hard volcanic rocks is slow, while derasion valleys (dells) easily form on tuffs and loose sandy-clayey deposits. On harder material they are steep and even hanging valleys, on looser deposits they are flat with gentle slopes. The conditions for mass movements are favourable along the Balaton shore. High relief and porous sediments contributed to slides as early as the Pleistocene. As the wave action of the lake destroyed the debris accumulations along the margins, instability was increased, particularly where seeping waters lubricated the layers. Loading and improper water management as human interventions also contributed to movements on slopes. Landslips took place in the zone from the Csúcs-hegy to Hosszú-hegy.

Bars accumulated along the shores not affected by mass movements. On the western and southwestern sides of the peninsula bars built up of coarse basalt tuff, geyserite and travertine debris reach 0.5 m height. Wave-cut platforms rise 3-

4 m above lake level and only preserved in some localities. The Outer and Inner Lakes are also surrounded by 2-3 m high steps indicating ancient and recent changes in water level.

September 2

L o c a l i t y 2

BAKONYNÁNA

ÁDÁM KERTÉSZ*

Experiments in the Gaja valley, near Bakonynána began in the mid-1970s. The Gaja valley lies in the Bakony Mountains, north of Lake Balaton *(Fig. 1)* in the Sió catchment, on the border of the Marcal catchment.

The field plots for erosion measurement were designed in the test area of the Mid-Transdanubian Water Management Authority (KÖVIZIG), which was established by cooperation of the KÖVIZIG and the Research Centre for Water Resources Development (VITUKI) in 1963. It belongs to the national network of test areas for hydrological experimentation and representative areas of landscape units. We can benefit from the continuous record of the KÖVIZIG available for comparison. Hydrologists measure runoff and precipitation in the catchment and have shorter records of evaporation and soil moisture, too. Naturally, meteorological observations are also made. Another advantage is that there is a climatological station nearby, at Zirc (established at the turn of century) and a gauging station operates at Fehérvárcsurgó (since 1953 - cf. ZSUFFA, I. 1973, SZÖLLÖSI, D. 1981).

First, *large field plots* (further: plots) are treated. The oldest was inaugurated on the south-western slope of the Gaja stream valley in 1973 *(Fig. 1)*. The original dimensions were: length: 36.6 m, width: 12 m, with a triangle of 6.4 m

---

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

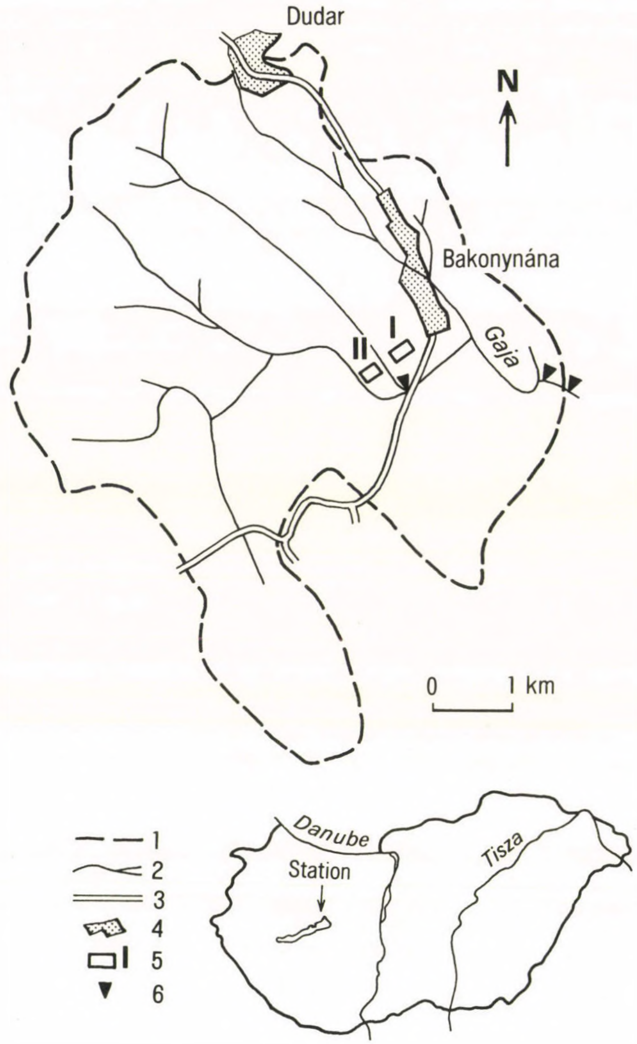


Fig. 1 Location of test areas at Bakonynána (after Á.KERTÉSZ)

1 = boundary of catchment; 2 = water-courses; 3 = public road; 4 = settlement; 5 = test areas; 6 = river gauge of KÖVIZIG

height at its base (total area: 477.6 m^2). The dimensions of the plot were changed in 1980 and plots of uniform size were established on the opposite slope of the Gaja valley and at Pilismarót. The plot was increased to 45 X 15 m (total area: 688.7 m^2 - cf. *Fig. 2*). None of the plots reaches as far as the divide. However, since the south-eastern slope forms part of a lower interfluvial ridge, the new plot (no 2) approaches the divide, while the upper edge of the first plot (no 1) lies 60-70 m downslope from the summit level. The old plot has an average slope angle of 15-16°, uppermost segment: 17-18°, inflection zone: 20°, lower segment of accumulation: 8-12°. The new plot (no 2) has a somewhat gentler (13-14°) and rather uniform slope.

The large plots are supplemented with a series of *small plots*. Their pattern is shown in *Fig. 2*. The small plots are designed for the study of processes of downslope material transport. They are of various length and conform to the micromorphology of the slope at Pilismarót. The explanation is that small plots were first delimited on the hillslope of more variable micromorphology at Pilismarót. For comparison, the lengths of small plots at Bakonynána are the same as at Pilismarót.

The test area of Bakonynána is located on the *covered karst* of the Bakony Mountains. The Triassic-Cretaceous sequence is overlain by Tertiary (mostly Miocene) gravelly-sandy sediments, thick loess or loess-like slope deposits.

The *soils* were studied by L.GÓCZÁN. Parent material is Tertiary sand. Brown earth on summit terrain is severely eroded and the soils along the middle and upper segments of the plots are removed to the parent material. Human influence leads to the shift of the inflection zone and, thus, allows renewed soil formation ('anthropogenic humus carbonates' are produced).

The *equipment for measurements* used in the large plots was designed by L.GÓCZÁN, I.SCHÖNER and P.TARNAI (1973). It consists of three units: delimiting plates, recipients of runoff and sediment and instruments.

The delimiting plates show the limits of the experimental plot and direct concentrated water, into the recipients. The

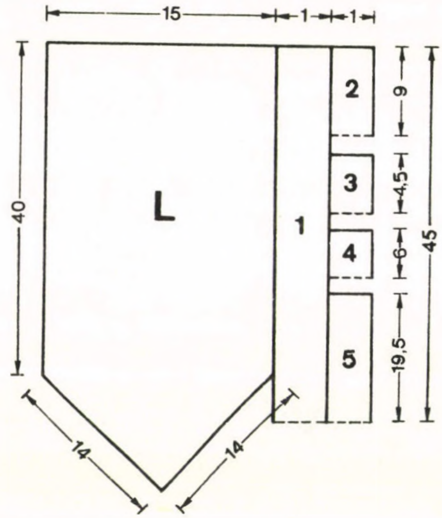


Fig. 2 Experimental plots in test areas (after Á.KERTÉSZ)

L = large plot; 1 = control plot; 2-5 = small plots. Data in metres

recipient unit of runoff and sediment (Figs 3 and 4) comprises three vessels. The first is connected to the bottom triangle of the plot by a pipe. In the vessel three sieves are placed one below the other (with hole diameters of 2 mm, 0.25 mm and 0.05 mm resp.) to sort washed-down aggregates of different size. The sieves can be removed and the intercepted material is measured. On the bottom of the vessel the silt fraction is collected. Runoff is transmitted from the first vessel to the second and the third through a dividing part. Sediment concentration and fractioning take place in the first vessel, while the second receives colloidal suspension. The capacities are dimensioned to receive overland flow present on 40 % slope in the case of 50-year precipitation maximum (for the soil type with maximum runoff).

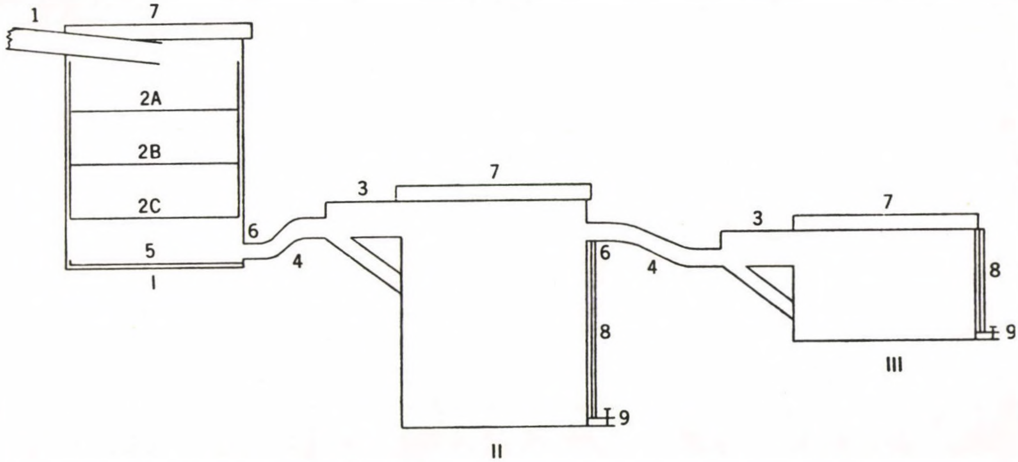


Fig. 3 Sketch of equipment for measuring runoff and sediment discharge (after L.GÓCZÁN-I.SCHÖNER-P.TARNAI)

I = sediment fractioning and collecting unit; II-III = suspension collecting unit; 1 = inlet pipe; 2A-2B-2C = fractioning sieves; 3 = dividing part; 4 = rubber hose conduit; 5 = silt-tray; 6 = by-pass unit; 7 = cover; 8 = piping gauge; 9 = drain cock

Helman's raingauge and an ombrograph are installed. The latter had been in operation until 1980. A new one could only be obtained in 1986.

The checking and reading of instruments and determining amounts of runoff and sediment took place after the individual events of rainfall (if possible) from spring to autumn. During spring meltwater was also measured occasionally.

In the small plots *(see Fig. 2,* plots nos 1-5) Schmidt's recipient troughs were applied (R.G.SCHMIDT 1979). They are 100 cm wide and 65 cm deep *(Pict. 1)*. There is a plate of 100 X 45 cm size lying closely on soil surface; collecting canal is 15 cm wide and 7 cm deep, gently sloping towards the outlet pipe at one end. The outlet pipe is connected to a plastic tank of 10 l volume in front of the recipient trough.

The mean annual *precipitation* of the test area is 689 mm *(Table 1)*. In *Tables 2-10,* in addition to monthly precipitation values for the plot, the frequency of precipitation by categories and the number of days with precipitation are included. The large number of days with light rains and the absence of extreme amounts of precipitation are striking.

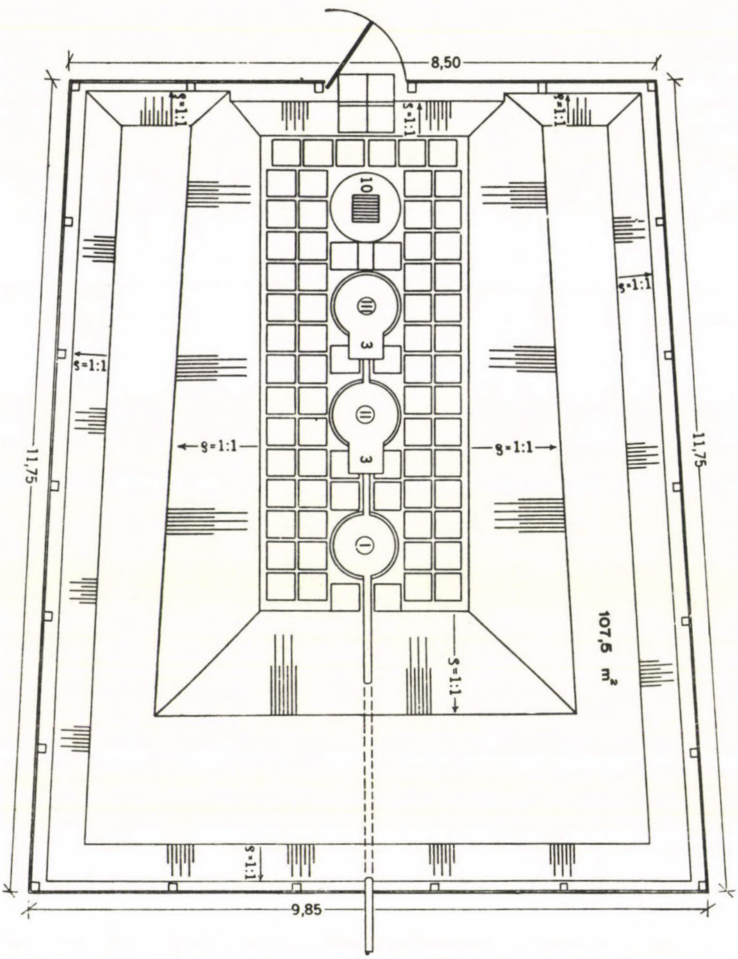


Fig. 4 View of equipment from above (after L.GÓCZÁN-I.SCHÖNER-P.TARNAI) Top view of equipment location. For 1-9 see Fig. 3 ; 10 = water purifier

The *measurements of runoff and sediment discharges* are presented in *Tables 11-19*. Calculations were made by J.SZILÁRD for the period 1976-80, and by Á.KERTÉSZ for 1980-84. No rainfall intensity measurements are available for the latter period. Thus, only absolute amounts of precipitation were taken into account.

The measurements were made in the lot no 1 (established in 1976). *Table 20* summarizes the results of measurements in the large plots of test sites nos I and II for the period when data from both plots could be interpreted. Test site no II could only start to operate by late 1983.

Table 21 provides the results of measurements in small plots. The conclusions drawn from the measurements are included in the paper by L.GÓCZÁN and Á.KERTÉSZ (in the Proceedings volume, under preparation).

In the future the cultivation and fertilization of plots are planned. We intend to grow different crops. It would give an opportunity to determine the rate of fertilizer loss. As a matter of course, it preconditions regular sampling and laboratory analyses.

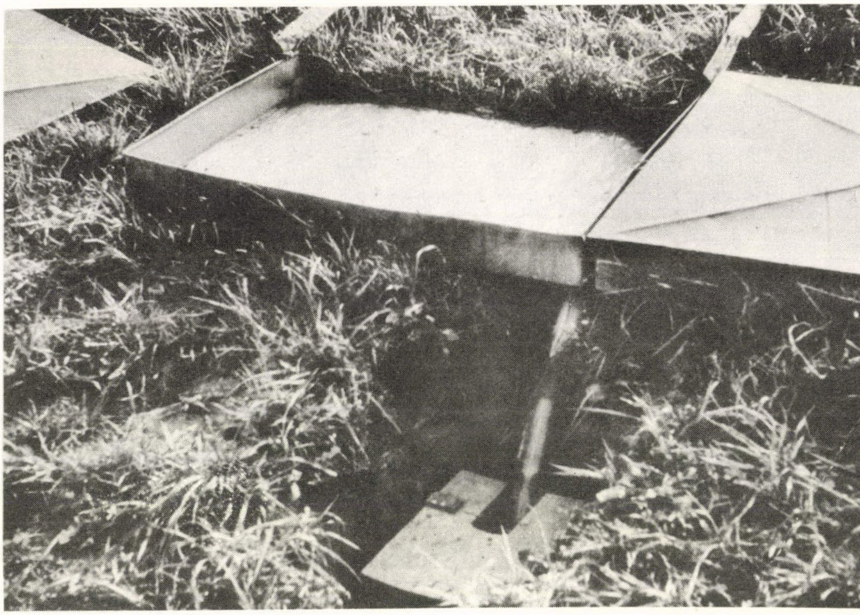
REFERENCES

GÓCZÁN, L. - SCHÖNER, I. - TARNAI, P. 1973: Új tipusú berendezés a geomorfodinamikai folyamatok analiziséhez, talaj- és környezetvédelmi kontrolljához (A new equipment for the analysis of morphodynamic processes and for environmental protection). - Földrajzi Értesitö 22. pp. 479-482.

SCHMIDT, R.G. 1979: Probleme der Erfassung und Qualifizierung von Ausmaß und Prozessen der aktuellen Bodenerosion (Abspülung) auf Ackerflächen. - Physiogeographica, Bd. 1, 240 p.

SZÖLLÖSI, D. (ed.) 1981: Adatgyüjtemény a Gaja-völgyi kisérleti terület (Bakonynána) hidrológiai és hidrometeorológiai viszonyairól (1963-1980). (Collected data for the hydrological and hydrometeorological conditions of the experimental plot at Bakonynána, Gaja valley, 1963-1980). - Székesfehérvár, KÖVIZIG Vizgazdálkodási Osztálya, 101 p.

ZSUFFA, I. 1973: Bakonynána kisérleti telepen végzett hidrológiai kutatások. (Hydrological research on the Bakonynána experimental plot).- BME VFK, Baja



Picture 1 Schmidt's recipient troughs installed at the base of small plots of the Bakonynána experimental station

Table 1 Monthly precipitations at Bakonynána (averages of 1901-1950)

Months	I	II	III	IV	V	VI	VII	VIII
	41	43	46	56	73	64	66	70
Months	IX	X	XI	XII	Year	IV-IX	X-III	
	63	59	58	50	689	392	297	

Table 2 Monthly precipitation (mm) and number of days with rainfall in the experimental plot at Bakonynána (compiled by J.SZILÁRD, 1976)

Categories of rainfall mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5				4	5	5	9	6	5	2	8	-
5-10				1	5	-	2	1	1	2	-	-
10-15				4	-	1	-	1	3	1	-	
15-20				-	-	1	-	1	3	1	-	
20-25				1	-	1	-	-	-	1		
25-30				1								
30-35				-								
35-40				-								
40<				-								
Total number of days with rainfall				8	10	7	12	9	11	6	8	
Monthly precipitation, mm				84.4	44.6	44.7	58.3	48.5	107.8	50.4	39.1	

Table 3 Monthly precipitation (mm) and number of days with rainfall in the experimental plot at Bakonynána (compiled by J.SZILÁRD, (1977)

Categories of rainfall, mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
o-5	-	-	2	6	3	2	9	4	3	4	7	-
5-10			-	-	3	2	3	1	4	2	-	
10-15			1	1	1	-	2	2	-	-	1	
15-20												
20-25						1						
25-30												
30-35				2								
35-40												
40<												
Total number of days with rainfall			3	9	7	5	14	9	7	6	8	
Monthly precipitation, mm			13.5	99.0	48.2	37.5	55.3	81.1	43.8	15.9	-	

Table 4 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by J.SZILÁRD, 1978)

Categories of rainfall, mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5					8	2	3	-	6	5		
5-10					2	2	5	1	-	-		
10-15					2	1	-	2	-	-		
15-20					-	1	1	1	-	1		
20-25					-		-	-	-			
25-30					1		-	-	1			
30-35												
35-40												
40 <												
Total number of days with rainfall					13	6	9	4	7	6		
Monthly precipitation mm					77.9	48.5	33.5	52.2	32.4	23.8		

Table 5 Monthly precipitation (mm) and number of days with rainfall in the experimental plot at Bakonynána (compiled by J.SZILÁRD, 1979)

Categories of rainfall, mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5			8	9	3	7	8	6	4	6	13	15
5-10			3	-	2	2	3	-	-	1	3	1
10-15			-	1	-	1	-	2	-		-	
15-20			1	-		1	1	1	1		1	
20-25			-	-	-	-	-	-	-	-	-	-
25-30			-	-	-	-	-	1	-	-	1	
30-35			-	1	-	-	-	-	-	-	2	-
35-40	-	-	-	-	-	1	-	-	-	-	-	-
40 <												
Total number of days with rainfall			12	11	5	12	12	10	5	7	20	16
Monthly precipitation mm			44.7	73.2	19.6	99.1	57.4	79.9	25.8	15.5	150.6	-

Table 6 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by J.SZILÁRD, 1979)

Categories of rainfall, mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5	-	13	8	10	7	8	9	3	7	4	15	10
5-10		-	2	1	2	4	3	2	1	4	2	-
10-15			1		3	1	1	1		-		
15-20						1	1	1		2		
20-25										1		
25-30												
30-35												
35-40												
40												
Total number of days with rainfall		13	11	11	12	14	14	7	8	11	17	10
Monthly precipitation mm		13.9	25.6	23.0	63.5	87.0	74.1	72.1	18.7	108.9	62.3	9.1

Table 7 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by Á.KERTÉSZ, 1981)

Categories of rainfall mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5				-	3	4	3	3	7	6	1	-
5-10				-	3	4	1	2	4	1		
10-15				-	1	3	2	1	1			
15-20				1	-	1		-				
20-25						1		1				
25-30												
30-35												
35-40												
40 <												
Total number of days with rainfall				1	7	13	6	7	12	7	1	
Monthly precipitation mm				19	44.7	82.4	35.2	60.4	46.9	18.0	7.0	

Table 8 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by Á.KERTÉSZ, 1982)

Categories of rainfall mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5	-	-	-	1	4	3	2	3	3	-	-	-
5-10	-	-	-	-	4	3	3	1	5	-	-	-
10-15	-	-	-	-	1	1	2	1	2	-	-	-
15-20	-	-	-	-	-	-	1	1	1	-	-	-
20-25	-	-	-	-	-	1	1	1	-	-	-	-
25-30						-	-	-	-	-	-	-
30-35						-	-	-	-			
35-40						-	-	-	-			
40<						1	-	1	1			
Total number of days with rainfall				1	9	9	9	8	12			
Monthly precipitation mm				1.9	47.7	102.3	99.3	134.5	77.0			

Table 9 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by Á.KERTÉSZ, 1983)

Categories of rainfall mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5	-	-	-	-	5	1	3	1	3	1	-	
5-10					3	2	1	-	2	1	-	
10-15					2	3		1	-	1	-	
15-20					-			-	-	-	-	
20-25					-			-	-	-	-	
25-30					-			-	-	-	-	
30-35					-			-	-	1	1	
35-40					-			1	1	-	-	
40 <					1			-	-	-	-	
Total number of days with rainfall				-	11	6	4	3	6	4	1	
Monthly precipitation mm				17.4	101.7	53.8	11.4	50.5	59.9	48.4	27.2	

Table 10 Monthly precipitation (mm) and number of days with rainfall in the experimental plot of Bakonynána (compiled by Á. KERTÉSZ, 1984)

Categories of rainfall mm	Number of days with rainfall											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0-5	11	15	-	4	9	6	6	-	1	5	1	6
5-10	3	-		-	6	2	1	-	-	3	-	-
10-15	2	-		1	2	2	2	-	1		-	1
15-20		1		1	1			3	-		1	
20-25				-	-			1	-		-	
25-30				1	-			2	-		-	
30-35					1				3		-	
35-40					-				-		1	
40					-				-		-	
Total number of days with rainfall	16	16	-	7	19	10	9	6	5	8	3	7
Monthly precipitation mm	56.6	39.3	-	64.5	132	47.8	35.8	128.7	128.5	30.2	55.6	17.6

Table 11 Precipitation, runoff and sediment data in plot no 1 at Bakonynána (compiled by J.SZILÁRD, 1976)

Date	Rainfall intensity (mm/hour)	Precipitation mm	Amount of of rainfall received by plot(m^3)	Runoff (m^3)	Runoff in percentage (m^3) of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
II.1	snowmelt	30.0	14.4	1.45	10.0	-	-	
IV.24	2	22.2	10.6	0.35	3.4	0.007	2.0	dry
IV.26	3	32.5	15.6	0.60	4.0	0.03	5.0	wet
VII.21	5	23.5	10.1	0.52	5.1	0.04	8.0	dry
VIII.16	20	22.2	10.6	1.00	10.0	0.10	10.0	dry
IX.16	20	8.5	4.1	0.35	8.5	0.02	7.0	wet
IX.17	2	24.1	11.6	0.49	4.3	0.01	2.0	wet
X.16	3-4	18.5	8.9	0.46	5.2	0.01	2.0	wet
X.30	gentle rain	15.8	7.4	0.22	3.1	-	-	dry
XI.14	5-6	11.2	5.4	0.15	2.8	-	-	wet

Table 12 Precipitation, runoff and sediment data in plot no 1. at Bakonynána (compiled by J.SZILÁRD, 1977)

Date	Rainfall intensity (mm/hour)	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
II.4	rapid snowmelt	21.0	10.1	1.2	10.0	-	-	frozen
II.24	slow snowmelt	15.0	7.2	0.14	2.0	-	-	thawed
III.14		11.4	5.5	0.14	2.5	-	-	intensive infiltration
IV.2	rapid snowmelt	31.0	14.9	0.16	1.7	0.009	6.0	dry
IV.4		13.2	6.3	0.28	4.4			wet
IV.8		35.7	17.1	0.45	2.7			wet
V.14	10	12.0	5.8	0.42	7.3	0.03	8.0	dry
VI.21	2-3	21.3	10.2	9.12	1.3	0.003	3.0	preceeded by hoeing dry
VII.14	10-12	13.0	6.2	0.59	9.5	0.05	9.0	dry
VIII.10	7-8	15.0	7.9	0.90	11.3	0.05	6.0	slightly moist
VIII.21								hoeing, hewing
hoeing and hewing	11-12	20.0	9.6	0.80	8.3	0.08	10.0	hewing
IX.21	2	7.7	3.7	0.10	2.8	-	-	wet
XI.13	1-2	13.9	6.7	0.20	2.9	-	-	dry

Table 13 Precipitation, runoff and sediment data in plot no 1. at Bakonynána (compiled by J.SZILÁRD, 1978)

Date	Rainfall intensity (mm/hour)	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
V.17	3-4	12.5	6.0	0.17	2.8	0.007	4.0	dry
V.19	2-4	26.1	12.5	0.45	3.6	0.073	3.0	wet
V.22	1-2	10.1	4.8	0.12	2.5	-	-	dry
V.10	1-2	17.8	8.5	0.26	3.0	0.010	4.0	dry
VI.28	1-2	13.4	6.4	0.18	2.8	-	-	dry
VII.14	10	7.1	3.4	0.14	4.2	0.005	3.5	hoeing dry
VII.20	7	16.7	8.0	0.34	4.0	0.017	5.0	wet
VIII.4	17	17.2	8.3	0.50	6.0	0.050	10.0	dry
VIII.13	4-6	14.8	6.9	0.28	4.1	0.016	8.0	dry
IX.30	4-5	25.7	12.3	0.16	1.3	0.008	5.0	hoeing dry
X.1	3-4	17.9	8.6	0.40	4.6	0.030	7.0	wet

Table 14 Precipitation, runoff and sediment data in plot no 1 at Bakonynána (compiled by J.SZILÁRD, 1979)

Date	Rainfall intensity (mm/hour)	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
II.9	snowmelt	water content of snow 20.5	9.8	0.47	4.8	0.02	4.4	-
III.22	2-3	15.9	7.6	0.15	2.0	0.006	4.0	dry
III.29	gentle rain	7.0	3.3	0.08	2.4	-	-	dry
IV.28	2-4	31.3	15.0	0.12	8.0	0.007	6.0	wet
V.1	2-3	7.4	3.5	0.09	2.6	-	-	slightly moist
VI.12	5-6	13.3	6.4	0.32	5.0	0.019	6.0	dry
VI.20	4-5	37.5	18.0	0.52	2.9	0.02	4.0	hoeing wet
VII.20	4-5	18.9	9.1	0.60	6.6	0.03	5.0	dry
VIII.9	25	16.5	7.9	0.80	10.1	0.09	11.2	dry
VIII.19	8-10	28.2	13.5	0.90	6.7	0.07	9.0	dry
VIII.24	4-5	11.8	5.7	0.63	11.1	0.03	5.0	dry
XI.24	2-3	19.3	9.3	0.25	2.7	0.012	4.0	dry
XI.18	2-3	33.2	15.9	0.27	1.7	0.014	5.0	wet
XI.19	2-3	30.1	14.4	0.23	1.6	0.007	3.0	wet

Table 15 Precipitation, runoff and sediment data in plot no 1 at Bakonynána (compiled by J.SZILÁRD, 1980)

Date	Rainfall intensity (mm/hour)	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
II.7	snowmelt	water content of snow 60	28.8	2.9	10.1	-	-	frozen
IV.21-22	snow-melt	10.1	4.8	0.06	1.3	-	-	wet
V.4	4	12.5	6.0	0.1	1.6	-	-	dry
V.9	16	12.6	6.1	0.6	10	-	-	dry
VI.9	5	8.5	4.1	0.2	5	0.08	4	dry
VI.20	7	12.7	6.1	0.3	6	0.09	3	dry
VI.29	10	18.1	8.7	0.7	9	0.04	6	dry
VII.6	1-2	11.3	5.4	0.1	2	-	-	slightly moist
VII.21	3-4	16.7	8.0	0.1	1.3	-	-	dry
VIII.8	15	15.4	7.4	0.9	12.0	0.08	8.9	dry
VIII.11	20	25.9	12.4	1.4	11.3	0.16	11.4	dry
X.8	5	18.5	8.8	0.07	0.8	0.03	4	wet
X.25	2	12.0	5.8	0.2	3	-	-	wet
XI.30	snow-melt	17.0	8.2	0.6	7.2	0.04	7	wet

Table 18 Precipitation, runoff and sediment data in plot no 1 at Bakonynána (compiled by Á.KERTÉSZ, 1983)

Date	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
I.1-I.18	40.8	28.01	0.256	0.9	neg		wet
II.28-III.1	snowmelt	-	0.350	-			wet
III.1-III.7	snowmelt	-	0.136	-			wet
III.7-III.27	35.7	24.59	0.237	0.9			wet
V.8	10.6	7.30	0.068	1.0			dry
V.9	13.3	9.16	0.203	2.1			wet
V.23	42.3	29.13	0.362	1.2	neg		dry
VI.15	12.3	8.47	0.068	0.8			wet
VI.22	10.0	6.89	0.057	0.8			wet
VIII.2	35.2	24.24	0.791	3.3	neg		dry
VIII.29	13.6	9.37	0.136	1.5	neg		dry
IX.17	6.7	4.61	0.102	2.2	neg		wet
X.11	28.9	19.90	0.158	0.8	0.008	5.1	dry
X.18	10.1	6.96	0.057	0.8			wet
XI.27	27.2	18.73	0.362	1.9			wet

Table 19 Precipitation, runoff and sediment data in plot no 1 at Bakonynána (compiled by Á.KERTÉSZ, 1984)

Date	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3)	Runoff in percentage of rainfall received by plot	Sediment (m^3)	Sediment in percentage of runoff	Soil condition
III.7	snowmelt	-	4.856	-	neg		wet
IV.9	19.6	13.50	0.016	0.1	neg		wet
IV.12	26.9	18.53	0.090	0.5	neg		wet
IV.13	11.7	8.01	0.056	0.7	neg		wet
V.13	11.3	7.78	0.114	1.5	neg		wet
V.20	30.7	21.14	0.169	0.8	neg		wet
V.23	17.1	11.78	0.068	0.6	neg		wet
V.29	14.5	9.97	0.090	0.9	-		wet
VI.7	15.8	10.88	0.152	1.4	-		wet
VI.23	12.9	8.88	0.034	0.4			dry
VII.26	10.2	7.02	0.068	1.0			dry
VII.28	11.5	7.92	0.079	1.0			wet
VIII.6	24.1	16.60	0.133	0.8			dry
VIII.7	26.3	18.11	0.170	0.9			wet
VIII.8	21.3	14.67	0.192	1.3			wet
VIII.9	19.7	13.57	0.057	0.4			wet
VIII.10	19.0	13.09	0.113	0.9			wet
VIII.12	18.3	12.60	0.283	2.2			wet
IX.23-25	109.2	75.21	4.588	6.1	neg		wet

Table 20 Precipitation and runoff in the (large) plots nos 1 and 2 at Bakonynána (compiled by Á.KERTÉSZ, 1984)

Date	Precipitation mm	Amount of rainfall received by plot (m^3)	Runoff (m^3) plot no 1	Runoff in percentage of rainfall received by plot no 2	Runoff (m^3) plot no 2	Runoff in percentage of rainfall received by plot no 2
1984.III.7	snow-melt	-	4.856	-	4.974	
IV.9	19.6	13.50	0.016	0.1	0.036	0.3
IV.12	26.9	18.53	0.090	0.5	0.040	0.2
IV.13	11.7	8.01	0.056	0.7	0.018	0.2
V.20	30.7	21.14	0.169	0.8	0.036	0.2
V.23	17.1	11.78	0.068	0.6	0.039	0.8
V.29	14.5	9.97	0.090	0.9	0.049	0.5
VI.7	15.8	10.88	0.152	1.4	0.019	0.2
VI.23	12.9	8.88	0.034	0.4	0.057	0.7
VII.26	10.2	7.02	0.068	1.0	0.011	0.2
VII.28	11.5	7.92	0.079	1.0	0.013	0.2
VIII.6	24.1	16.60	0.133	0.8	0.045	0.3
VIII.9	19.7	13.57	0.057	0.4	0.026	0.2
VIII.10	19.0	13.09	0.113	0.9	0.042	0.3
VIII.12	18.3	12.60	0.283	2.2	0.015	0.1

Table 21 Runoff from small plots of test site no 2 at Bakonynána (compiled by Á.KERTÉSZ, 1984)

Date	Precipitation mm	Plot no 1 Runoff l	%	Plot no 2 Runoff l	%	Plot no 3 Runoff l	%	Plot no 4 Runoff l	%	Plot no 5 Runoff l	%
1983.X.11	28.9	5.0	0.4	10.0	3.8	10.0	7.7	7.0	4.1	5.0	0.9
XI.27	27.2	-	-	not interpretable							
1984.IV.12	26.9	overflow in each tank									
IV.13	11.7	10.0	1.9	8.0	7.3	8.0	11.3	8.0	11.4	5.0	2.2
V.13	11.3	-	-	1.9	2.0	3.8	0.8	3.8	5.4	7.6	3.5
V.20	30.7	4.0	0.3	2.0	0.7	1.5	1.1	1.5	1.9	1.0	0.2
V.23	17.1	7.5	1.0	7.5	5.0	5.0	0.7	5.0	5.0	5.0	1.5
V.29	14.5	9.5	1.5	3.8	2.9	3.8	0.6	3.7	4.1	-	-
VI.7	15.8	-	-	3.8	2.7	1.9	0.3	5.7	5.7	1.9	0.6
VI.23	12.9	not interpretable									
VII.26	10.2	0.5	0.1	0.2	0.2	0.2	0.4	0.1	0.2	0.1	0.1
VII.28	11.5	1.0	0.2	0.4	0.4	0.5	1.0	4.0	5.7	5.0	2.3
VIII.6	24.1	4.0	0.4	1.0	0.5	5.0	4.5	5.0	3.6	4.0	0.9
VIII.7	26.3	0.6	0.1	1.2	0.5	4.5	3.8	5.0	3.1	5.0	1.0
VIII.8	21.3	0.6	0.1	0.2	0.1	1.1	1.1	4.5	3.5	5.0	1.2

September 2

L o c a l i t y 3

ZALAHALÁP

LÁSZLÓ GÓCZÁN,* DÉNES LÓCZY* and LÁSZLÓ SZALAI*

The influx of nutrients, pesticides and sediment aggravates the danger of eutrophication of Lake Balaton. Five years ago measurements began to find ways of efficiently reducing surface runoff and the wash-off of nutrients.

The *experimental plot* is designed in a vineyard on the southern slope of the Haláp Hill (358 m above sea level). There are nine plots of vine-stocks on the plot of 25 per cent *average slope (Fig. 1)*. The amounts of soil loss, surface runoff and the fertilizer content of eroded soil are trapped in recipients *(Fig. 2)* and measured under controlled conditions (registered rainfall intensity and set amounts of fertilizer - *Table 1)*. (The use of fertilizers on the catchment of Lake Balaton has been strictly restricted recently.)

To reduce soil erosion by high-intensity summer showers, the vineyards previously weeded are increasingly protected by grass. The experiments showed that densely grown grass did not inhibit the runoff induced by prolonged low intensity autumn rainfalls, because the water flowed down over the surface of the full wet grass, for that reason the runoff is increased in autumn and spring.

Under the *climatic conditions* of Hungary soil moisture replenished by autumn and winter rainfalls is indispensable for plants. In vineyards of the southern slopes moisture from autumn and winter precipitation stored in the soil is available with traditional cultivation. With grassing, however, in drier springs drought may occur.

---

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

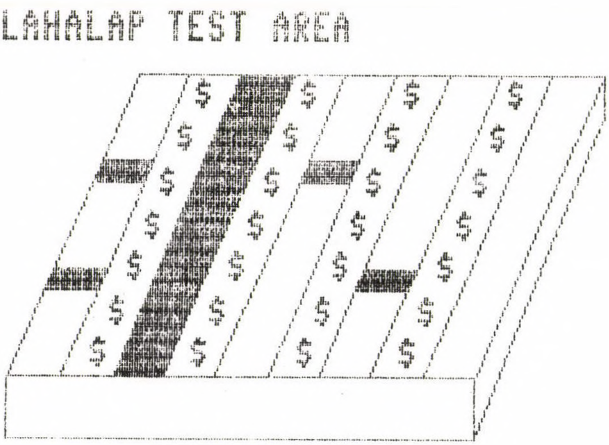


Fig. 1 Zalaháláp test area

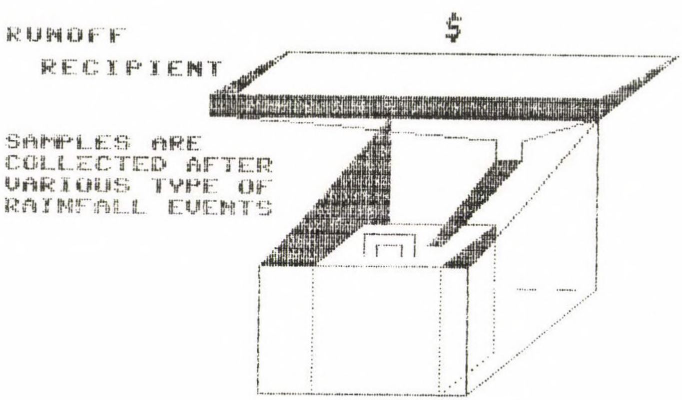


Fig. 2 Runoff recipient at Zalaháláp

In our *experiments,* in the inflexion zone of slope a strip of grass of only 1 m width was left rectangular to the isohypses *(Fig. 1).* On the margin of the concave slope segment another 1 m wide strip of grass was grown. Other soil surfaces were weeded. The two narrow strips of grass proved to be efficient in reducing soil erosion and to filter the suspension leaving the surface during summer showers. At the same time,

Table 1 Measurement at Zalahaláp test area

plot number / measurements	1	2	3	4	5	6	7	8	9
20.11.84 26 mm rain	< 50	320	410	-	2000	1850	800	-	150*
30.01.85 melt water	7700	510	22080	-	22550	22050	1605	-	550*
21.05.85 rain after dry spring	1950	440	170	1960	710	990	1160	-	600*
06.06.86. 39 mm rain	560	620	700	4370	600	660	90*	-	-

*

error in data because of technical problems the low intensity rainfalls in autumn and winter provide infiltration into the soil. Consequently, autumn and spring surface runoff becomes minimum and pollution remains at insignificant levels.

The two narrow strips of grass proved to be efficient in saving chemical fertilizers, pesticides, rain, and melt water into the soil in autumn and spring.

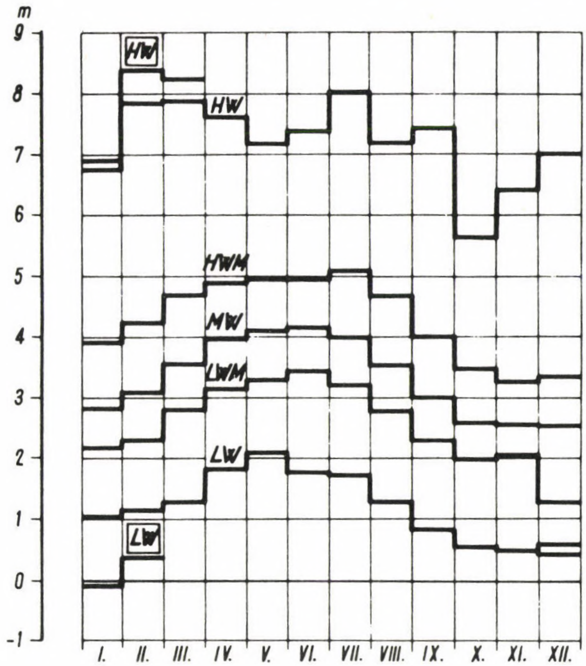


Fig. 3 The water budget of the Danube at Budapest. Characteristic water levels between 1901 and 1960 (after W.LÁSZLÓFFY)

HW = High Water; HWM = High Water Medium; MW = Middle Water; LWM = Low Water Medium; LW = Low Water

but ordinarily the Danube is navigable during the whole year except in dry and cold winters when it is covered with ice for several weeks. The discharge of the Danube at Budapest is 600 m^3/sec. at the lowest water level, and 10,000 m^3/sec. at the highest. The water level difference between the highest and lowest levels is as much as 8 metres (26 ft.) yearly. Experience has shown that in constructing dams, flood waves of a maximum of 10 metres (33 ft.) above low water level have to be reckoned with on the Great Plain.

The Danube, however, does not freeze every year. At Budapest, for instance it is on the average only every second year that the Danube freezes over, and then freezing usually occurs in the period between December 25 and February 25. With the exception of the periods of drifting ice and of complete freezing, the Danube is navigable throughout its Hungarian

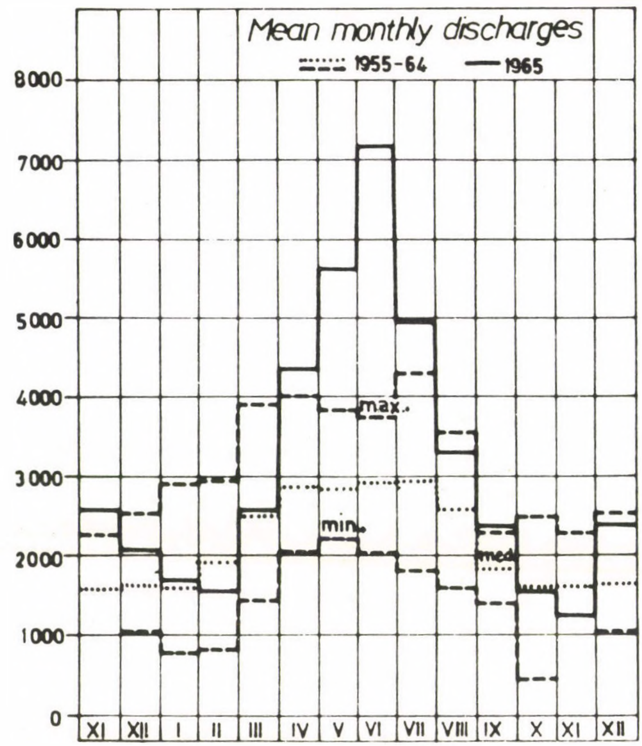


Fig. 4 Mean monthly discharges of the Danube in Budapest 1955-1964 and 1965

section. Significant trade takes place among the countries lying along the Danube. Smaller marine vessels can be in service up to Budapest. While Hungary does not possess a seaport, the Danube is a very important waterway to the seaports of Southeastern European countries. The Bös(Gabčikovo)-Nagymaros Barrage System under construction *(Fig. 5)* and the projected Danube-Tisza canal serve the improvement of this function *(Fig. 6)*.

The Danube is of great economic importance not only for transport but also in supplying drinking and industrial water to the towns on its banks. In addition, ever increasing areas are being included in the irrigation schemes whose water requirements are supplied by the Danube. It is a very important task to safeguard the Danube's water quality because the towns

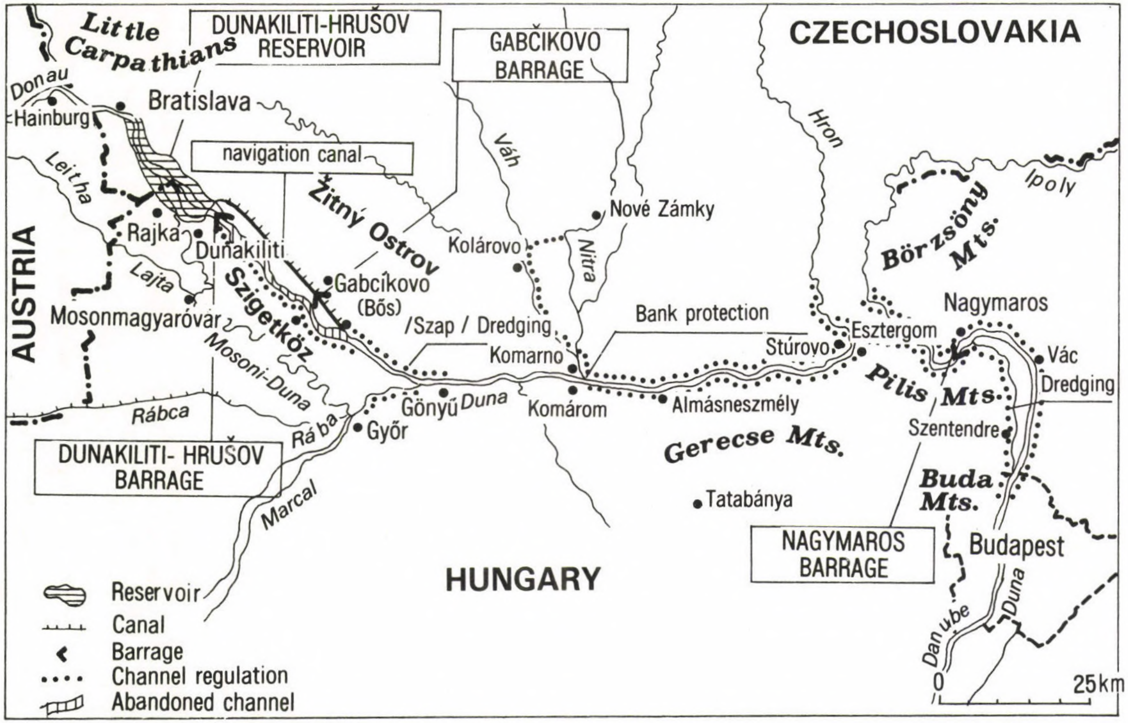


Fig. 5 Location of the Bös(Gabčikovo)-Nagymaros barrage system

1 = reservoir at Dunakiliti-Hrušov; 2 = barrage at Dunakiliti; 3 = diversion canal; 4 = barrage, hydro-electric power station, dam at Gabčikovo; 5 = bed dredging; 6 = barrage, hydro-electric power station, dam at Nagymaros

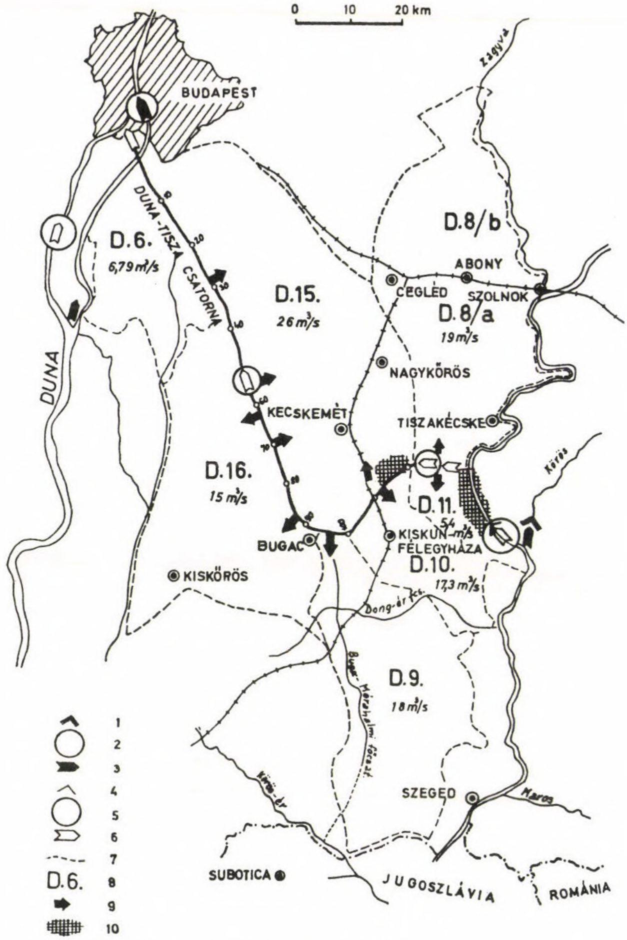


Fig. 6 Location of the Danube-Tisza canal

1 = existing barrage; 2 = existing hydro-electric power station and/or pumping installation; 3 = existing dam; 4 = planned barrage; 5 = planned hydro-electric power station and/or pumping installation; 6 = planned dam; 7 = irrigation system; 8 = number of irrigation systems; 9 = intake; 10 = reservoir

settled close to it can only be supplied with satisfactory quantities of water by the Danube.

The right-bank tributaries of the Danube within Hungary have a small discharge. In the Little Plain there are larger rivers which include the *Lajta* and the *Rába,* as well as the *Répce* and the *Marcal* which flow into the Danube at Györ. From the Transdanubian Mountains only small brooks flow into the

Danube. Only the *Sárviz* is worthy of note. It meets the Danube with the *Sió,* which is the gutter of Lake Balaton. The *Kapos* flows into the Sió before it meets the Sárviz.

The only right-bank tributary of appreciable discharge is the *Dráva* (Drave). Its catchment area is 40,000 sq.km., and it is 720 km long. This river constitutes the Hungarian-Yugoslav frontier, but its mouth lies in Yugoslav territory. The Dráva has as many as three floods, one in early spring, the second in early summer, and the third (a Mediterranean feature) in early autumn.

Some of the left-bank tributaries of the Danube flow from outside of Hungary, and their mouths are located along the Czechoslovak border; the rest are insignificant.

REFERENCES

Duna. 1-4. 1970-1971: VITUKI-Kartográfiai Vállalat, Budapest (Vizrajzi Atlasz sorozat - Hydrological Atlas series)

PÉCSI, M. 1971: The development of the Hungarian section of the Danube Valley. = Geoforum. 6. pp. 21-32.

PÉCSI, M. - SOMOGYI, S. 1971: The hydrography of Hungary. = Hungary. Geographical studies. IGU European Regional Conference. (Ed. by M.PÉCSI - Gy.ENYEDI - S.MAROSI) Budapest. Geogr.Res.Inst. Hung.Acad.Sci. pp. 125-134.

LÁSZlÓFFY, W. 1982: A Tisza. Vizi munkálatok és vizgazdálkodás a tiszai vizrendszerben. (The Tisza river. Water management in the Tisza water system.) - Akadémiai Kiadó. Budapest. 610 p.

September 3

LOESS BLUFFS ALONG THE DANUBE

MÁRTON PÉCSI*

More than half of the territory of Hungary is covered by loess of various type and thickness. In addition to slope loess on pediments and hillslopes, low plateau loesses are also widespread. The latter are deposited on higher alluvial fan surfaces and their thicknesses vary between 40 and 60 metres. This loess type is mostly located along the western banks of the Danube in the Great Hungarian Plain section of the river, south of Budapest. The westward shifting lateral erosion of the Danube formed a series of loess bluffs of 30 to 50 m height along a section of 180 km length, where landslides and other mass movements repeatedly occur *(Fig. 1)*.

Six bluff sections are distinguished:

1. The *Érd bluff* is 30 to 50 m high, subvertical and about 3 km long. Along this stretch the Danube directly undercuts the base of the bluff constituted of Miocene clay and sand layers. Several minor instabilities have recently been recorded here.

2. Most of the *Ercsi bluff* is vegetated and the vertical walls typical of the Érd bluff are absent here. Average slope inclination is 30 to 40°. There are no alluvial deposits at base. Locally, 60 to 80 m long landslides produced 5 to 10 metre wide rupture fronts or scarps. Fossil slumps are partly or completely overgrown by vegetation. River bank is protected near the village of Ercsi (terracing, careful garbage disposal). South of the village the river gradually moves away

---

*

Geographical Research Institute Hungarian Accademy of Sciences, Budapest

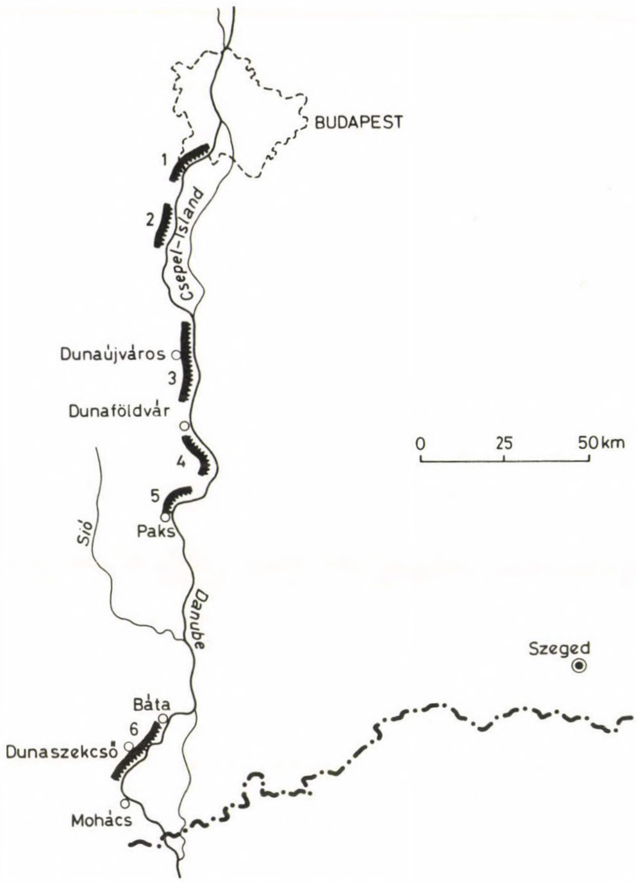


Fig. 1 High bluffs along the right bank of the Danube River on the Great Hungarian Plain (after M.PÉCSI)

1 = Érd bluff; 2 = Ercsi bluff; 3 = Kulcs-Dunaújváros bluff; 4 = Dunaföldvár bluff; 5 = Paks-Dunakömlöd bluff; 6 = Báta-Dunaszekcsö bluff

from the bluff and the channel runs along the margin of the early Holocene flood-plain of the so-called 'Adony embayment'.

3. The *Kulcs-Dunaújváros bluff* is 20 km long. Landslides have been most frequent and most damaging here. Consequently, a number of features (scarps, debris lobes) can be observed. To the south the bluff becomes gradually lower and lower. 5 to 10 m thick fluvial sandy gravel deposited between the Danube channel and the bluff. Thus, direct bank erosion only occurs during floods. Slump tongues have been removed by

floods. The springs issuing forth at the base of the bluff do not 'swell back' and, therefore, landslide hazard is insignificant.

4. Along the *Dunaföldvár bluff* the Danube undercuts the Mezöföld plains by lateral erosion. The major slab landslide of 1970 took place south of the railway bridge, where the bluff is vertical and 50 m high.

5. The Danube meander below the *Paks-Dunakömlöd bluff* was regulated (canalized) in 1854. Before regulation and road and railway constructions the river had intensely eroded the bank. The bluff is subvertical and only a narrow zone is left at its base for the communication lines. Remnants of fossil and recent slides are observed and have been mapped.

6. The *Báta-Dunaszekcsö bluff* is a 15 km long eastern margin of the loess-mantled Baranya Hills undercut by the Danube. To the south the undulating surface of fossil and recent slides slopes towards the alluvial plain. Still further south the vertical bluff is deeply dissected by recent slides.

REFERENCES

PÉCSI, M. 1972: Magyarország geomorfológiai térképe (Geomorphological map of Hungary) 1:500,000. Kartográfiai Vállalat, Budapest.

PÉCSI, M. - SCHWEITZER, F. - SCHEUER, Gy. 1979: Engineering geological and geomorphological investigation of landslides in the loess bluffs along the Danube in the Great Hungarian Plain. - Acta Geol.Hung. 22. pp. 327-343. (= Studies on on Loess. Akadémiai Kiadó, Budapest, 1980.)

PÉCSI, M. ed. 1985: Environmental and dynamic geomorphology. Case studies in Hungary. Akadémiai Kiadó, Budapest. 220 p. (Studies in Geography in Hungary, 17.)

Locality 5

LANDSLIDE CONTROL AT DUNAÚJVÁROS

MÁRTON PÉCSI*, FERENC SCHWEITZER* and GYULA SCHEUER**

Important settlements and industries are located along the margin of the loess plateau. Dunaújváros (population: (62,000) has Hungary's largest iron and steel works (Dunai Vasmü) built in the 1950's. It is near the Danube, a waterway and source of industrial water. The housing development of this new ('socialist') town is also on the loess plateau, 40 to 50 m above the flood-plain of the Danube. In spite of detailed preliminary geotechnical research, safe foundations and other precautions, landslides took place along the loess bluff. Engineering geological research revealed the location of shear planes and failure fronts, founded the strategies for river bank protection.

Over a considerable part of the Dunaújváros bluff loess was formed on the terraced alluvial fan of streams flowing from the Mezöföld towards the Alföld *(Figs. 1 and 2)*. Four terraces buried between loess horizons are clear along 2 km stretch (Fig. 3). The streams depositing this alluvial series formed a broad terraced valley running northwest-southeast across the loess surface during the Upper Pleistocene. The valley was filled by 10 to 15 m of loess at the end of the last glaciation.

Borehole data show that the Miocene surface lies at 91-101 m above sea level under the eastern part of the town and

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

** Institute for Geodesy and Geotechnics, Budapest

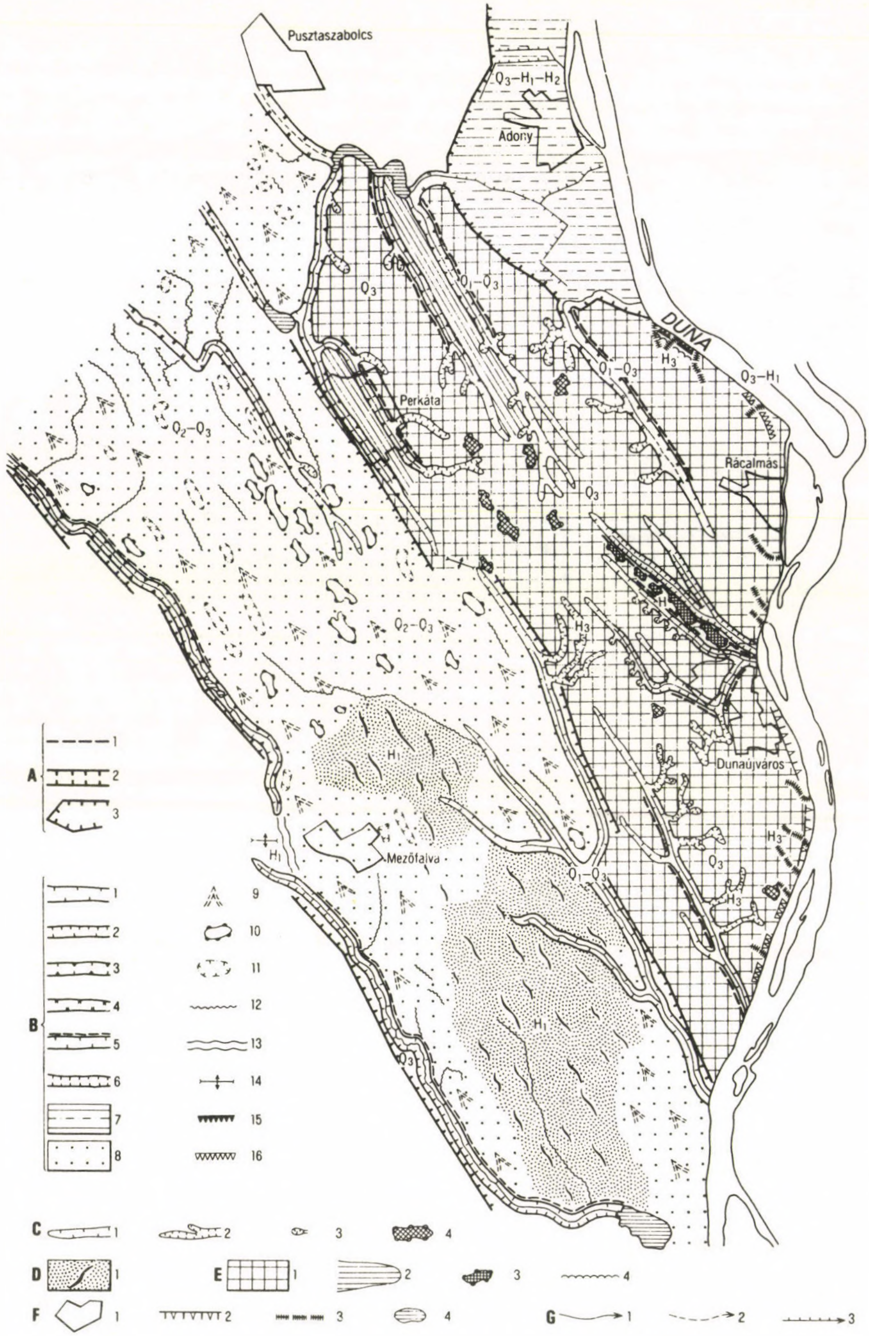


Fig. 1 Geomorphological map of Dunaújváros and environs (L.ÁDÁM)

Fig. 1 (cont.) - A. Tectonic features: 1 = fault line; 2 = tectonic graben; 3 = tectonic basin; B. Fluvial erosion and accumulation features: 1 = erosion valley in general; 2 = asymmetric erosion valley; 3 = deep erosion valley; 4 = filled flat erosion valley; 5 = terraced erosion valley; 6 = derasionally retouched erosion valley; 7 = flood-plain; 8 = alluvial fan; 9 = minor alluvial fans; 10 = residual elevation; 11 = flat depressions; 12 = abandoned waterlogged channels; 13 = breached valley; 14 = valley divide; 15 = active bluff; 16 = inactive bluff; C. Derasion features: 1 = derasion valley in general; 2 = hanging derasion valley; 3 = hanging derasion cirque; 4 = derasional residual hill; D. Deflation features: 1 = blown sand surface (dunes and wind furrows); E. Features of complex origin: 1 = loess plateau; 2 = erosion-derasion ridge; 3 = erosion-derasion residual hill; 4 = slope with landslide hazard; F. Man-made features: 1 = settlement; 2 = artificially terraced bluff; 3 = deep-cut track, gorge in loess; 4 = fish-pond; G. Hydrography: 1 = permanent water-course; 2 = intermittent water-course; 3=canal; H. Age of landforms: Q = Quaternary in general; Q_1 = Lower Pleistocene; Q_2 = Middle Pleistocene; Q_3 = Upper Pleistocene; H = Holocene in general; H_1 = Early Holocene; H_2 = Late Holocene; H_3 = recent

along the edge of loess plateau, while it is found at 108-112 m further west. Late Miocene sediments have a thickness of 670-680 m, the majority of which deposited in the shallow Pannonian sea. Below the marine sequence lie 954 m of Miocene rhyolitic tuffs on crystalline slates of the basement.

The marine sequence is subdivided into two formations. The upper is highly variable and consists of a rhythmic sequence of shallow water deposits accumulated during marine regression (sand, silty clay, dark marsh deposits and, at the base, sandstones with calcareous and clay horizons). The lower formation has thicker strata and a 10 to 20 cm lignite bed.

Cores do not indicate any significant tectonic movements affecting the marine sediments; the dark marshy and sand deposits can be followed throughout the bluff. There were no significant changes in the deposition environment either. A trial pumping successfully reduced groundwater table in similar aquifers over large areas. This would not have been possible if major tectonic activities had occurred.

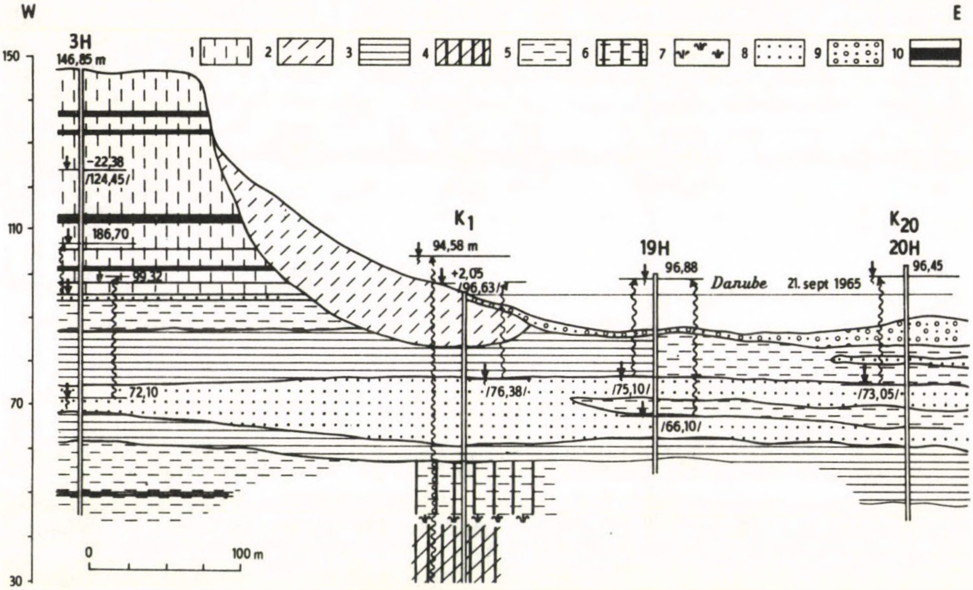


Fig. 2 Geological section across the loess bluff at Dunaújváros (after Gy. SCHEUER)

1 = loess; 2 = slope-loess; 3 = clay; 4 = clay with sandstone beds; 5 = silt; 6 = silt with limestone beds; 7 = bog; 8 = sand; 9 = gravelly sand; 10 = loam

Dunaújváros is situated at a distance of 1581 km from the mouth of the Danube and 1280 km from its source. Here the catchment area of the river is 188,000 km^2 (23 % of total catchment).

The 80 km stretch of the Danube from Ercsi to Paks is identical in physique, being characterized by the asymmetry of the river-bed and valley cross-section *(Fig. 4)*.

The river channel is wider over the more resistant gravel beds than over the less consolidated alluvium where the bed is deeply incised, and for this reason the channel varies in width between 380 and 800 m, being 480 m wide opposite the city at mean water level.

Because of the heterogeneity of the bed material involved neither the longitudinal section of the river-bed nor the depth of water relating to different stages of flow are uniform. For example, at low water stage the river varies from 3 to 7 m depth. Gradients vary from 4 to 15 cm in channel

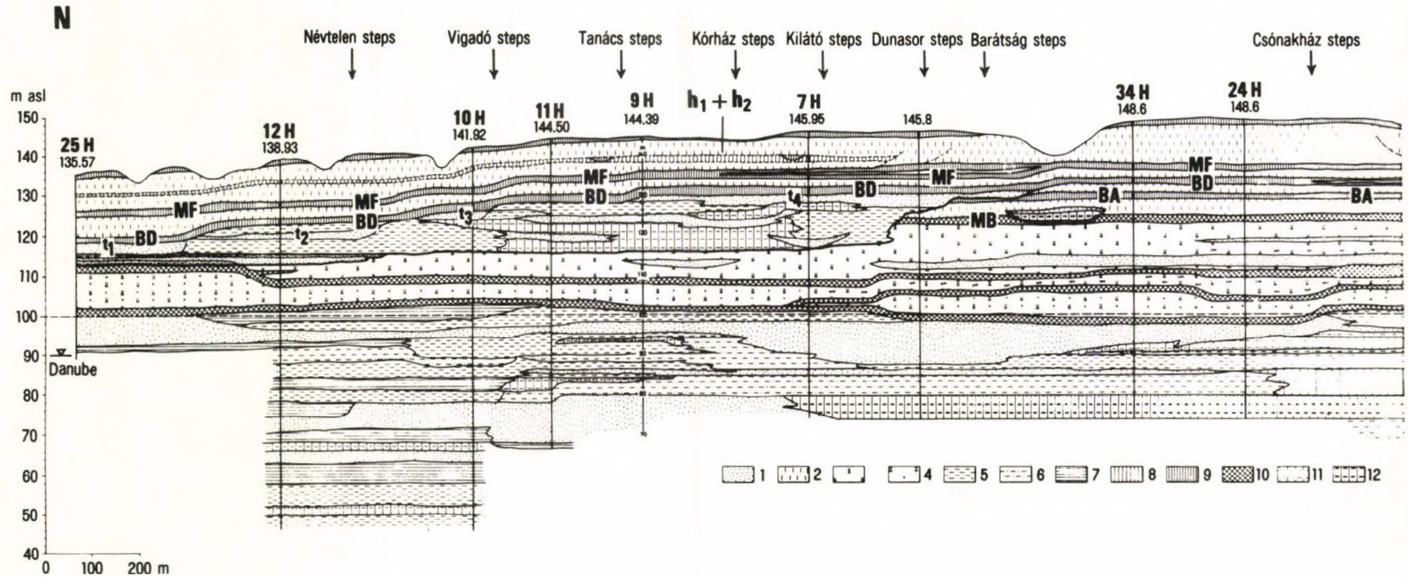


Fig. 3 Lithological profile of the loess bluff at Dunaújváros (compiled by M.PÉCSI-E.SZEBÉNYI)

1 = sand; 2 = loess; 3 = old loess; 4 = loess silt; 5 = silt; 6 = sandy silt; 7 = clay; 8 = embrionic humic soil; 9 = steppe soil; 10 = brown forest soil; 11 = hydromorphic soil; 12 = meadow soil; t1-t4 = alluvial fan terraces of a Danube tributary covered by loess; H = hydrogeological boreholes; MB, MF, BA, BD and PD = marker paleosol complexes

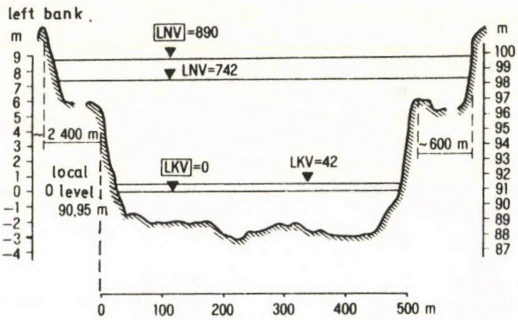


Fig. 4 Cross-section of Danube at Dunaújváros (from Hydrological Yearbook)

cross-section, from 5 to 21 cm at low water and from 4 to 8 cm at high water stage. As a result, identical rates of discharge are carried in given cross-sections of the stretch in question at different water stages.

Record water levels over the stretch under consideration were all recorded in summer, the early summer flood in 1965 being the all-time maximum at 742 cm. The record low (42 cm), by contrast was provoked by the dry autumn of 1947, giving a range of variation of exactly 7 m. Water level measurements have been conducted at Dunaújváros since 1872, and by the data files, low and high water levels may occur in any month of the year, but in other periods changes in level are generally more moderate.

Water levels affected by freezing or drifting *ice* are exceptions to this. The stretch both upstream and downstream from Dunaújváros is shoaly. Despite regulation, drifting ice-jams when the river freezes over or when the pack-ice breaks up, provokes especially low stage values downstream and high stage values upstream, respectively. For example, the lowest water level ever observed at Dunaújváros on such occasions was 0 cm, while the maximum was as high as 890 cm, giving an absolute amplitude of 890 cm. These record values were recorded in 1946 when the river froze over in autumn and in 1956 when the vernal ice flood travelled down the river.

Differences in *discharge* are partly compensated for by changes in the velocity of flow. As shown by recent measurements, the lowest discharge is about 573 m^3/s, with a mean of 2380 m^3/s, while the velocity of flow varied according to water level, ranging from 0.5 to 1.8 m/s. Discharge is highest at the beginning of summer and lowest in autumn, the discouraging navigation being generally known. The strikingly high water levels associated with periods of ice are due to the backing-up effect of ice-jams, rather than to any particularly high rate of flow. Water temperature cannot drop below 0°C. The average temperature of the water varies from 0 to 25°C over the Dunaújváros stretch. Ice has appeared as early as 16 November, although the mean is as late as 16 December. The earliest freezing-over took place on 14 December, but the average date for this is 13 January. The river has remained frozen as late as 25 March, although the ice usually disappears around 19 February. Accordingly, the ice period may last in extreme cases for as long as 91 days, although the average is 38 days. The greatest ice thickness ever measured is 46 cm. The breaking up of the ice is never due to local climatic factors, but is always provoked by meltwater from the upper reaches of the river. Long-term observations show that the probability of the occurrence of ice is 90 %, and that of freezing-over is 50 %.

Sediment discharge varies with water level and rate of flow. Between 1931 and 1940 the average of sediment load was 1159 g/m^3, equivalent to a rate of transport of 370 kg of sediment per second over the Dunaújváros stretch. This corresponds to 11,700,000 tons a year and, recalculated for the catchment as a whole, implies the erosion of 62 tons of material per square kilometre. Bed load is low compared with suspended sediment, barely attaining 28,000 tons a year, i.e. 0.9 kg/s. At times of flood the amount of sediment transported rises to 1200 g/m^3, suspended sediment load being as high as 9200 kg/s, and bed load increasing to 17 kg/s.

Water quality varies with the input of pollutants from both banks and the distance needed for their elimination by the mechanism of self-purification. Pollution from Budapest agglomeration decreases downstream from around the village of Ercsi, which means that at Dunaújváros the water is again of an acceptable quality. South of Dunaújváros, however, the polluting effect of local industrial plants can again be observed.

The Danube has been regulated since 1895, primarily for the purpose of reducing the impact of ice-induced flooding, by narrowing wide shallow sections of the river and by the closure of subsiduary channels. This is why Szalki island has been artificially joined to the right bank, thus producing an area of quiet-water which has been developed into a winter harbour and docks for the industrial plants of Dunaújváros.

In the Dunaújváros region *groundwater* is stored in sand, loess, Danubian gravels and landslide accumulations associated with the Danubian bluff. Its role in landslide development is decisive. The groundwater in loess is at depths of 10 to 30 m, depending on the morphology and the precise position of intercalated sand and paleosol layers. Sand aquifers of 3-4 m thickness are found at two main levels. The upper sand layers is 20-25 m below the surface, while the lower is at 30-35 m (on average 114 m above sea level). Their permeability surpasses that of loess. Where sand are thicker, large amounts of water emerge as springs or form spots of poor drainage, which may induce landslides.

Groundwater issues from sand layers interbedded in loess as the *upper row of springs*. Water discharges fluctuate but some have yields amounting to 10 l per min. The discharges do not depend on precipitation.

The *lower springs* were along the base of the bluff and in the Danube bed. After the construction of the embankment most of them disappeared. the analyses of their chemistry indicated that these springs were fed from Late Miocene sand aquifers. Since these are aquifers under pressure, spring water is able to rise several metres through the river deposits. Spring activity along the Danube bed was often impeded by flood conditions involving increased groundwater pressure. After floods, the activity of the lower row of springs used to increase markedly and they would be able to transport considerable amounts of sand and finer sediments, producing piping features in the sand layer.

Deeper lying sand aquifers contain confined groundwater. They are generally of regional extent but some are only local. The uppermost sand aquifer lies at 95 to 101 m above sea level, it extends over the line of the Danube, mainly under the northern part of the town. Water pressure in this aquifer decreases gradually from the river to the bluff with an abrupt drop at the edge of the loess plateau.

Five further aquifers are found; water pressures increase with their depth. The layers slope gently towards the Danube and are not interconnected. The changes in water level observed in wells cannot only be explained by the water regime of the Danube. They are rather influenced by the general hydrological regime affecting deeper-lying aquifers.

Gy.SCHEUER suggested that pumping and water intake would reduce groundwater table over large areas and thereby significantly reduce landslide hazard along the Dunaújváros bluff. The experience of the last 10 years confirmed that terracing the bluff and draining its groundwater can completely stop mass movements. The embanked slopes are now reinforced and planted with grass.

Archaelogical data for the Bronze Age and various military maps show that some parts of the *bluff* have *receded* 60 m since Roman times. The rate of recession was 3 to 5 m per hundred years. The inhabitants of Dunaújváros (earlier Dunapentele) remember several major slumps along the bluff both before and after the Second World War. The landslides of 1943-44 and 1947-48 were particularly big; in the 1950's movements took place near the new town and the iron works.

The most serious *landslide* took place on February 29,1964. Along a 1300 m stretch, 10 million m^3 of clay to a depth of 20-25 m slipped towards the Danube. It was a rapid movement and the transported material accumulated in a series of islands rising 3-5 m above the mean water level of the Danube. Fortunately, nobody was injured, but the water supply of the iron works was disrupted and production held up. This event encouraged preventive measures based on geological and hydrogeological surveys.

Field research confirmed that both natural and human factors contributed to the landslide. The chief factor certainly was the steady westerly displacement of the Danube channel through undercutting and, thus, allowing gravity landslides. An additional factor is the actual geological structure of the bluff. Although loess is dominant, intercalated sands and paleosols have physical properties facilitating landslides.

Currents in the Danube erode the lobes of earlier landslides and as the new equilibrium is repeatedly upset, landslide hazard is always present somewhere. In the Dunaújváros area the water regime of the Danube has a range of 8 m. At high water groundwater flow is impeded, water pressures increase. Reduction of water level and release of pressure contribute to the formation of landslides. At low water piping induced by groundwater flow removes particles and weakens the bluff. The shear plane is found in Upper Miocene sand at cca 85 m above sea level, i.e. 8-10 m *below* the bluff base. The precise position could be established from the fact that chemical analysis indicates the intermixing of free and confined groundwater.

According to Á.KÉZDI (1970), leakage from the water supply and sewage system raises water table in loess. Where it is intensive, the low horizontal permeability of loess results in groundwater dome formation. In this view the occurrence of landslides may be correlated with these domes, rapid rises in groundwater table. In author's opinion, such a process may highly influence the date and location of landslides, but it cannot explain how a shear plane forms at the base of the slide.

Characteristics of slab landslides are treated at *Locality 6* (Dunaföldvár).

REFERENCE

KÉZDI, Á. 1970: A dunaújvárosi partrogyás (Bankslide at Dunaújváros).- Mélyépitéstudományi Szemle, 20. pp. 281-297.

Locality 6

LANDSLIDE CONTROL AT DUNAFÖLDVÁR

MÁRTON PÉCSI* and GYULA SCHEUER**

The village Dunaföldvár is 20 km the south of Dunaújváros, also on the loess bluff margin *(Fig. 1)*.

Here *layers* are subhorizontal *(Fig. 2)*. The loess sequence of cca 50 m thickness comprises typical, sandy and alluvial loess as well as intercalated paleosols. The old loess overlies Pliocene inland sea formations of sand, silt and clay. Along certain short sections, the location of clay layers corresponds to the mean water level of the Danube, while in other places they are 25 to 30 m lower than that.

Earlier landslides occurred along reaches where the clayey basement is in higher position, closer to mean water level. In the sandy layer between clay and loess infiltrating water moistens loess. At the foot of the bluff, groundwater is unable to reach the surface because the tongues of previous landslides obstruct its flow. Groundwater is not only recharged from the precipitation of the immediate neighbourhood but also from remote catchments. A sandy layer is also found in high position but it retains only a small amount of water and cannot initiate landslides.

A major *landslide* took place at the 1560 km mark of the Danube on September 15,1970 *(Fig. 3)*. The process of the landslide with slab failure can be reconstructed as follows: During the summer preceding the landslide above 600 mm precipitation

---

* Geographical Research Institute Hungarian Academy of Sciences, Budapest

** Institute for Geodesy and Geotechnics, Budapest

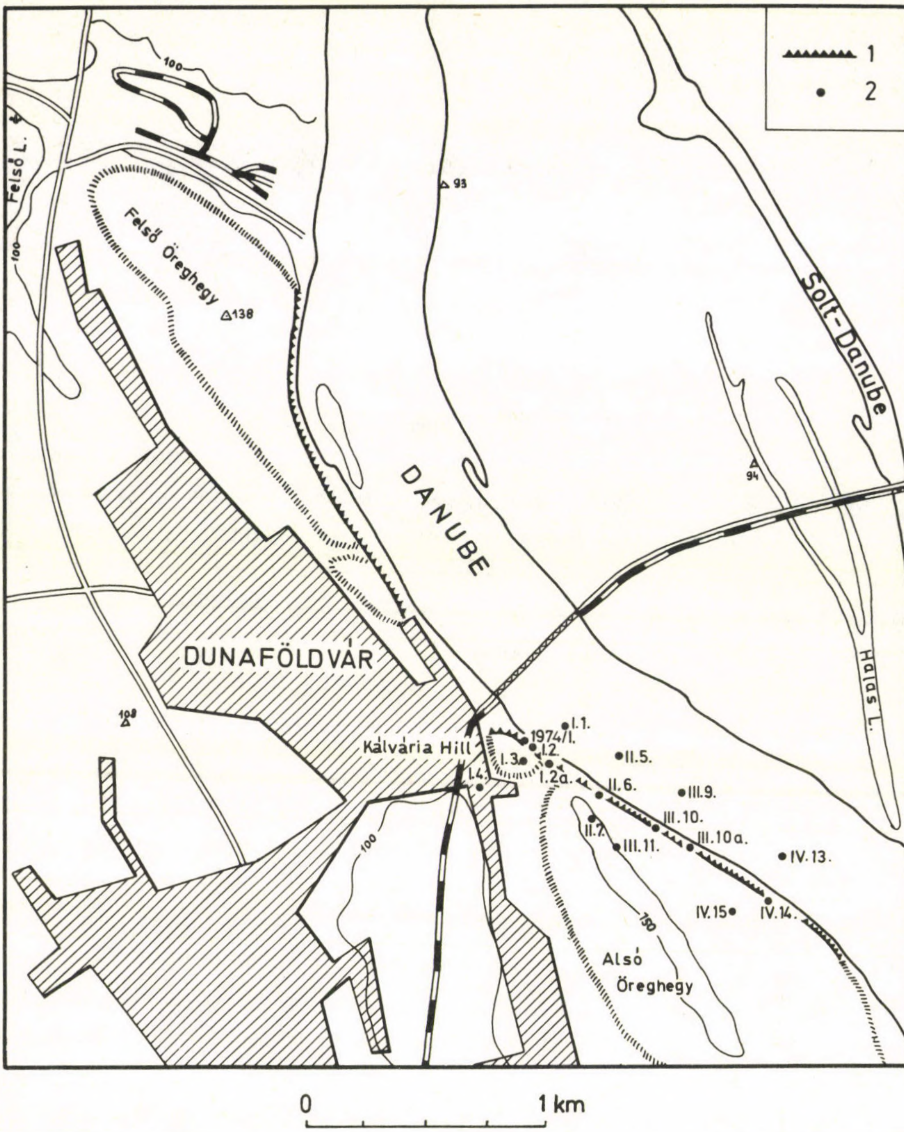


Fig. 1 Location of boreholes in the Dunaföldvár loess bluff (after M.PÉCSI)

1 = high and steep loess bluff; 2 = borehole site and number

was measured versus the average 500 mm. Several months before vertical fissures appeared on the margin of the loess plateau. The fissure network gradually deepened and widened. It occurred when the silty-sand layer below the otherwise dry loess sequence moistened and cohesion bonds weakened between its grains. The loess bluff was deeply ruptured along a network of fissures of 75 to 85°. The failure, however, was incomplete, since the separated slabs were still supported by the bluff, which remained stable and solid for weeks or months, until the basal layers of old loess moistened. The pressure exerted by the slabs suddenly reduced cohesion at a critical value of moisture and pressure. Simultaneous to the formation of the abrupt shear failure, the whole of the overlying slab collapsed and fell onto the lubricated clayey base layer. (According to local dwellers, it was accompanied by a loud bang).

The potential sliding plane was preformed in the contact zone of red clay of subhorizontal stratification and the loess sequence. Huge slabs slid down, under enormous pressure, along a concave curve. In the foreground of the landslide, clay was squeezed out in a form of a scaled imbricated structure. It built two arcs of islands rising from the Danube bed. They consist of Miocene-Pliocene clay and a red clay cover.

Slab landslides can be characterized as follows:

1. the potential sliding plane is geologically and geomorphologically preformed;

2. slab failure and its sliding plane develop on a horizontal impermeable clay layer at bluff base, in the form a gently sloping undercut;

3. the moistening effect of the aquifer above the impermeable layer;

4. the lower moistened loess loses its stability under the load of the cover layers; at a critical value of moisture shear occurs;

5. collapsing thick land slabs move rotationally without considerable horizontal displacement.

The most important in *protecting* the bluff against slab failures is to drain free and confined groundwater. Ob-

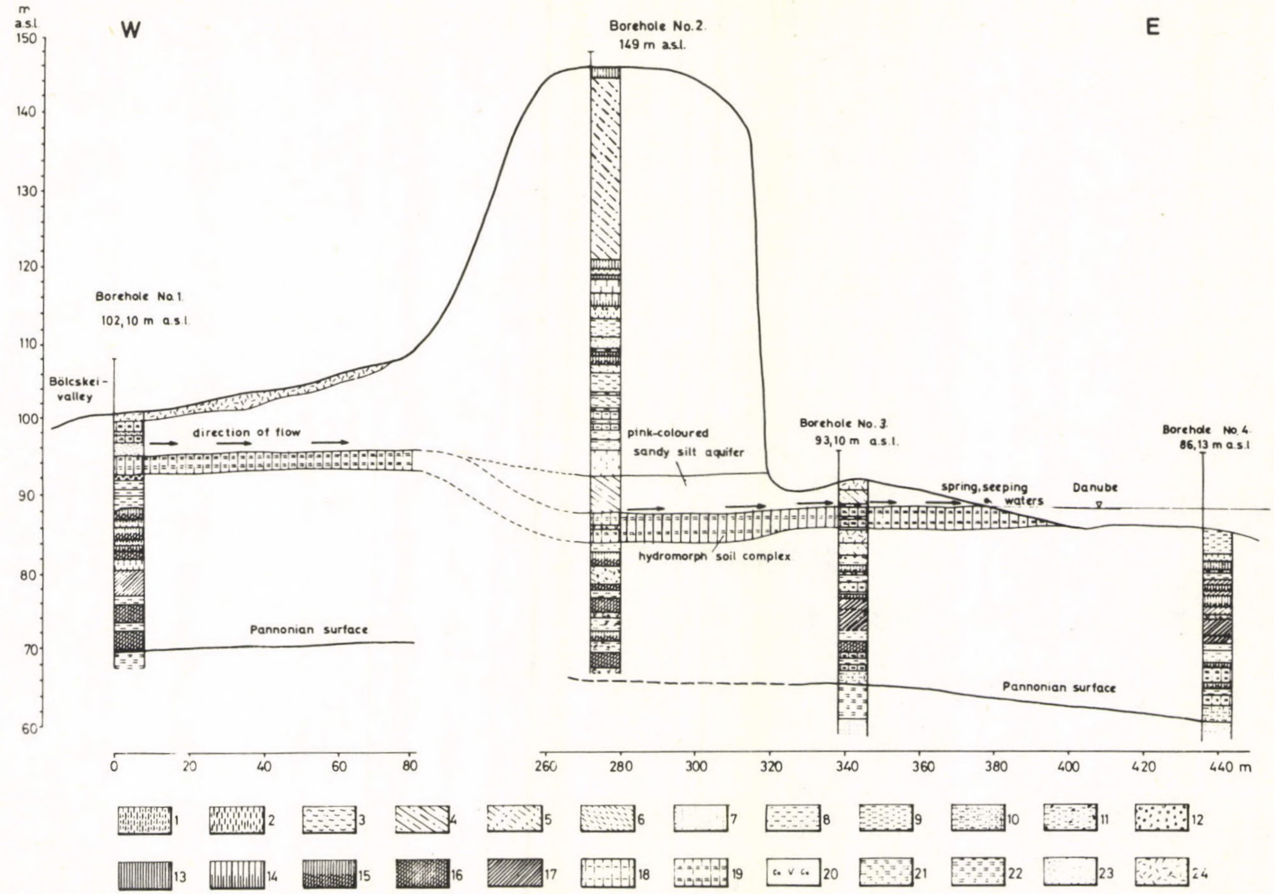


Fig. 2 Stratigraphic profile of the Alsó-Öreghegy at Dunaföldvár based on borehole data (after M.PÉCSI-Gy.SCHEUER)

Fig. 2 (cont.)

A. Eolian sediments: 1 = sandy loess; 2 = loess; B. Colluvial, deluvial sediments; 3 = sandy loess, stratified fill of a buried derasion valley; 4 = pink coloured fine sandy silt; 5 = stratified loessy sand; 6 = stratified loess; C. Fluvial-proluvial sediments: 7 = sand; 8 = silty fine sand; 9 = silty sand; 10 = coloured Fe and Mg spots in clay; 11 = brownish-yellowish $CaCO_3$ concretions in silty clay; 12 = sandy gravel; D. Recent and fossil soils; 13 = 'humus carbonate' soil; 14 = steppe-type soil; 15 = chernozem brown forest soil; 16 = brown forest soil; 17 = semipedolite; 18 = hydromorphic soil; 19 = alluvial boggy soil; 20 = $CaCO_3$ accumulation; E. Pannonian; 21 = grey-yellow clay; 22 = grey-yellow silty sand; 23 = sand; F. Anthropogenic forms: 24 = man-made fills

servations show that the sections where considerable infiltration takes place above the impermeable làyer or where spring activity diminishes.

Landslides repeatedly occur in response to the joint effect of factors like humid years, major fluctuations of the Danube level, coincidence of minor seismic tremors, influences of man-induced damming of water and the clogging of the aquifer at bluff base resulting from previous slides.

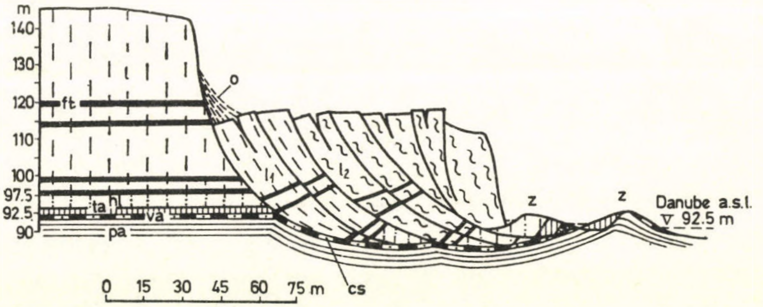


Fig. 3 The Dunaföldvár river-bank landslide to the S of the Danube's 1560 kilometre mark (M.PÉCSI-Gy.SCHEUER-F.SCHWEITZER)

l = loess sequence in primary position (autochtonous); l_1 = loess recently displaced by sliding; l_2 = waste of earlier slides; hl = pale pink sandy loess; o = talus; z = earth heap and Pannonian clay arising from the Danube's bed; ft = fossil soils; ta = dark grey clayey loam soil; pa = Pannonian clay; va = red clay; cs = sliding plane

REFERENCES

PÉCSI, M. 1978: Landslide at Dunaföldvár in 1970 and 1974. = Geographica Polonica. 41. pp. 7-12.

SZEBÉNYI, E. - SCHWEITZER, F. - PÉCSINÉ DONÁTH, É. - WAGNER, M. - PEVZNER, M. A. 1979: Complex evaluation of Dunaföldvár loesses and fossil soils,. (Bio- and lithostratigraphical, paleopedological, thermal and paleomagnetic investigation.) = Acta Geologica. 22. 1-4. pp. 513-537. = Studies on Loess. INQUA Loess Comm. Conference 1979. - IGCP Programme Magnetostratigraphy. P. 128.

HAHN, Gy. - PÉCSI, M. - SCHWEITZER, F. 1985: Environmental geomorphological investigation of loess bluffs for protection against landslides. In: PÉCSI, M. (ed.) Environmental and dynamic geomorphology. Case Studies in Hungary. Akadémiai Kiadó, Budapest. 85-96. (Studies in geography in Hungary, 17.)

Locality 7

LOESS PROFILE AT PAKS

GYÖRGY HAHN *

The most completely studied of loess exposures, the Paks brickyard (PÉCSI,M. 1979) with the adjoining loess bluff between Dunakömlöd and Paks has a length of about 3 km and is situated 105-108 km south of Budapest, in the vicinity of the Hungarian nuclear power plant. The Pleistocene series can be best studied in the 50-60 m slope of the brickyard, to the north in the exposure near the Paks railway station and at Dunakömlöd. A borehole at the latter locality exposed an additional 40 m deep Plio-Pleistocene sequence. Thus, total thickness is about 90 m (50-55 m from exposure and 40 m from borehole) can be described here, based on detailed lithological, pedological, paleontological, paleomagnetic and thermoluminescence analyses.

The sequence of the loess profiles in the area of Paks are divided into four chronological units *(Fig. 1):*

1. *The Dunaújváros-Tápiósüly loess series* in the youngest, 8-10 m deep series of the Paks exposure. It comprises stratified and non-stratified loose, porous, light yellow true loess and its sandy varieties. Among loess horizons two pale embrionic soils or humus horizons are generally intercalated and partly represent fills of derasion valleys (dells). In the upper of these horizons charcoal remnants occur in several

---

*

Geographical Research Institute Hungarian Academy of Sciences, Budapest

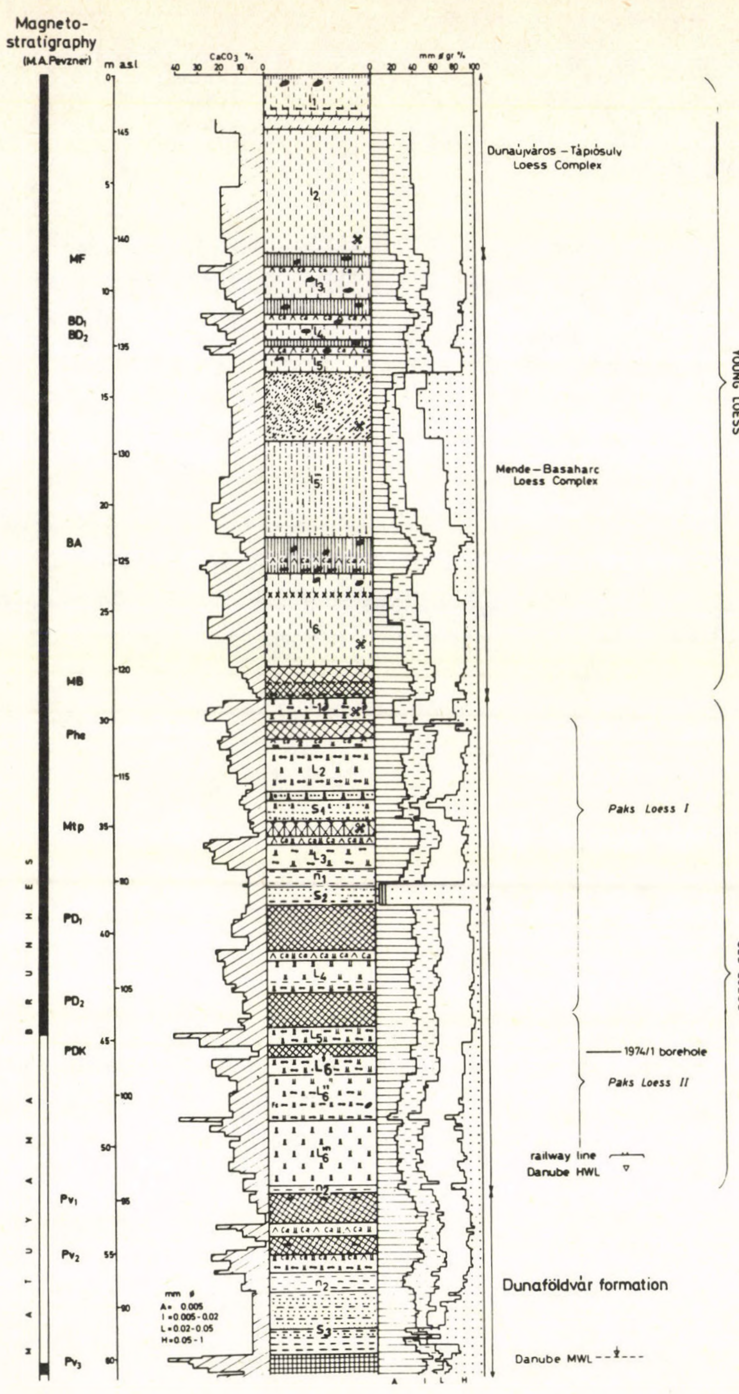


Fig. 1 Lithostratigraphical subdivision of the old and young loess-formation at Paks. The lithological and pedological analysis made by M.PÉCSI-E.SZEBÉNYI, the paleomagnetic measurements made by M.A.PEVZNER (Institute of Geology Acad.of Sci.USSR,1974)

loess exposures in Hungary. The stratotype was identified at Tápiósüly and the humus layer was dated 16,500-18,000 years *(Fig. 2)*.

The second humus horizon of the Paks exposure lies at 2-5 m depth from the surface. Its TL age is 21,700 ± 2,600 years. Its stratotype was described at Dunaújváros. Radiocarbon data suggest 20,000-22,000 years for this second humus horizon on the basis of analyses of several exposures in Hungary. The regional distribution of the charcoal of this humus horizon with Magdalenian culture finds (at Ságvár, Solymár etc.) indicates the activity of early men, also assuming extended natural forest fires. Above this humus horizon, at about 2 metre depth in the Tápiósüly key section and scattered at Paks horn remnants of Rangifer tarandus were abundant as a marker horizon. In the loess above the Mende Upper soil complex of the Dunaújváros-Tápiósüly loess series, skeletons of Elephas primigenius were found, in Hungary at Mende, Beremend and others. The uppermost part (Dunaújváros-Tápiósüly series) is typical young loess and its sandy varieties and only subdivided by humus horizons of 10,000-26,000 years.

2. *The Mende-Basaharc loess series* of young loess comprises four steppe soils and three loess horizons of 15-20 metre thickness. The upper member of the Mende Upper soil complex (partly or totally eroded at Paks) is pale grey chernozem steppe soil. By the radiocarbon dating of enclosed charcoal remnants it is dated 26,000-29,000 years in the Hungarian exposures. The lower member of the soil complex is locally well developed chernozem, while in other places chernozem-like dark brown forest soil with typical light brown spots of humus deficit. The charcoal debris recovered from the lower part of the soil complex (at Solymár) is dated 32,500 ± 2,000 years. Earlier this soil complex was evaluated as Last Interglacial, during the investigations by M.PÉCSI and his co-workers (1982) however, it was identified as formed in the youngest interstadial between the Middle and Upper Würm. By TL analyses at Paks its age is 33,500 ± 4,000 years.

Below loess 13 lies the 3.0 m thick double chernozem soil complex called *Basaharc Double*. Its age was determined from

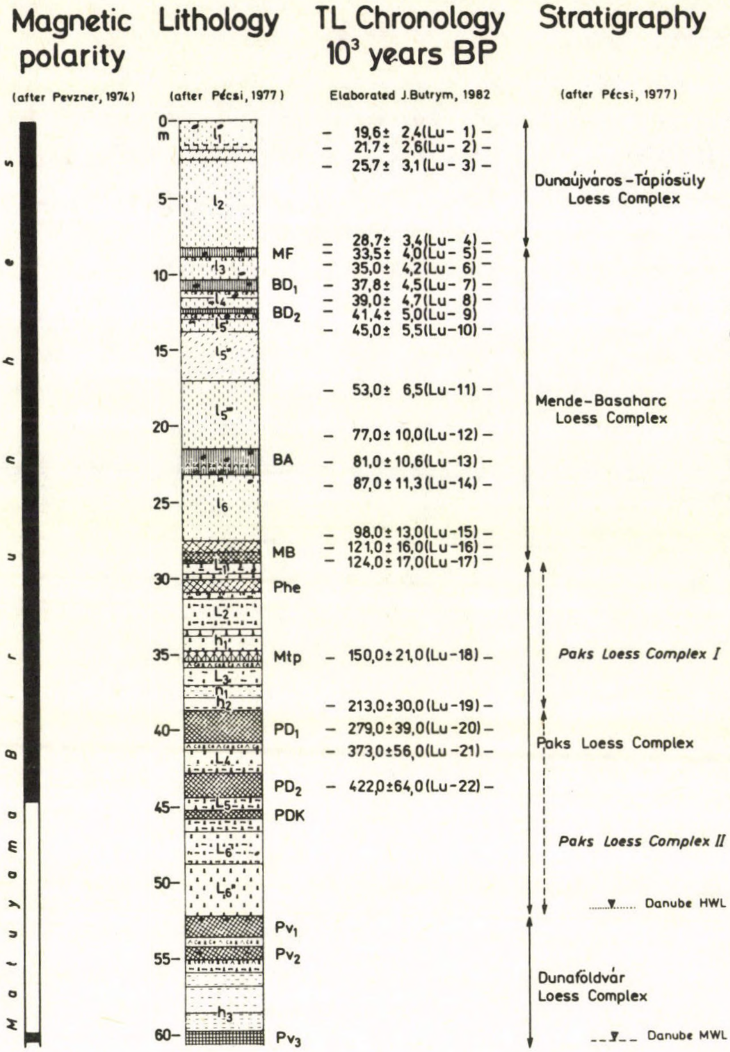


Fig. 2 Thermoluminescence chronology of the examined lithostratigraphical layers of the loess profile at Paks. Lithological and stratigraphical differentiation and the correlation with magnetic polarity diagram according to M.PÉCSI et al. (1977) and M.PÉCSI (1979), to the depth of 46 m - an exposure, below - a borehole 1974/1

l_1/l_6 = younger loesses; L_1/L_6 = older loesses; h_1/h_3 = fluvial sands; n_1/n_3 = silts the thickness of loess between the Mende Upper and the Basaharc Double paleosols, from the about 0.5-1.0 m per 1,000 years accumulation rate of loess, from the 1 m per 3,000-5,000 years of soil formation, depending on soil thickness and from absolute dating of charcoal fragments and was estimated at 37,000-50,000 years. Below this soil complex the thickest loess horizon (to about 8 m) is settled locally. This is sandy stratified loess and derasional valley fill.

The best developed soil in the young loess is the Basaharc Lower, a locally 2 m thick chernozem-type compact paleosol. It has intermediate $CaCO_3$ contents and chocolate brown colour, typical traces of strong biological activity can be observed. Its TL age is 81,000 ± 10,000 years. From the loess horizon in the base of the Basaharc Lower soil complex, first at Paks and subsequently in other loess profiles in Hungary, layers of andesitic tufite were described. These tufite layers were associated with the volcanism in the Hargita Mountains, Transylvania, active during the Pleistocene, and its age was estimated, on the basis of MILANKOVIĆ-BACSÁK's theory, at Penultimate Glacial. Today, evidenced by the Mende Base soil complex in its base, it is placed at the beginning of the Last Glacial.

Similar to the Mende Upper, the *Mende Base* paleosol is a marker horizon in numerous Hungarian and other European profiles and promotes correlation. Above it only early man finds (Gravettian and Mousterian) and gastropod and vertebrate fauna were recovered. It is typical that to the first forest soil young loess is only subdivided by forested steppe soils, indicating the alternations of the present European arid moderate climate with cold spells.

In contrast, the upper member (MBz) of the Mende Base paleosol complex is typical lessivated brown forest soil formed under more humid and warm Submediterranean climate and may be Last Interglacial. The Mende Base soil complex TL ages are 100,000-125,000 years.

3. The old loess in Hungary, after the Paks exposure, is called the *Paks series*. It has a compact structure and charac-

terized by six loess horizons of large $CaCO_3$ concretions, two sand layers, five paleosols, and some erosion hiatuses.

The upper 8-10 m of the Paks series is subdivided into two horizons by two sand layers and two paleosols. From the cover of the upper, poorly developed forest soil a molar and tusk of Elephas trogontherii were recovered. The lower soil is hydromorphous, alluvial one with Allohippus teeth of the Biharian stage. TL age is 150,000 ± 21,000 years. The sand layer in the upper part of the Paks series (Sz) is a regarded by many as a remnant of the Penultimate Interglacial, TL age is 213,000 ± 30,000 years (Penultimate Glacial with alternating cold and warm, humid climatic periods).

The lower part of the Paks series is 13-15 m thick. It includes three thick (1.5 m) reddish brown forest soils of Mediterranean type with krotovinas. It is heavily calcareous in its base and indicates dry and warm climate. The paleosols subdivide into three loess horizons indicating cold periods. The upper two paleosols of the series (Paks Double) lie above the Brunhes-Matuyama paleomagnetic boundary (0.71 Ma). They formed in the Brunhes period of normal polarity, presumably in the Cromer interglacial. Their TL ages are 320,000 and 490,000 years, respectively. The 5-6 m thick old loess below the Paks Double was produced in the Matuyama period of reverse polarity. This loess horizon lies in the base of the open-air exposure, at the highest flood level of the Danube. The borehole into the base of the exposure at Paks and Dunakömlöd also disclosed a third reddish brown paleosol, the *Paks-Dunakömlöd paleosol*. Below 3 m thick pink sandy silt deposited in the base of the Paks series, its top contains the Jaramillo event (0.9 Ma).

4. The 30-40 m thick Eopleistocene-Pliocene series below the Paks series down to the Pannonian base is called the *Dunaföldvár silt and red clay formation*. It begins with the so-called 'stony loess', a 5-6 m thick stratified, pink, sandy silt layer with intercalated horizons of sandstone concretions. This proluvial-fluvial sediment was first described at Dunaföldvár and was also identified later at the Paks-Dunakömlöd

and the Putnok-Serényfalva areas, North-Hungary. Beneath the 'stony loess' a strikingly thick, hydromorphous, dark grey, paludal-alluvial, meadow clay double soil is deposited. It contains thick (1.5 m) $CaCO_3$ accumulation (60 per cent) of which indicates intensive seasonal desiccation. Underneath there are six red soils of Mediterranean type alternating dry and warm humid climatic spells and concretion horizons with intercalated thick gleyed (alluvial-fluvial-paludal) grey silt and clay layers with gastropod fauna indicative of cooler climate. Most of the series show reverse polarity. M.PÉCSI (1985) places the red clays (numbers 1 to 6) into the Pliocene. Between the red clays numbers 1 to 4, there are thin (1-2 m) intercalations, while at Dunakömlöd between nos 4 and 5 and nos 5 and 6, the thickness of the intercalate layer of gleyed silt and sand amounts to 6-8. Most of the red soils are of clay texture, the lowermost, however, is sandy and very conspicuous. The lowermost red soil was identified as Pliocene red clay on Pannonian clay (cca 5 million years) in the area of Kulcs, south of Budapest.

According to the recent investigations the 40 m sequence of the Dunaföldvár series ranges from the loess formation 1 million years ago to the sediments of the Pannonian inland sea deposited 5.3 million years ago. The formation of the series of red clays completed on the Plio-Pleistocene boundary (2.2-2.4 Ma), reaching over the Gauss-Gilbert paleomagnetic interval (2.4-5 Ma). Presently, the identification of the 80-90 m Plio-Pleistocene series removed at Paks with the complete sequence in boreholes in the Great Hungarian Plain.

REFERENCES

PÉCSI, M. 1979: Lithostratigraphical subdivision of the loess profiles at Paks - Acta Geol. Hung. 22. pp. 409-418. - Studies on Loess, Akadémiai Kiadó, Budapest, 1980.

PÉCSI, M. 1985: Chronostratigraphy of Hungarian loesses and the underlying subaerial formation - Loess and the Quaternary. Chinese and Hungarian case studies, Akadémiai Kiadó, Budapest, pp.33-49.

THE TISZA RIVER

MÁRTON PÉCSI* and SÁNDOR SOMOGYI*

The Tisza is a typical lowland river (total length 977 km, in Hungary 579 km; catchment area 157,186 km^2). Along the central, lowest section of the Great Plain, the river meanders lazily. The country along the Tisza has a peculiar aspect of its own - the vast sinuous loops of the river, the willow groves of the flood area, the cut-offs and silted-up fens and oxbow lakes, as well as the frequent bank dunes give the extensive flood plain of the river a varied aspect. Until the middle of the last century when the Tisza was regulated, it frequently changed its bed in its extremely wide flood area. The heavy and frequent floods inundated nearly two million hectares of land.

The regime of the Tisza is very changeable, its water level fluctuation is three to four metres greater than that of the Danube. The Tisza also has two floods - one in early spring, the other in early summer - and like the Danube, its early summer flood is higher. The early spring flood on the Tisza comes from the snowmelt in the Carpathian and Transylvanian ranges. The spring floods of this river and its tributaries usually overlap; the culminating points, however, do not coincide, so that they do not reinforce one another. The early spring floods of the Danube and the Tisza also frequently occur at the same time. The Tisza cannot discharge into the Danube and it swells rapidly. This circumstance caused the disastrous Szeged flood in 1879 which devastated the whole

* Geographical Research Institute, Hungarian Academy of Sciences, Budapest

city. There are no iceplugs on the Tisza because the warm air masses from the scuthwest melt the ice of the lower regions before that of the upper reaches *(Fig. 1)*.

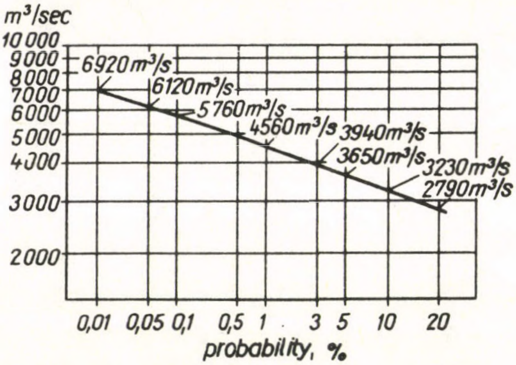


Fig. 1 Flood discharges of different probability of the Tisza, at Szeged (after W.LÁSZLÓFFY)

The early summer flood is due exclusively to rainfall, and arises simultaneously on the Tisza and on its tributaries. Its vehemence decreases from north to south. The early summer floods of the Danube and the Tisza do not usually concur, as the early summer precipitation maximum occurs earlier in the upper reaches of the Tisza. East of Tokaj there also occasionally is a second maximum of precipitation in October which can result in a third flood-wave, but it is attenuated as it progresses downstream.

It is most characteristic of the extreme regime of the Tisza that at Szolnok it transports 53 times as much water at flood stage as at low water (72 m^3/sec. at low water, 3,800 m^3/sec. at flood stage). In the upper reaches of the Tisza the difference between low water and flood stage is even greater. At Vásárosnamény, for example, the flood discharge is 87 times the discharge at low water *(Fig. 2)*.

Because of the decrease in water level after regulations, the Tisza until recently was navigable by larger ships only up to Szolnok, while smaller ones could only proceed to Tokaj. The Tiszalök Dam, completed between 1952 and 1954, however,

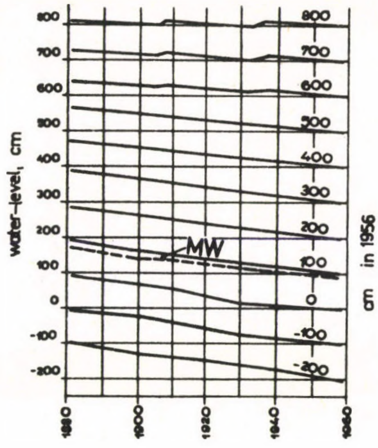


Fig. 2 Water-level changes caused by bed deepening taken place between 1880 and 1960 in the case of identical water discharge in the profile of the Tisza at Szolnok

made the Tisza navigable up to Dombrád, and the Bodrog navigable up to Sárospatak. At Tiszalök the water is conducted by the *East Main Canal* at a rate of 60 m^3/sec. to the droughly land of the Körös. With the aid of this canal irrigation takes place on about 140,000 hectares. Electric power is also produced.

North of Szolnok at Kisköre the second Tisza Barrage was completed (see Locality 8 in this volume).

The most important of the right-bank tributaries is the *Bodrog*, a union of five rivers, which joins the Tisza at Tokaj. Like the Tisza, it is a meandering, characteristically graded river. The point of confluence of the two rivers has changed frequently. The changes are clearly shown by the numerous oxbows and point bars in the vicinity of Tokaj.

The *Sajó* is joined by the *Bódva* in the Miskolc Gate, and further south, on the margin of the Great Plain, it unites with the *Hernád* before it joins the Tisza. Below Tiszafüred, the Tisza is joined by the *Eger*, and at Szolnok it meets with the *Zagyva* which carries the waters of a few smaller rivers. Further downstream the Tisza does not receive so much as a single stream from the sand plateau between the Danube and the Tisza. The eastern margin of the sand plateau is only furrowed with dry valleys.

The left-bank tributaries of the Tisza are of greater importance. The *Szamos* and the *Kraszna* join the Tisza in the vicinity of Vásárosnamény. These two rivers carry the water excess of the northern part of the Transylvanian Basin into the Tisza. It was with the help of the system of canals connected with the Kraszna that the marshes of the Ecsed Swamp, a subsidence between the Nyirség and the Érmellék Districts, were drained.

The *Körös* carries the waters of five smaller rivers into the Tisza. The river resulting from their confluence is called the Hármas *Körös* (Triple Körös). Like the Tisza it is a graded river; it meanders a great deal and often has changed its bed. Along the banks of the Körös irrigation is practised over a large area. Between the three rivers - the Körös, the *Berettyó* and the *Hortobágy* - there was once an endless swamp called the Sárrét. Now the area is covered by a network of irrigation canals extending several hundred kilometres and by a network of drainage canals many thousand kilometres long.

The *Maros* is the largest tributary of the Tisza but only a short section of it flows through Hungarian territory. It is 754 km (467 mi.) long and collects the water excess from 30,330 sq. km (11,700 sp. mi.) in the southern part of the Transylvanian Basin.

REFERENCES

PÉCSI, M.-SOMOGYI, S. 1971: The hydrography of Hungary.-In: Hungary. Geographical studies. IGU European Regional Conference. Geogr. Res.Inst.Hung.Acad.Sci., Budapest, pp. 85-107.

SOMOGYI, S. 1971: Natural endowments of the Great Hungarian Plain. - In: SÁRFALVI,B. ed.: The changing face of the Great Hungarian Plain. Akadémiai Kiadó, Budapest, pp. 35-87.

PÉCSI, M. - SÁRFALVI, B. 1977: Physical and economic geography of Hungary. Budapest, Corvina. 197 p.

REGULATION OF THE TISZA RIVER

GÁBOR MEZŐSI*

Before the flood control and river regulation measures in last century, extended surfaces were permanently or seasonally inundated along the Hungarian section of the Tisza valley *(Fig. 1)*. In 1840 almost 0.5 million hectares were waterlogged throughout the year and 1.5 million hectares inundated during floods. The two categories make up almost 40 per cent of total area with more than 1,000 villages and towns. The explanation lies in the geomorphic evolution of the Great Hungarian Plain.

During the Pleistocene the whole Great Plain *(Fig. 2)* was affected by intensive *subsidence*. It was a tectonic movement uneven in space and time. It had an above-average rate in the Körös region and along the Middle and South Tisza valley, where locally more than 700 m sediments have accumulated. Until the Middle Würm (last glacial) the depressions controlled the drainage of the Great Hungarian Plain. For instance, the old Tisza, Szamos, and Maros rivers ran towards the Körös region, the old Danube crossed the Middle Tisza region and the Lower Tisza valley, tectonically preformed, was the centre of a centripetal drainage pattern. When reaching the Plain, the rivers built large alluvial fans; examples are the Danube-Tisza interfluve, the Nyirség and the Körös-Maros interfluve and others. Regional subsidence continued through the Pleniglacial and the Holocene and its intensity was highest along the basin margins. As a consequence, it was not only the

* Department of Physical Geography, József Attila University, Szeged

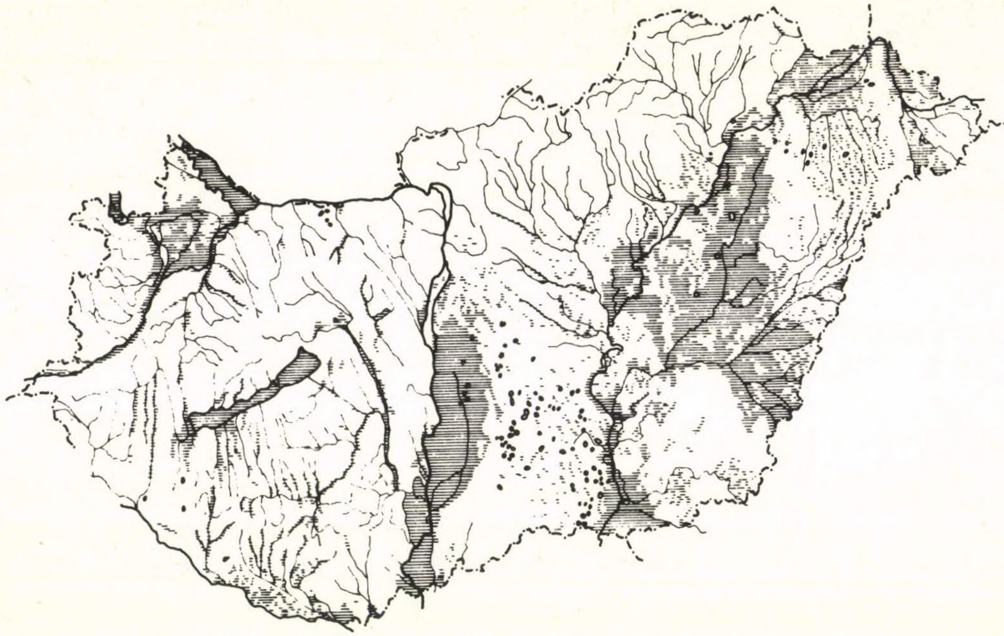


Fig. 1 Permanently waterlogged and seasonally flooded areas in present-day Hungary before river regulation (after W.LÁSZLÓFFY)

drainage pattern that was reshaped, but the present high and low flood-plain levels also date back to that time. The rivers (the Tisza, Szamos, Bodrog and others) shifting to the margins of alluvial fans or forced into the marginal depressions, their gradient became reduced, braided channels with sluggish water flow developed. According to the Hungarian typology of stream mechanism, they were depositing and meandering-accumulating rivers. On the enclosed surfaces backswamps of poor drainage and under slow filling processes occur. The numerous meanders made actual length of river several times exceed the length measured in air kilometres.

In the Carpathian Basin early spring snow-melting and the early summer rainfall maximum cause *flood waves* on streams. As a consequence of the geomorphological and hydrological conditions outlined above, the flood waves arriving onto the Great Hungarian Plain from all directions reinforced each other. The travel time of flood waves was reduced not only by low gradient and the plenty of meanders, but also by the

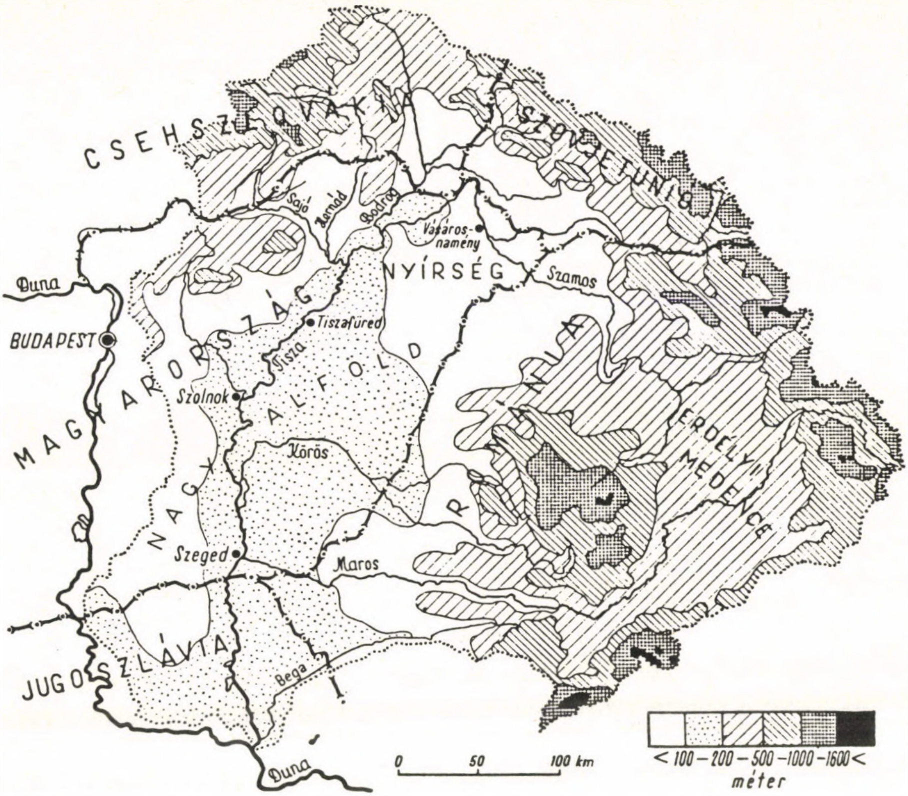


Fig. 2 Catchment area of the Tisza river (after W.LÁSZLÓFFY)

backswamps of flood-plains. It should be pointed out that the Tisza river, or at least its section south of Szolnok, is not a hydrologically independent stream, its water levels are influenced by the flow of the Danube, Maros and Körös rivers *(Fig. 3)*. Before regulation, the Tisza had cca 3.7 cm per km average gradient *(see Table 1)* along the then 960 km (today 600 km) Great Plain section. Flood waves passed within 2 to 6 months.

Increasing population and an agricultural boom encouraged *river regulation* and *flood control* in the second half of 18th century on a national scale. Growing demand for land could not be satisfied through forest clearance and rapid drainage of floods became vital. Flood hazard to settlements had to

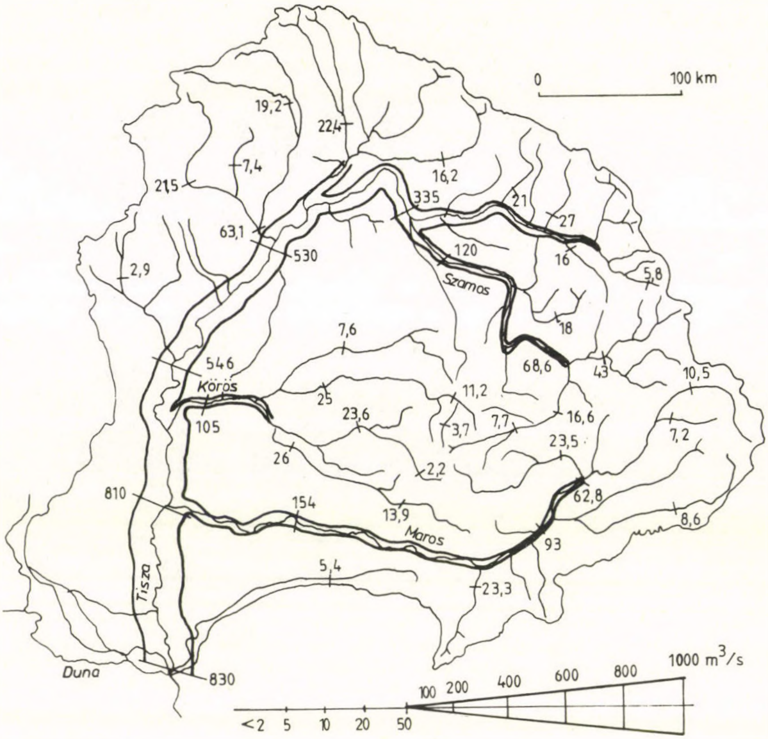


Fig. 3 Average water reserve of the Tisza drainage system (after W. LÁSZLÓFFY)

be eliminated, continuous navigation ensured and the world of swamps, previously even artificially extended for defence purposes, drained.

In the 17th-18th centuries local regulation measures were implemented on the Tisza. However, the coordination and organization are the merits of Çount István Széchenyi in the 1830's and 1840's. The concept of PÁL VÁSÁRHELYI for the comprehensive regulation of the Tisza river was based on the principle that effective measures should increase stream gradient through *cutting through* meanders. He proposed *embankments close* to the river channel, as concentration of water would promote channel development preventing floods. After his death his concept was not developed further into a detailed project.

In order to save costs, the opposite proposals elaborated by PIETRO PALEOCAPA, engineer in the regulation of the Po river were also considered. He only suggested to cut off 15 meanders (as opposed to Vásárhelyi's more than 100 cutoffs). In his opinion, *dykes in great distances* from each other ought to have been built to store flood discharge on the flood-plain *(Fig. 4)*. For economic considerations elements of both ideas were implemented. Meanders were cut off as proposed by Vásárhelyi and dykes built in accordance with Paleocapa's views. This hybrid solution has not proved to be optimal.

Regulation activities began in 1847 and were performed simultaneously along the lower, middle, and upper reaches of the river, at speeds permitted by financial sources. Neglect-

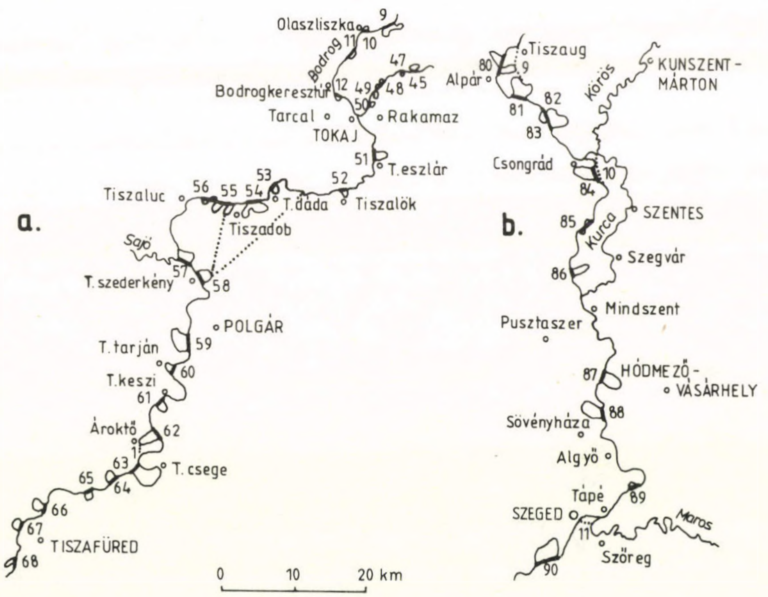


Fig. 4 Two sections of the Middle Tisza river. Heavy line indicates meander cutoffs proposed by Vásárhelyi and dotted line shows those suggested by Paleocapa (after W.LÁSZLÓFFY)

Table 1 Main data on the regulation of the Tisza river (after S.SOMOGYI)

Section	Old length (km)	Present length (km)	Cut-off channels (km)	Length of meander cut-offs (km)	Shortening in percentage	Gradient before and after regulation (cm per km)	
						before	after
Forrás-Tiszabecs	208	208	-	-	-	-	-
Tiszabecs-Tokaj	335	208	169	42	38	7.5	12.2
Tokaj-Tiszafüred	205	117	113	25	43	3.0	5.2
Tiszafüred-Csongrád	326	191	160	25	41.4	2.1	3.7
Csongrád-Szeged	100	67	46	13	33	2.5	3.8
Szeged-national border	28	17	19	8	39.3	-	-
National border-confluence	217	158	82	23	27	1.9	2.7
Total	1419	966	589	136	32	3.7	6

ing the *development rate* of channels through meander necks was a mistake. It was accepted that the transformation into main channel needs several years. Paleocapa's proposal for the relocation of tributary confluences was also ignored. Most of the meander cuts along the section south of Szolnok were unsuccessful as only 15-20 per cent of new beds developed into main channel, while the channels along the upper reaches developed relatively rapidly (35-45 per cent). All these had the influence that flood waves reached the Middle Tisza more rapidly and often overtook each other there. Between 1850 and 1870 several meander cuts had to be deepened further *(Fig. 5)*. A new impetus was given to regulation after the disastrous floods of 1855 and 1867. by 1870 the most important tasks of regulation were completed. The 1214 km lowland length was 453 km shortened (by 37 per cent); 112 of the 135 meander cuts became main channels. Notwithstanding, the 1879 flood, almost totally destroying the town of Szeged, called attention to the *deficiences* of flood control. Although the length and mass of the *dyke system* built in Hungary in the 19th century several times surpassed the values for the Netherlands (held in great respect) and more than 10,000 ha agricultural land became protected, flood-control dykes were not constructed systematically and, thereby, the efficiency of the whole system was reduced. The great floods in 1879 and 1881 contributed significantly to enlivened activities leading to the completion of the dyke system *(Fig. 6)*. The length of embankments along the Tisza proper is 1439 km, but with the related system along tributaries it is cca 4500 km. At the 1895 flood the dyke system 'held water'. It is constantly expanded and elevated. It served well in 1970, when the highest flood level was recorded (more than 1.5 m exceeding the 1879 level).

The most obvious *impacts* of river regulation are the changes in the hydrological and hydrodynamical conditions. The most important is *reduction in river length* and a general narrowing of channel *(see Table 1)*. It resulted in a considerable increase of gradient, the erosive capacity of the Tisza grew and dissection intensified. Measurements and calculations indicate that sediment load from bank undercutting and channel

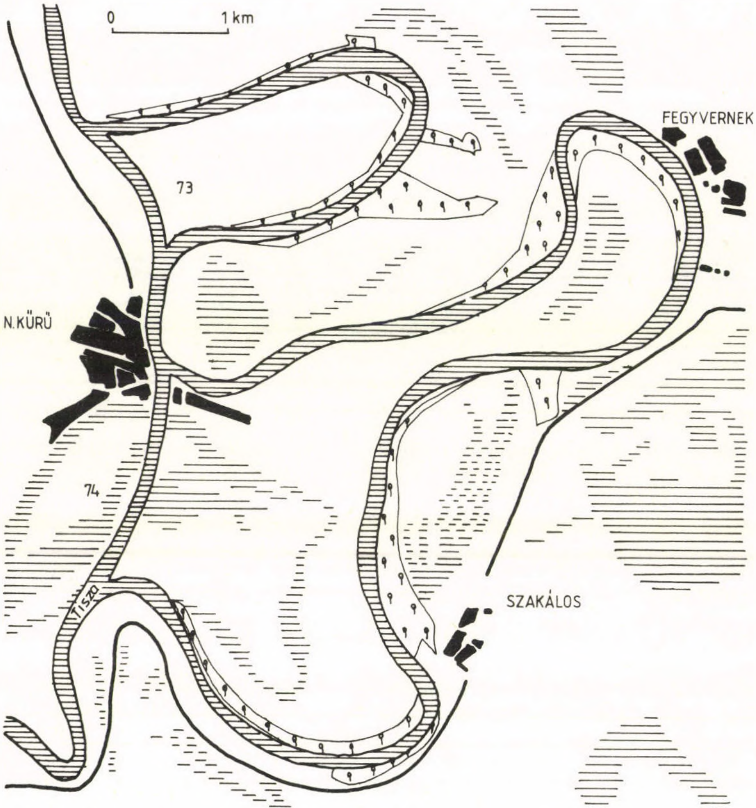


Fig. 5 Slowly developing meander cutoff on the Middle Tisza at Nagykörü, Szolnok county. Both meander cutoffs (nos 73 and 74) were insufficiently excavated in 1858 and 1861 to promote channel development

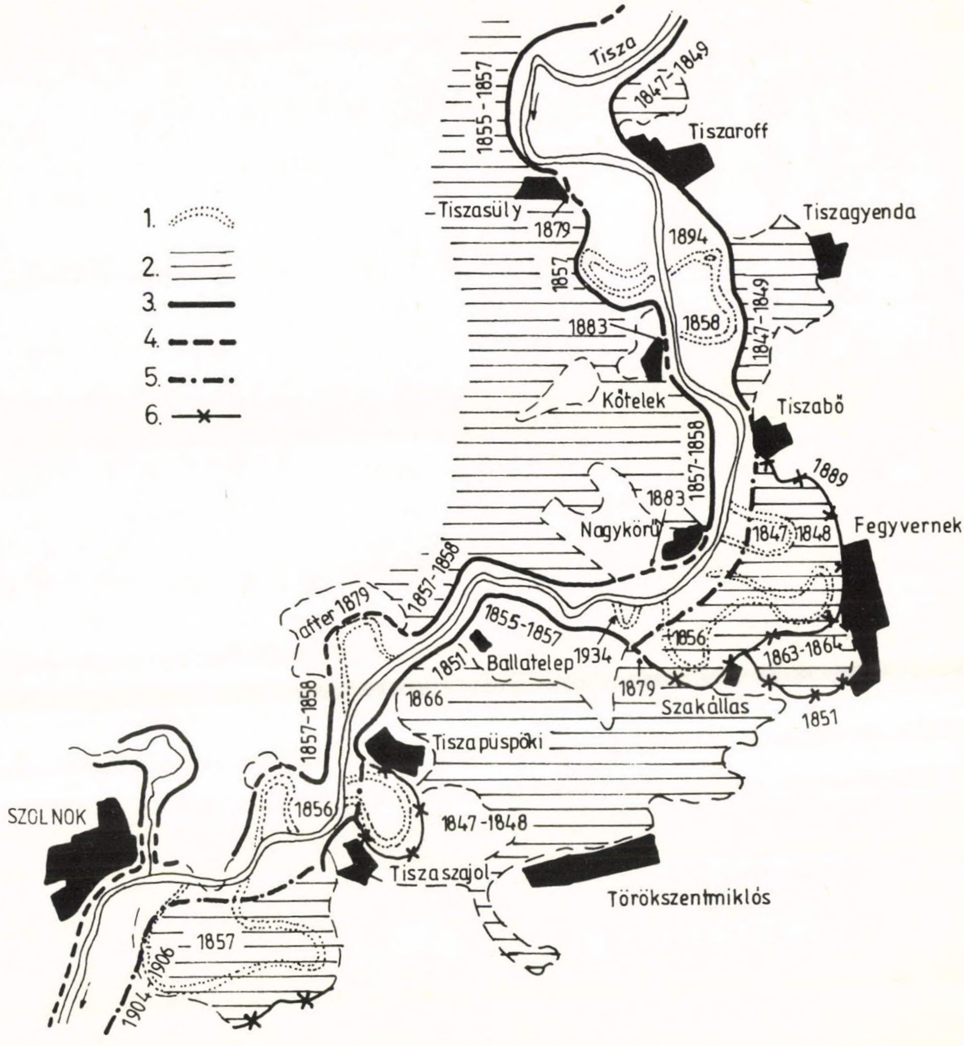


Fig. 6 Example of design and development of flood control along the Tisza river

1 = cut-off meander with date of cutting; 2 = boundary of high bank and protected embayment; 3 = dykes built before 1860; 4 = dykes built between 1879-1889; 5 = dykes built after 1891; 6 = dykes now unnecessary;

erosion ranges from 6,000 to 65,000 m^3 per year km. Increased travel time of floods has led to *more extreme river regime*, low water levels and minimum discharge were reduced (navigation was spectacularly affected), while high water levels elevated markedly. The range of water regime 2-4.5 m rose after regulation. *River mechanism* was also modified. Along the Kisköre-Szeged stretch accumulation nature was replaced by meandering and downcutting. In spite of this, it is characteristic for the whole length of the Tisza river that regulated sections regained their state of dynamic equilibrium and began to develop meanders. This underlies the 5 km growth of regulated length between 1890-1952.

As a result of dykes placed further away from the channel than necessary, *in active flood-plains accumulation* is predominant. Gradual accumulation slightly but constantly increases high water levels. It also creates a new ecological facies, the amphibiotic flood-plain. Flood-control and drainage measures transformed, first of all, the ecology of the low flood-plain level. Without permanent inundation, other geomorphic agents replaced fluvial evolution. The resulting features (ox-box lakes, cut-off channels) became disconnected from the processes that had produced them and were preserved. The aquatic-paludal *natural vegetation* has completely changed and sinking *groundwater level* induced chernozem dynamics in soils. A major achievement of river regulation is seen in the convertion of *2 million ha land for agricultural use* and the protection of almost 400,000 homes from damage by floods.

Unreliable precipitation and regular droughts in the Great Hungarian Plain called for *irrigation* efforts on agricultural land parallel with their drainage. The necessary system of reservoirs and canals has been under construction since 1950.

REFERENCE

SOMOGYI, S. 1979: Regulated rivers in Hungary. - Geographia Polonica, 41. pp. 39-53.

BARRAGES OF THE TISZA RIVER AND TRIBUTARIES

LÁSZLÓ NAGY*

In the Tisza basin the first barrage was built on the Fehér (White)-Körös river, at *Gyula* in 1896 *(Fig. 1)*. It was not aimed at flood control or river regulation, but to supply the towns of Békés, Békéscsaba and Gyula with water from the reservoir behind the dam. Some years later (in 1907) the *Bökény Barrage* was constructed on the Hármas(Triple)-Körös river, first for navigation purposes and to be used later for irrigation, too.

The first *hydroelectric station* was completed in 1903. It is located at Gibárt, on the Hernád river, a right-hand tributary to the Tisza, the most important for hydroelectric energy. The plant was succeeded by similar, low capacity stations at *Felsödobsza* (1906) and *Kesznyéten* (1943). The total capacity of plants on the Hernád river is 5.4 MW.

The *Békésszentandrás Barrage* on the Hármas-Körös was inaugurated in 1942. The main motives of its construction were the promotion of navigation and supplying irrigation water.

The first barrage on the *Tisza* proper was established at *Tiszalök* (542.2 km from confluence with the Danube) in 1954. The hydroelectric plant of 14 MW capacity was connected to the national electricity network in 1957. Its primary objective is supply of irrigation water through the Eastern and Western Main Canals, improvement of waterway and utilization of hydroenergy.

---

* National Water Authority, Budapest

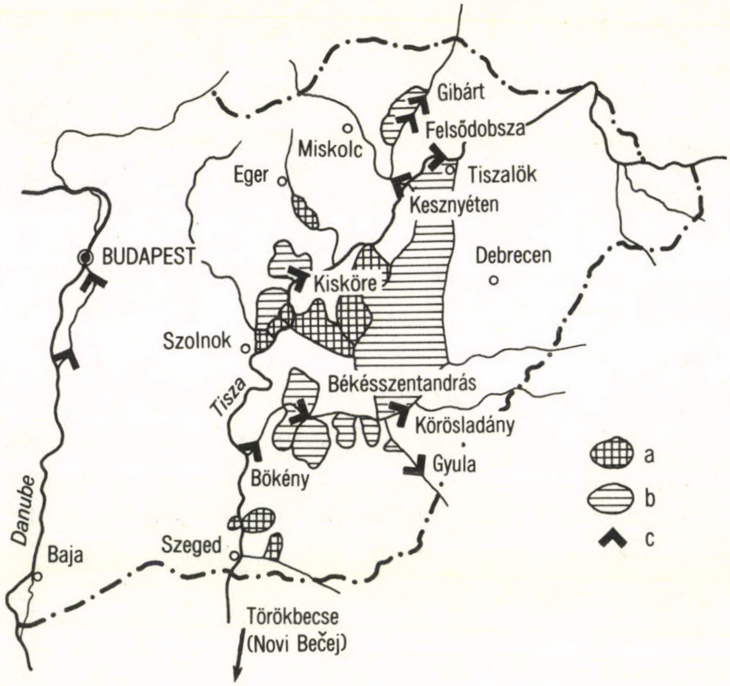


Fig. 1 Irrigation systems in the Great Hungarian Plain

a = existing irrigation system; b = proposed irrigation system; c = existing dams;

In 1969 the Békés Barrage was completed on the Kettös (Double)-Körös. It provides water for irrigation and industrial purposes and improves the conditions of local navigation.

On the lower reaches of the Tisza, in Yugoslavia (63 km from confluence) the *Novi Bečej* (Törökbecse) *Barrage* was inaugurated in 1977 for irrigation and navigation.

In the same year the *Körösladány Barrage* was finished on the Sebes(Rapid)-Körös river. Damming up the river, it ensures a better supply of water for industry, communal uses and irrigation as well as improves local navigation.

L o c a l i t y 8

KISKÖRE BARRAGE

LÁSZLÓ NAGY*

The *Kisköre Barrage* was built 404 km from the Danube-Tisza confluence in 1973. Its hydroelectric plant of 28 MW capacity began to operate in 1975. Water storage in the reservoir dates to 1978, when the second phase of construction, aiming at industrial and agricultural water supply, started.

The Kisköre Barrage and the related reservoir are among the most important establishments in the management of the Tisza valley *(Fig. 1)*. The complex near the village giving its name comprises a dam a lock and power plant. It is supplemented by inner flood-plain dike as well as related establishments on the banks. Along the more than 100 km section between Kisköre and Tiszalök the river is dammed up to produce a *reservoir*, which regulates water reserves in the area *(Fig. 2)*. When it is completed, the total water surface of the reservoir, covering the active flood-plain, will be 127 km^2; useful capacity will be, at first, 300 million m^3 and, in the next stage, 400 million m^3. The reservoir is enclosed by a reinforced protective embankment, which safely retains dammed back water and even higher flood levels. The rise of groundwater table due to damming is prevented by drains built parallel to the embankments. Their water level is regulated by pumping stations and, thus, groundwater table is kept under control.

---

* National Water Authority, Budapest

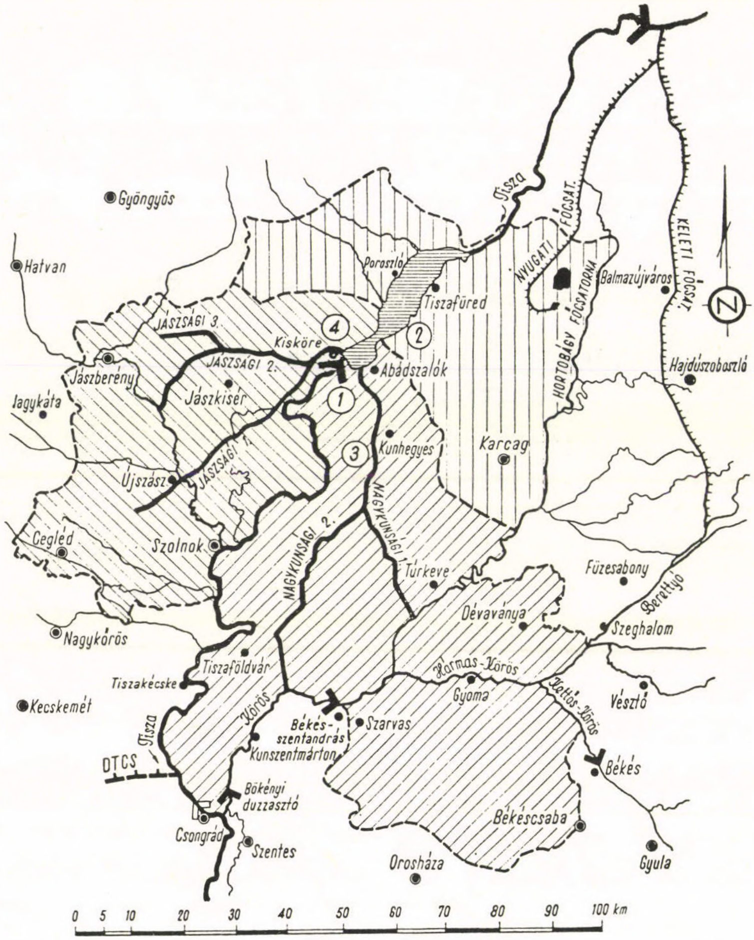


Fig. 1 General layout of the Kisköre Barrage and the main structures of the project

1 = Barrage; 2 = Reservoir; 3 = Nagykunság Main Canal; 4 = Jászság Main Canal

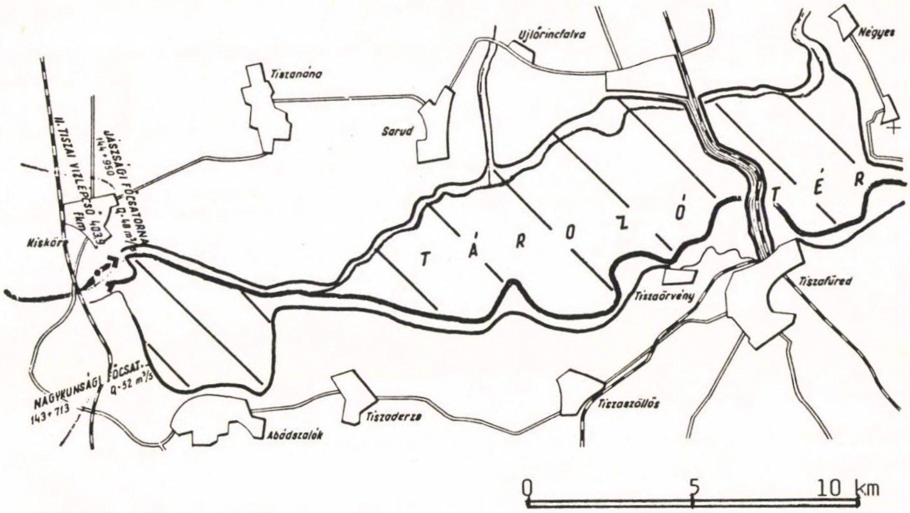


Fig. 2 Sketch of reservoir

The fundamental establishments of the water distribution system based on the reservoir are the *Nagykunság Main Canal* and the *Jászság Main Canal* with capacities of 82 m³ per sec. and 48 m³ per sec, respectively. To the main canals secondary and tertiary canals, feeding canals and irrigation plants are attached. The eastern branch of the Nagykunság Main Canal supplies 25 m³ per sec. of water to the driest area in the Great Plain, the Körös valley.

The Kisköre Barrage is located on a terrain of 87-89 m altitude above sea level. In addition to improving waterway and utilizing hydroelectric power, its basic functions are the storage of water reserve (in reservoir) and its distribution (through canals, regulators and pumping stations).

Construction takes place in three phases, the second of which was finished in 1985. Water level was first raised to

87.50 m above sea level and by 1986 it was dammed up to 89.00 metres. The latter value means the storage of 100 million m³ water. By early 1987 a 110 km long network of intercepting canals was built adjusted to dammed water levels. This has to be doubled to raise water level to 90.50 m and storage capacity to 300 million m³. The reservoir can only attain the volume of 400 million m³ if the contemplated Csongrád Barrage should be built downstream and damming should reach to Kisköre *(Fig. 3)*.

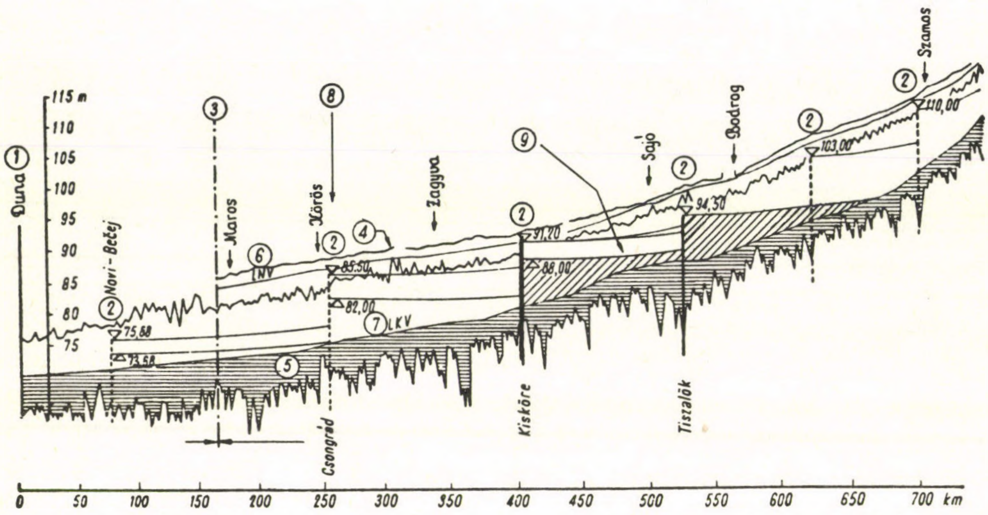


Fig. 3 Longitudinal profile of the Tisza River

1 = Confluence with the Danube; 2 = Barrages contemplated, under construction, or completed; 3 = Boundary between Hungary and Yugoslavia; 4 = Levee crest; 5 = Bottom; 6 = Highest water level; 7 = Lowest water level; 8 = Danube-Tisza Canal; 9 = Net storage volume, 400 million cu.m

The zone where the environmental impacts of the reservoir and the system of intercepting canals has an average width of 1.5 to 2 km. The technical devices to control groundwater and the effects of damming are efficient (Fig. 4). It is clear from the ten years' experience of operation that the excess water, regularly present before implementation, has disappeared even from the zone next to the embankment. At the same time, flood control, which had involved large-scale activi-

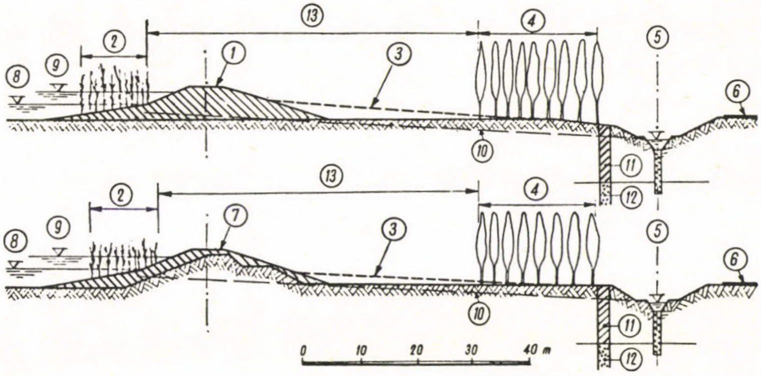


Fig. 4 Typical cross-sections through new and reinforced reservoir embankments

1 = New embankment; 2 = Reed strip; 3 = Dredgings deposit; 4 = Forest belt; 5 = Intercepting and drainage canals with relief wells; 6 = Dirt road; 7 = Reinforced embankment; 8 = Raised water level; 9 = Flood level; 10 = Nappe at operating level; 11 = Cohesive cover; 12 = Sand; 13 = Grassed slope

ties, is essentially limited to observation. Flood control costs are considerably reduced. The rise in groundwater table and excess water outside the immediate impact zone results from direct precipitation, snowmelt or lack of amelioration and drainage.

The excess water and *groundwater* conditions are naturally also influenced by the properties of *soils* in the area. A cohesive cover layer is characteristic underlain by sandy and loessy (permeable) layers. Infiltration is retarded on the cohesive topsoil and in areas where there is no permeable layer or it is located deep water is retained on or near the surface for long periods.

Regular observations of groundwater since 1950 compared with raingauge data indicate that minimum groundwater tables approached the average level, while maxima were radically reduced through the operation of intercepting canals, exclusively in the 1.5-2 km wide zone.

Apart from the extremely high inundation in 1942, major *excess water* coverage was observed in the area in 1956, 1963, 1966-67 and 1969-71. Since the inauguration of the Kisköre Barrage in 1972, no or hardly any inundation by excess water has been observed. Although in 1977, a year before damming up, excess water caused some damage, but it cannot be connected with the implementation of the barrage.

In function of precipitation, the areal extension of excess water has generally reduced since 1979. It can be attributed to planned amelioration activities (over 120,000 ha in the period) and construction of drainage canals by the collective farms. Water is received by the network of intercepting canals along the embankment of the reservoir.

During the drought in 1986, streamflow had no recharge from precipitation over a long time. In the area affected by the Kisköre Reservoir, however, damming and intercepting by canals did not allow groundwater table to drop below the average level and the beneficial influences on water budget were felt even behind the above mentioned zone.

In spite of the stumps and undergrowth left behind on the bottom of the reservoir, processes affecting *water quality* were beneficial, too. With the present water level, the self-purifying effects strengthened to the degree that even the pollution imported is partly compensated.

In some parts of the reservoir water quality can be compared with the conditions prior to intensive fertilizing and increased pollution of industrial origin. This is significant for water intake from the lower reaches of the river (e.g. water supply of Szolnok and environs, water intake from the Nagykunság Main Canal and water transfer to the Hortobágy-Berettyó canalized river system and the Hármas-Körös). The pollution and nutrient load from the Trans-Tisza region and from abroad would have led to critical situations and unforeseen damage (particularly along the Berettyó river) if water of good quality had not been supplied. A similar function is fulfilled by the Jászság Main Canal by transfering water into the Zagyva river.

The *recreation* and *touristic* prospects are bright on the shores of the reservoir of 60 km^2 water surface area and of up to 2 m depth, clean water and rich bird population. The area has even today the best angling sites, where ten thousands of people spend the weekends by angling and water sports. New camp-site facilities opened in May 1987.

REFERENCES

DÉGEN, I. 1973: A Kiskörei Vizlépcsö vizgazdálkodási jelentösége. (Significance of the water management of the Kisköre Barrage.) Vizügyi Közlemények. Budapest. pp. 7-39.

KARCAGI, G. 1983: A Kiskörei Vizlépcsö hatása a vizjárásra. (Effects of the Kisköre Barrage on the water regime). Magyar Hidrológiai Társaság, Szolnok.

BÜKK FOOTHILLS (BÜKKALJA)

ZOLTÁN PINCZÉS*

The Mesozoic Bükk Mountains drops steeply along the Eger-Miskolc fault-line. The 5 to 8 km wide landscape below, which is dissected by 250-350 m deep valleys is the pediment of the Bükk Mountains *(Fig. 1)*. The Paleozoic-Mesozoic rocks of the Bükk are replaced here by Miocene volcanics. The basement is overlain by Eggenburgian-Ottnangian rhyolitic tuff with intrusions of Carpathian rhyolite lava along a northeast-southwest double fault-line and of rhyolitic dacite lava (southern range) of the Carpathian-Badenian boundary. The end of volcanic activity is marked by the upper rhyolitic tuff series in the late Sarmatian. Its remnants fringe the second lava range from the south. The southern part of the landscape was also affected by Lower Pannonian (Upper Miocene) transgression. These formations (as well as the Oligocene and, in smaller areas, the Eocene and Triassic sediments) were truncated to the same level during the Lower Pliocene. Denudation was due to sheet-wash by showers under semiarid climate and dissection by torrents arriving from the hinterland, the Bükk Mountains. The sediment load of streams (deriving from the quartz pebbles and other cover layers of the Bükk) had an important role to play in the planation of the uniform surface of what is now the Bükk Foothills (Bükkalja). The evidence of planation is still seen in the quartz pebbles

* Department of Regional Geography Kossuth Lajos University, Debrecen

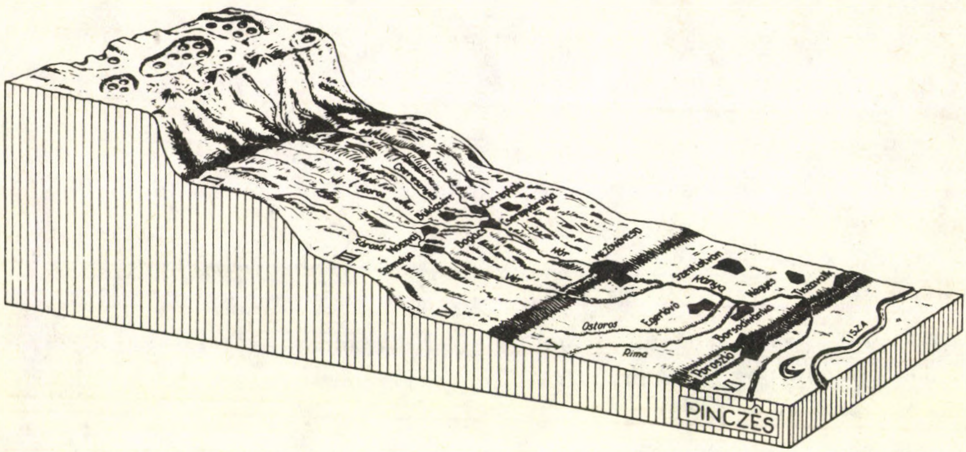


Fig. 1 Escarpments in the Bükk Mountains and its foreland (after Z.PINCZÉS)
I = High-Bükk, Upper Cretaceous to Middle Cretaceous exhumed peneplain; II = Middle-Bükk, Upper Cretaceous to Middle Eocene exhumed peneplain; III = Southern-Bükk, Upper Pliocene pediment; IV = Bükk Foothills, Early to Middle Pleistocene alluvial fan; V = Borsod Mezöség, Late Pleistocene alluvial fan; VI = Tisza flood-plain

transported by and deposited from torrential streams *(Fig. 2)*. Along valleys the pediment stretches into the mountains (e.g. Eger and Hór valleys). It can be traced at more than 100 m above the present stream. The uniform surface was dissected in the Pleistocene. Valleys formed on the south-southwest sloping surface of the pediment and a dense network of subsequent side-valleys adjusted to them. The main valleys are mostly of rather erosional origin, while the side valleys are formed by derasion. Derasion and other sheet wash processes are decisive in the minute dissection of the surface. They have carved two rows of scarps on hard lavas.

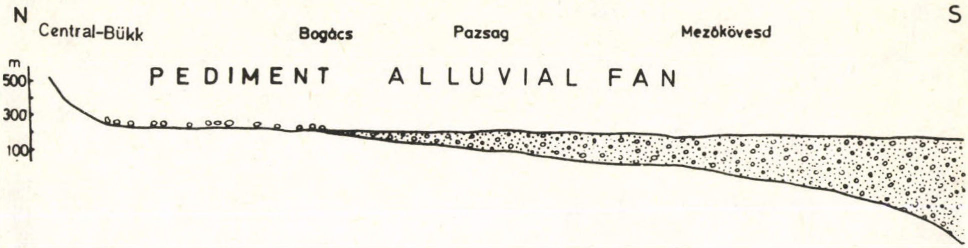


Fig. 2 Position of gravel on the Bükk pediment and the alluvial fan (after Z.PINCZÉS)

The *Bükk foothills alluvial fan* stretches from the pediment presented above to the trench of the Tisza river *(Fig.1)*. The basement is Lower Pliocene sand, clay and lignite overlain by an Upper Pliocene (Levantan) layer. The sand of the latter were deposited by streams on land surface, after the Pannonian inland lake was filled. The terrestrial series has a depth of 10 m even at the apex of the fan (south of Bogács). As a result of the uplift of the Bükk Mountains and the changing climate, streams began to deepen their valleys in the mountains and increased their load consisting of coarse gravel. The deposition at the foot of the mountains led to alluvial fan accumulation. In the first stage, the quartz pebbles removed from the Bükk cover layers were deposited. Subsequently, downcutting their valleys, the streams reached the rocks building up the Bükk Mountains. Evidence for it is found on the oldest Pleistocene terrace, where, in addition to quartz pebbles of further origin, gravels from the rock of the Bükk are also present. The fans accumulated by several streams merged into a single extended alluvial fan. Gravel materials, however, indicate different origins even now. Fluvial transport is proved by sorting. At the apex coarse deposits occur, while towards the fringes they are finer and younger. The subsidence of the foreland results in the thickening of the fan to the south *(Fig. 3)*. Along the Budapest-Miskolc railway line and main road the alluvial fan is divided into two parts.

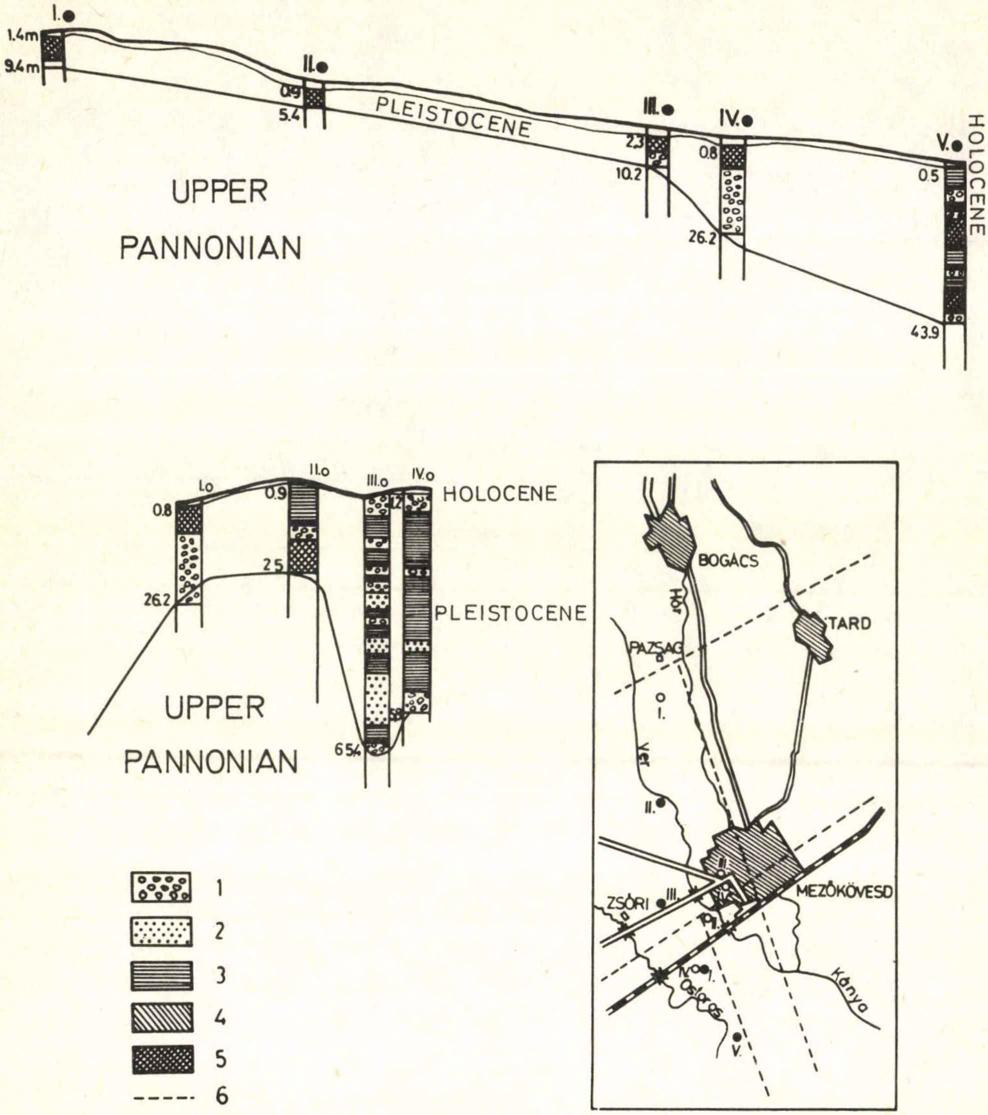


Fig. 3 Longitudinal and cross-sections of the middle Bükk foreland and the Hór alluvial fan (after E.E.SCHMIDT)

1 = gravel; 2 = sand; 3 = clay; 4 = clayey sand; 5 = sandy clay; 6 = fault-line

The higher lying *old alluvial fan (Figs. 1,3)* is to the north of the fault-line. It has a surface gently sloping from 200 m altitude to 120 m towards the south. The broad valleys running from the Bükk Mountains in NNW to SSE direction have dismembered the fan. There are generally two terraces above the broad valley floor. The lower terrace (no II) smooths into the younger alluvial fan surface along the mentioned fault-line. Between the valleys the remnant of the old fan appears. Its surface is dissected by numerous tributary valleys (derasion valleys or dells) eroding headward from the main valley. A dissected relief has come about, particularly in the northern higher terrain. The fan is mantled by red clay, loess-like deposit and mosaical loess. Part of the latter is redeposited along the slope by gelisolifluction. In the periglacials cryoturbation features, involutions developed.

The *young alluvial fan,* the *Borsod Mezöség* is situated south of the fault-line and stretches to the Tisza trench *(Fig. 1)*. Its sloping surface lowers from 120 m to 90 m. The fan was built up to the Würm glacial and in the south and east even to the Holocene. The material composition is diverse, but here finer sediments dominate compared with the older fan. Gravel is only exposed south of the town Mezökövesd *(Fig. 3)*. One-time streams left sandy deposits behind. The deeper-lying parts were filled by the loessy, silty, and clayey deposits of rivers. The western part is characterized by minutely dissected relief, extended flat surfaces and the dividing broad ridges. In the east fluvial deposition went on in the Holocene, too, and silty deposits occur. Here the fan surface shows scars of numerous abandoned river channels (of streams running from the Bükk and the Sajó river).

REFERENCE

PINCZÉS, Z. 1955: Morfológiai megfigyelések a Hór völgyében. (Morphological observations in the Hór valley). - Földr.Ért. 4. pp. 145-156.

PINCZÉS, Z. 1970: Planated surfaces and pediments of the Bükk mountains, In: "Problems of Relief Planation". Akadémiai Kiadó, Budapest, pp. 55-63.

L o c a l i t y 9

CSERÉPFALU EXPERIMENTAL STATION

ZOLTÁN PINCZÉS*

The most recently established research station of *soil erosion* investigations carried out for a quarter of a century in the Institute of Geography, Kossuth Lajos University. (Previously stations operated in Tokaj and the Tokaj Mountains.) The station of Cserépfalu *(Fig. 1)* was established in 1975 in a small tributary valley of the valley on the eastern slope of Nyomóhegy hill (340 m above sea level). Measurements are performed all over the catchment of the dell.

The main *goals* of the measurements are

1. To determine what the influences of slope angle and slope length are on runoff and soil loss under rainfalls of different amount and intensity.
2. To determine the amount of rainwater infiltrated into different depths at rainfalls of different intensity.
3. To determine runoff from rainfall on the surface and at various depths below the surface on slopes of various angles.
4. To set up a model for the water budget of the catchment area.

For the experiments *lysimeters* are employed. Soil erosion is measured in two sites (with slopes of 8° and 16°). For both sites involve measurements in uncultivated (mown) and cultivated land (one plot for each type). A site of measurement consists of four plots. Their width is 1 m and their

* Institute of Geography Kossuth Lajos University, Debrecen

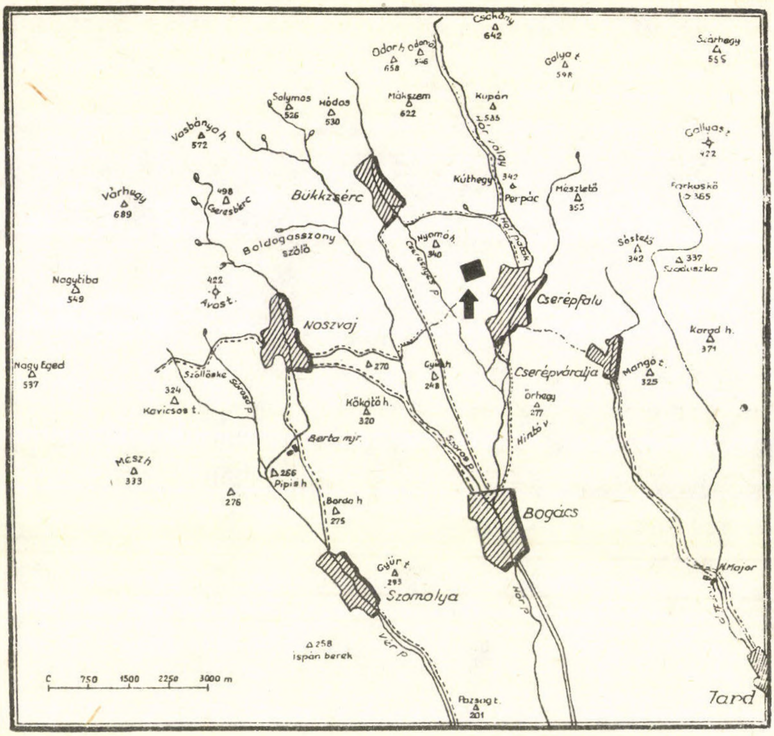


Fig. 1 Sketch of the Hór basin with experimental plot (Locality 9 - after Z.PINCZÉS)

lengths are different: 2.5 m, 5 m, 7.5 m, and 10 m. The infiltration of rainwater is recorded in an area of 40X50 cm. Soil depths are 5, 10, 20, 30, 40, and 50 cm. Infiltration into various depths is measured by recipients at 10, 20, 30, 40 and 50 cm. The amount of surface runoff is recorded by calibrated tanks placed one below the other.

where ascending in wells. The rise can amount to 3 m and groundwater table may reach the surface. The *salt* content of groundwater ranges widely (usually 2-3 g per litre, but in extreme cases it may amount to 20 g per l). Among ions dissolved in water Na is the predominant cation (0.5 to 4 g per l) and Mg is important. Among the anions, the amounts of HCO_3 and Cl are considerable and in the middle part SO_4 is worth mentioning.

The hydrographic axis of the plain is the *Hortobágy river* following the deepest point in north to south direction. The famous bridge over it is called Kilenclyukú-hid (bridge of nine bays), built in 1833, the longest stone-bridge in Hungary (92 m, with entering drives 167 m). There is a museum, tavern and open-air theatre nearby. Along the highway no 33 the largest fish-ponds of the country were established (Hortobágy fish-ponds and Ohat lakes).

Extremities are characteristic of the dry and continental *climate* in the Hortobágy. Mean values say very little about true conditions (average annual precipitation is 500-550 mm, its minimum is 297 mm, while its maximum is 944 mm). Summer droughts are decisive in the life of the puszta: by the end of summer the vegetation becomes scorched. It is interesting to note that even the most humid year of record had a month entirely without precipitation.

The chemical properties and range of groundwater produced, under arid climate, alkali soils, mainly of the solonetz type. In soils with considerable evaporation from the surface capillary rise of moisture reaches the surface, some of the water evaporates, solutions become concentrated and then salts precipitate. Colloidal soil particles adsorb large amounts of Na and this brings about unfavourable soil properties such as swelling by moisture making the soil surface sticky mud, while it is dry some cm below. In dry state it contracts strongly and desiccation cracks appear on the alkali surface. Meadow solonetz is characterized by columnar B horizon coloured dark grey by Na-humates. The columnar horizon (occasionally prismatic or blocky) may be located directly (2-3 cm) below the surface (crusty solonetz) or deeper (7-15 cm, medium solonetz). Maximum salt accumulation in typical solonetzes is in the B horizon, the amount of soluble salts is minimum near or on the surface. However, an alkali soil may be saline up to the surface with above 0.05 per cent salt content. This process is *solonchak formation*. The typical columnar B horizon of dark grey colour is replaced by a greyish yellow horizon without structure and the whole soil profile loses its morphology. The third type of alkalization is *solod'* formation. Powdery silica precipitation makes the soil surface whitish or mouse-grey. The powder is more characteristic of the depressions, it has 5-10 cm thickness, but, along cracks, it intrudes into deeper soil horizons too. Towards the margins of the region meadow soils and chernozems also occur.

With the predominance of solonetzes, the three types of alkali soils show a mosaic distribution adjusted to microrelief. Changes in the vegetation clearly indicate soil boundaries.

By their *vegetation,* solod' surfaces stand out as *vakszik* ('blind' saline spots). Early spring they are waterlogged and from late spring dry and barren until the plants appear in middle or late summer *(Puccinella limosa, Matricaria chamomilla, Artemisia monogyna, Champhorosma annua* and others).

Another habitat is the *szikfok* (saline flat) with long spring waterlogging and summer desiccation and cracking. Even during waterlogging *Puccinella limosa* and *Juncus gerardi* appear. In early summer gradual desiccation begins with the flowering of *Ranunculus lateriflorus, Plantago tenuiflora, Suaeda maritima, S.pannonica, Atriplex litoralis,* and *A.tatarica.*

Dry saline grassland, the puszta is dominant in the vegetation of the Hortobágy. They are not waterlogged even in spring and generally have medium meadow solonetz soils, occasionally crusty meadow solonetz. More heavily alkalized soils are overgrown by Artemisiae, while on soils with deeper A horizon Achilleae are characteristic. *Festuca pseudovina* forms extended grasslands.

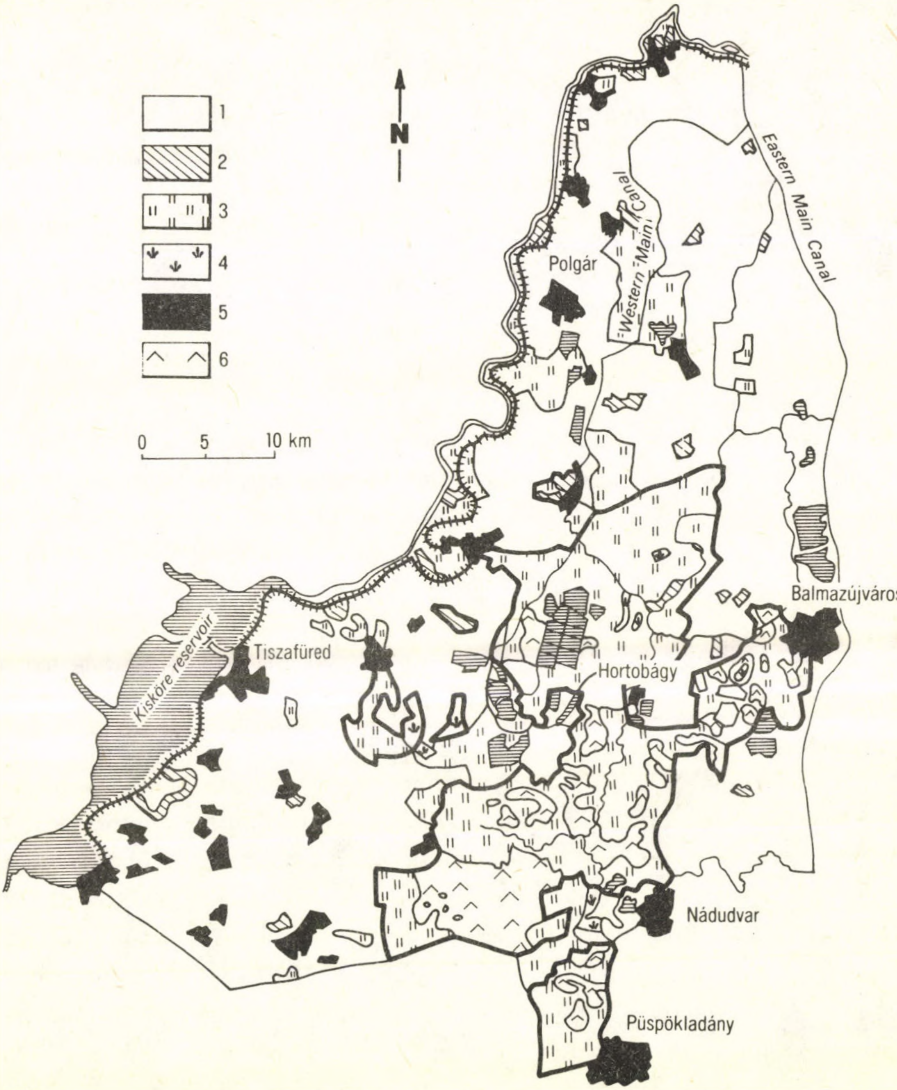


Fig. 2 Land use map of the Hortobágy (after D.LÓCZY). Revised from LANDSAT TM satellite image

1 = arable land; 2 = forest; 3 = meadow and pasture; 4 = wetland (reed and sedge); 5 = built-up area, gardens, orchards and vineyards; 6 = alkali puszta. The boundaries of the Hortobágy National Park are indicated

The two exceptional protected forests (known from 13th century records) at Ujszentmargita and Ohat are remnants of once extended salinic forested steppe associations.

The puszta in its present state resulting from natural processes and drainage measures (including the forests) constitutes the first National Park in Hungary established in 1973 *(Fig. 2)*.

REFERENCE

KOVÁCS, G. - SALAMON, F. (eds.). 1977: A Hortobágy a nomád pusztától a Nemzeti Parkig. (The Hortobágy from the nomadic puszta to the National Park). - Natura. Budapest. 352 p.

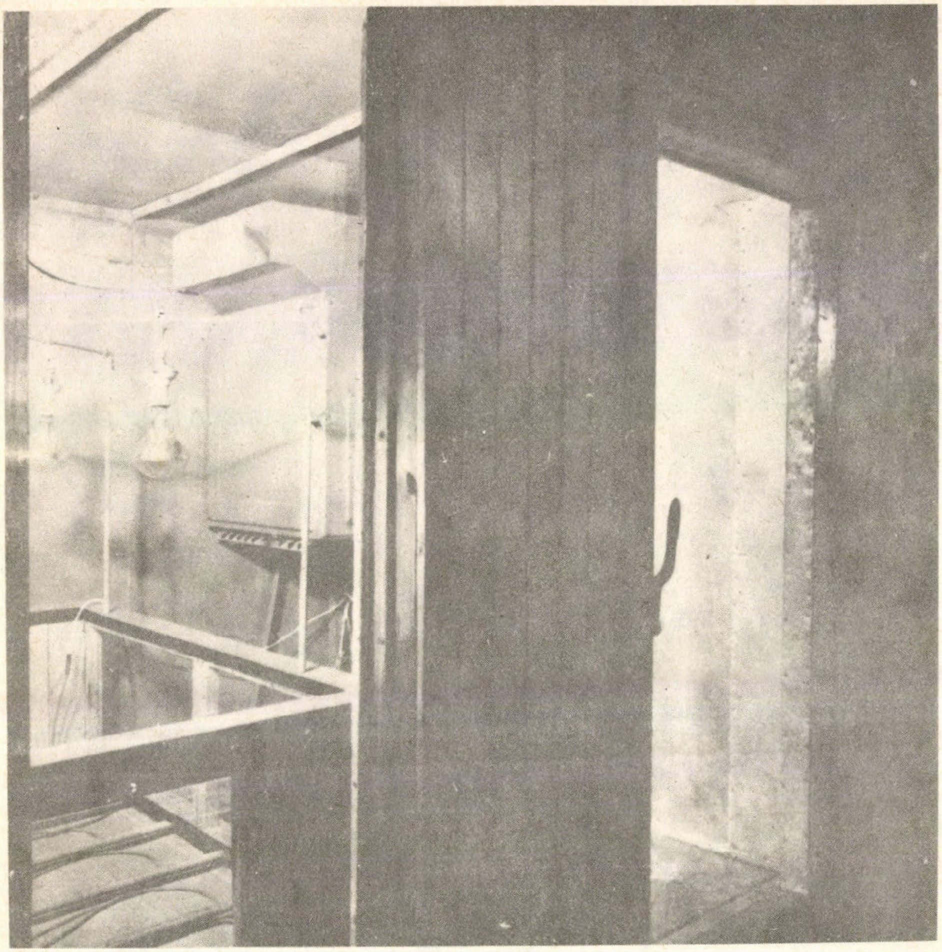


Fig. 9 The frost-chamber through the peep-hole

built. The ventilator can produce approximately 25,000 m^3 of air an hour. In the wind-tunnel wind velocities can be brought about ranging from a mild breeze to a gale of 100 kilometres an hour. The wind-tunnel is provided with an automatic sand feeder so that we should be able to simulate the conditions prevailing in nature as well as possible. At the end of the wind-tunnel there is a filtering plant which filters the sand and dust from the air leaving the wind-tunnel so that only pure air returns to the ventilator through an under-

Fig. 10 Measuring wind velocity of the wind above barchans in the wind-tunnel

passage. We have gained useful data concerning the regularity of sand movement. We have produced not only ripplemarks in our wind-tunnel *(Fig. 11)*, but also miniature sand dunes, e.g. barchans *(Fig. 12)*. The small windfurrows and yardangs are also extremely instructive *(Fig. 12)*. The development of these formations bears witness to the fact that our wind-tunnel is functioning suitably from the viewpoint of aero-dynamics.

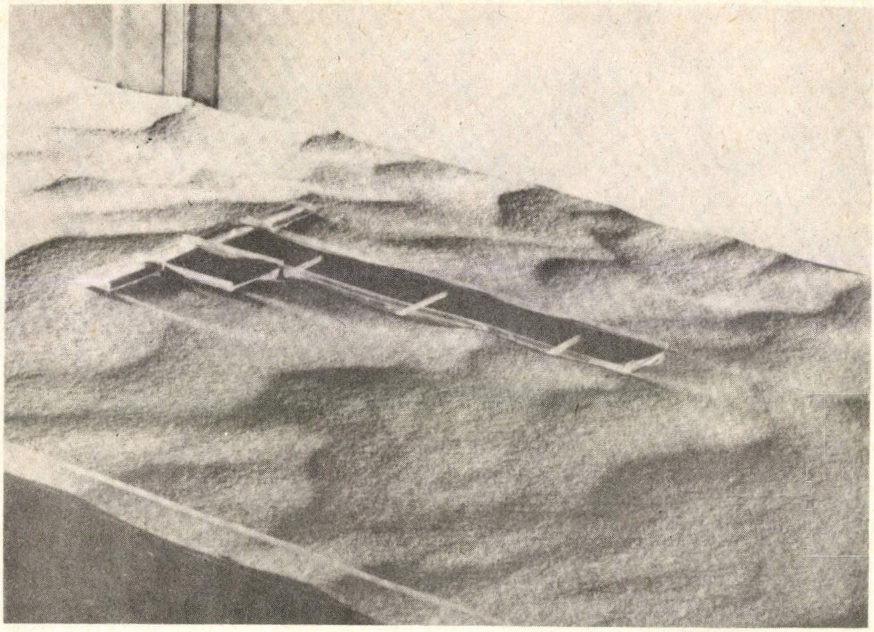


Fig. 11 Ripplemarks, sediment traps in the wind-tunnel

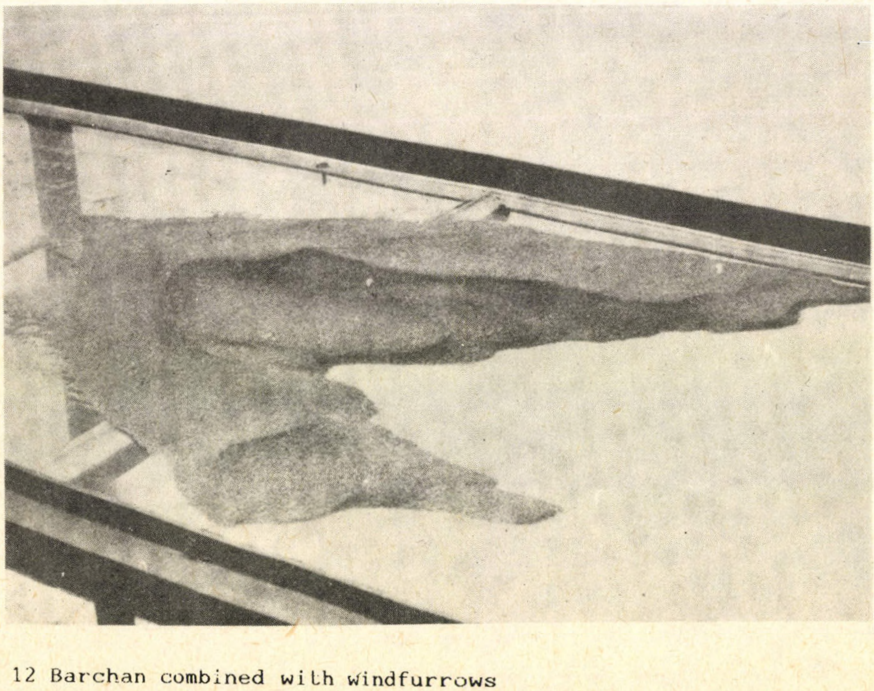


Fig. 12 Barchan combined with windfurrows

The physico-geographical laboratory has also been provided with a *photo laboratory*, first and foremost for the students. Here our students can learn geographical photography, while undergraduates preparing their thesis in geography can process here the photographs necessary for illustrating their work. Investigations concerning endogenous processes, karst phenomena, or pollen analysis, are also performed.

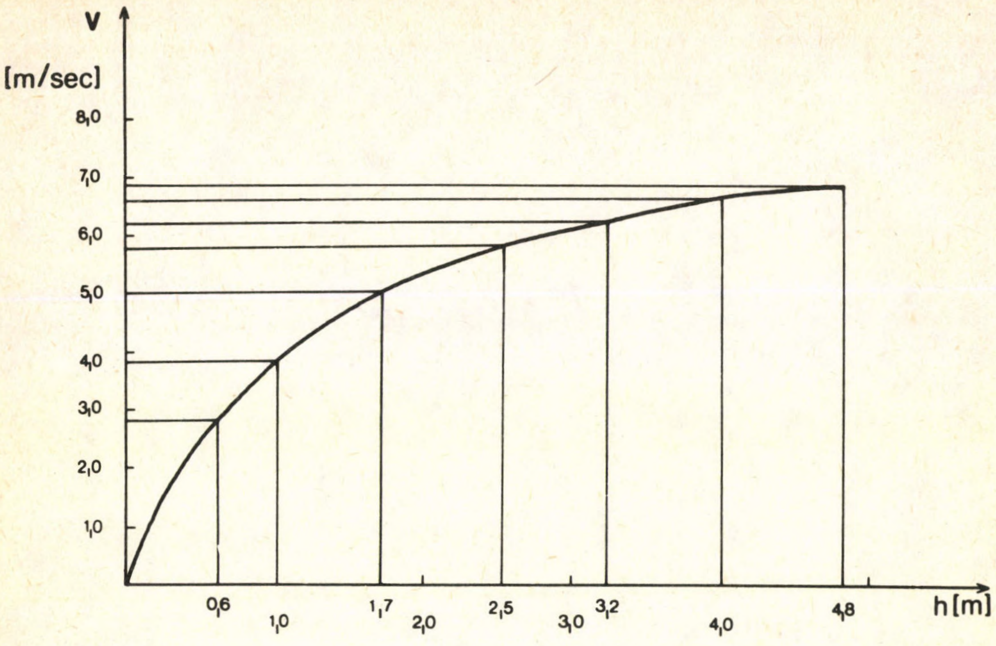


Fig. 3 Velocity of drops of 4 mm diameter (v) at various fall heights (h) (after A.KERÉNYI)

parison with the result of the above calculation will inform about the distribution of moisture in the soil profile.

The *threshold energy of splash erosion* for dry soil and of soils in various stages of wetting was determined. (Threshold energy means the value when the displacement of soil particles in trajectories is first observed.) The procedure is the following: Solum surface is covered by a metal ring. In the centre there is a hole of 17 diameter, where, the raindrop falls on the soil. A glass funnel sawed in two at neck is placed on the ring with the smaller hole above the ring *(Fig. 4)*. Then raindrops of 4mm diameter are let drop from a pipette of proper size installed on stand through the funnel. Surface changes can be observed. (The glass funnel can be substituted by a glass cylinder.)

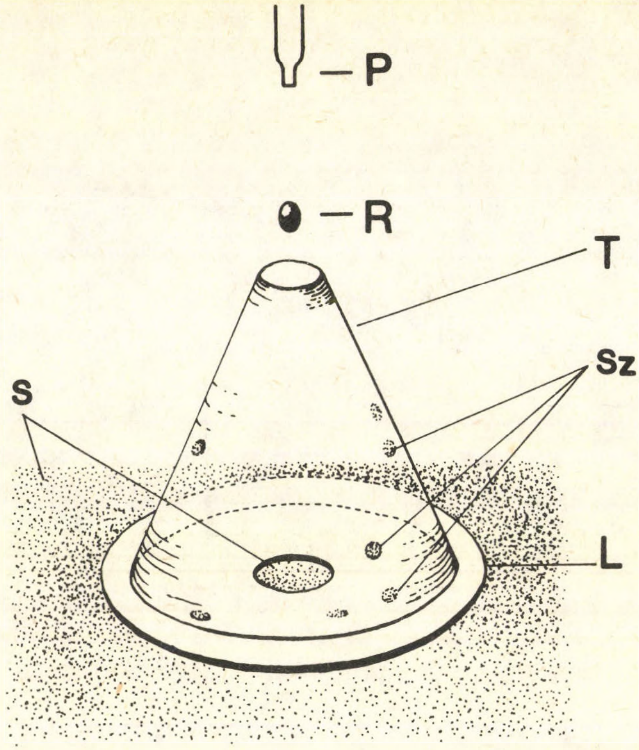


Fig. 4 Experiments with a glass funnel to study splash erosion mechanism (after A.KERÉNYI)

P = pipette; R = raindrop; T = glass funnel; S = soil; L = metal plate; Sz = water and soil suspension

The fall height of raindrops is increased from 5 cm by 2--3 cm intervals to the point when the first spattering particles of suspension fall on the metal ring or the wall of the glass funnel. When threshold energy is reached it should be checked at 8--10 points of the soil to reduce the effect of heterogeneity. Generally, *intervals* of threshold energy are given for a particular soil.

The experiment involves mass measurements too. On an analytical scale the mass of spattering suspension and soil particles to 0.0001 g exactitude and, thus, quantitative information is obtained on the precise mechanism of splash erosion.

A method has been elaborated to measure the *displacement of soil particles along slope*. Flat plates with 5 cm compartments are placed into the recipients at both ends of the slope *(Fig. 5)*. The plates were fixed in the plane of the solum surface (or sand body) at the angle of slope. For measurements, the solum surface was sheltered and soil particles could also start from a single 5 cm zone. After rainfall simulation the wet suspension in the compartments is dried and the mass of dry soil is measured by compartments. The method is capable to determine the mass of soil splashed in various distances downslope or upslope.

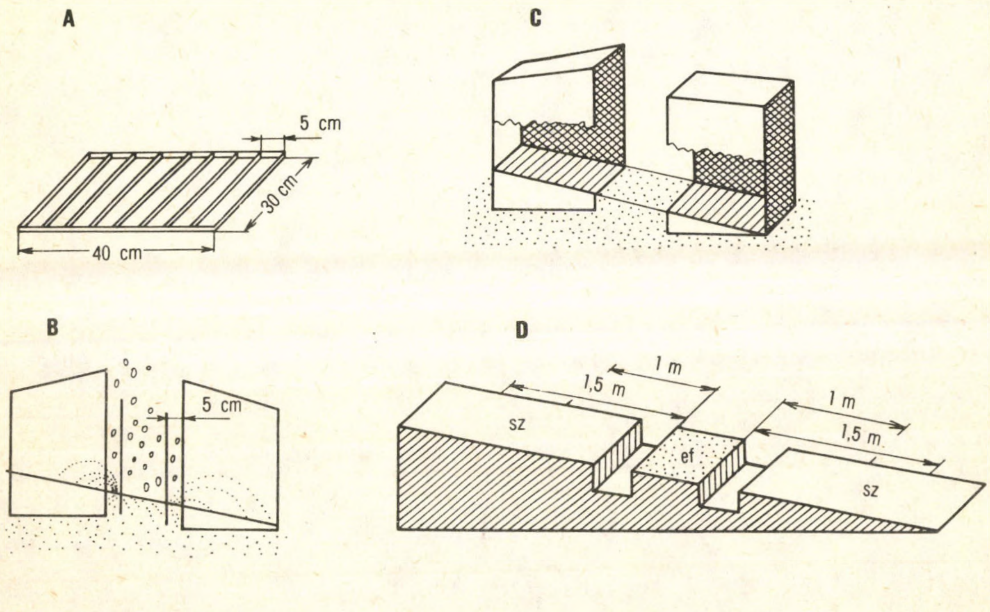


Fig. 5 Instruments to register the displacements of splashed particles along the slope (after A.KERÉNYI)

A = vessel divided into cells; B = position of vessels divided into cells during measurements; C = position of plates limiting the movement of soil particles; D = measurement of maximum distance of flight by paper filter; sz = paper filter; ef = rained surface

Maximum paths during rainfalls are also measured. A slope of 4-5 m length is built with the inclination of the solum and the lower and upper segments are covered by paper filter

(Fig. 5). Spattered raindrops are distinct on the paper filter and their distance from solum can be measured exactly.

Finally, the equipment for the measurement of *rill erosion* is presented *(Fig. 6)*. The system of vessels produced in our workshop is able to produce 0 to 0.5 dm^3 per sec discharge. The apparatus provides a permanent discharge during the experiment. It is ensured by keeping the height of the water column in the vessel N stable. In the vessel F a metal plate maintains laminar flow in the outlet K, without any turbulence.

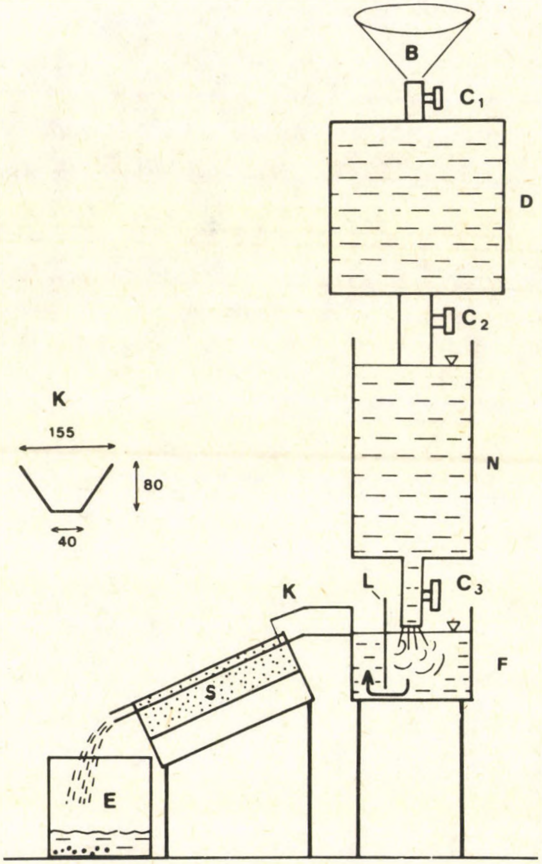


Fig. 6 Instrument to study the erosional effect of water flowing in rills (after A.KERÉNYI)

B = inlet; C_1,C_2, C_3 = taps; D = water tank; N = vessel to ensure permanent water pressure; F = vessel with overflow; L = plate to reduce turbulence; K = outlet (see cross-section top left, data in mm); E = recipient or removed soil suspension; S = solum

The water is conducted onto the solum through a polythene foil. Water flows on the soil surface of 10 degree slope for 20 seconds. Removed soil is collected in the vessel E and its mass is measured. The equipment serves to measure the resistence of soils to water flow with different discharges. Results allow comparisons.

REFERENCES

KERÉNYI, A. 1981: A study of the dynamics of drop erosion under laboratory conditions. - Erosion and Sediment Transport Measurement. - Proceedings of the Florence Symposium. IAHS Publ. no. 133. pp. 365-371.

KERÉNYI, A. 1984: A csepperózió hatása a homokszemcsék méret szerinti differenciálódására. (The effect of drop impact erosion on the size differentiation of sand particles). - Agrokémia és Talajtan. Akadémiai Kiadó. Budapest. 33. 1-2. pp. 63-74.

KERÉNYI, A. 1986: Csepperóziós kisérletek nyirségi homokon. (Splash erosion experiments on sand in the Nyirség). - Alföldi Tanulmányok. 10. pp. 75-98.

LOESS AND PERIGLACIAL PHENOMENA

LOESS ET PHENOMENES PERIGLACIAIRES

STUDIES IN GEOGRAPHY IN HUNGARY 20

Edited by

H.M. FRENCH

M. PÉCSI

The intimate link between periglacial geomorphology and Quaternary studies aimed at paleogeographical reconstruction is well illustrated by the problems presented by loess and loessic deposits. As a consequence, both the INQUA Commission on Loess and the IGU Commission on the Significance of Periglacial Phenomena welcomed the opportunity of sponsoring a joint field meeting in Normandy, Jersey and Brittany in August, 1986. The objectives were to examine loessic deposits from a stratigraphic and sedimentological viewpoint and methods for research as well as the definition of loess, periglacial features and deposits, to assess the paleogeographic implications of their occurrence.

Twenty-one of the papers presented at the Symposium are published in this volume which is recommended to researchers engaged in Quaternary environmental problems in earth science and to those concerned with engineering geology and soil mechanics.

* * *

Les rapports étroits entre la géomorphologie périglaciaire et les recherches du Quaternaire dans les reconstructions paléogéographiques sont bien manifestés par les problèmes que posent le loess et les dépôts loessiques. Par conséquent La Commission du Loess de l'INQUA ainsi que la Commission de la Signification des Phénomènes périglaciaires de l'IGU a félicité l'occasion d'être les sponsors d'un meeting sur terrain en Normandie, en Bretagne et à Jersey en août 1986. Les objectifs ont été d'examiner les dépôts loessiques de point de vue stratigraphique et sédimentologique, les méthodes de recherche pour définir le loess, les dépôts périglaciaires, leurs caractéristiques et les implications paléogéographiques de leur présence.

Vingt et un communications présentées au Symposium sont publiées dans ce volume qui est recommendé d'abord aux participants au Congrès de l'INQUA à Ottawa, aux chercheurs, aux professeurs d'université des sciences de la terre engagés dans les problèmes du Quaternaire et à tout ceux qui s'occuppent de la géologie d'ingénieur et de la mécanique du sol.

* * *

Excursion itinerary with localities