ENGINEERING GEOMORPHOLOGICAL MAPPING IN LOESS REGIONS OF HUNGARY

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MÉRNÖKGEOMORFOLÓGIAI TÉRKÉPEZÉS MAGYARORSZÁGI LÖSZÖS TERÜLETEKEN

Összefoglalás

A geomorfológiai térképezés fontos szerepet játszik olyan tervezési problémák megoldásában, mint nagyberuházások megvalósítási tanulmányai és a telephelyek megválasztása; az ilyen eljárásokat humánföldrajzi kutatások egészítik ki. Az egyik legfelelősségteljesebb feladat a veszélyeshulladék-tározók, köztük a kis és közepes radioaktív hulladék lerakók telephely választása, azok biztonságos üzemeltetése céljából. A Tisza vízgyűjtőjén 1998–2001 között ismétlődően bekövetkezett rekordnagyságú árvízhullámok és vízszennyezések nyomán új követelmények fogalmazódtak meg az árvízbiztonság és a vízgazdálkodás irányában. A Vásárhelyi terv továbbfejlesztése alapvető feladatnak tekinti a folyó nagyvízi medrének rendezését, az árvizek levezetése céljából. A térképezés a morfológiai változások nyomon követésére irányul, különös tekintettel a parti sávok feltöltődésére és az övzátonyok kialakulására.

Summary

Geomorphological mapping can be instrumental in the solution of a wide range of planning problems, from suitability and feasibility studies to site selection for large projects; the procedure should be supported by human geographical investigations. One of the most responsible tasks of mapping is site selection for depositories of hazardous wastes, including those of low and intermediary radioactive level, to secure their safe operation in the future. In the wake of disastrous overbank flooding and pollution events that occurred between 1998 and 2001 new expectations have emerged toward flood prevention and water management in the Tisza Basin. The amendment of the Vásárhelyi Scheme (VTT) was conceived to increase the effectivity of flood prevention through drainage over the flood bed during high water stages. Geomorphological mapping is to focus on morphological changes over the floodplain such as alluvial ridge development in the bank zone and formation of point bars.

Introduction

Investigations into the domain of *physical geography* have recently been conducted by the related sciences functioning as independent disciplines. A pivotal role belongs to *geomorphology* in general and *engineering geomorpholog*y in particular, with its specific topic.

Geomorphology in Hungary had long been characterized by landform evolution studies in detail, publications on topographic and morphographic conditions. An overwhelming part of research projects focused on paleogeomorphology and the experts put an emphasis on the study of evolution and age of the particular landscapes and landforms.

Traditional methods of engineering geomorphological mapping have been developed by the researchers of the Geographical Research Institute HAS into a specific branch dealing with the description, interpretation and typization of relief shaped by landslides and slumps and of surfaces with landslide hazard.

Relief is a fundamental and determinant component of geographical environment and landscape. Vegetation, soils, hydrographic network have formed, human settlements and technical infrastructure developed and most social activities take place upon it, and it is closely associated with land uses such as agriculture.

Beside natural processes, topography is being shaped by the technical and economic activities of humans i.e. by the anthropogenic processes.

Construction is one of the most ancient kinds of human activities initially providing protection against natural forces and harsh circumstances, later serving individual safety and social security, improvement of living standards. As a result of accelerating urbanization there has been an expansion of built environment prevailing in living space and conditions i.e. technosphere, and directs contact of humans with the natural environment vanishes.

Construction activities represent a form of interference into the formerly existing environmental equilibrium. Large projects demand an extensive use of territory and lead to the disappearance of non-recoverable natural endowments. Technical solutions completed with the neglect of safety measures and mismanagement for financial reasons had subsequently turned into environmental risk and material loss as the examples of the oil refinery at Százhalombatta, the Paks Nuclear Power Plant, the city of Komló, the Gabčíkovo–Nagymaros hydrocascade have shown. Miscalculations in the course of planning and implementation of these projects have led to serious environmental hazard.

Accelerated urbanization and global climate change have been responsible for extreme flood events at the turn of the millennium and staggered conviction in the effectivity of flood prevention system in the Tisza basin. As a consequence, the amended Vásárhelyi Scheme has put an aim of raising the standard of water management and taking measures in hydraulic engineering as an urgent task.

Engineering geomorphological studies

In the early 1960s M. PÉCSI (1970), and in the beginning of 1970s J. SZILÁRD (1972) inspired by B. BULLA (1954) called the attention of Hungarian geomorphologists to the necessity of quantitative and qualitative analysis of current processes of landform evolution. This way the results of geomorphological studies had become more exact and their practical usefulness increased. Elaboration of the theoretical and methodological foundations of the Hungarian geomorphological mapping and their practical application were an important outcome of this trend (BULLA, B. 1954; PÉCSI, M. 1970; BORSY, Z. 1961; SZILÁRD, J. 1972; HEVESI A.–JUHÁSZ, Á. 1973; SCHWEITZER, F.–TINER, T. 1996).

Engineering geomorphological thematic mapping in Hungary was elicited by the requirements of economy and technology. Extensive construction activities and a rapid technological development made it necessary to raise the standards of preliminary planning.

Traditional engineering geomorphological investigations, i.e. the study of geological features or the analysis of physical soil properties in the immediate neighbourhood do not meet the requirements of planning of large projects at a higher level. As hillslopes and piedmont surfaces in Hungary as a rule are mantled with loess, many of the large establishments were built on these surfaces.

After M. PÉCSI's study entitled „Problems of engineering geomorphology" was published (1970), it became widely accepted that the investigations into the relationship between the processes of relief formation, resulting landforms and technological practice on the one hand and mapping at 1 : 2000, 1 : 5000, 1 : 10 000, 1 : 25 000 scales belong to the domain of engineering geomorphology.

The planning and construction activities to provide safe environment for large projects made the representation of topography on geomorphological maps indispensable. When preparing for any large investment (oil refinery, power plant, motorway, residential quarters, embankments), it should be studied what kind of relief forming processes are anticipated after implementation, i.e. environmental impact assessment has to be made. For instance, calculations were made on the expected dimensions of erosional processes for the period of operation of the technical object, which might be several decades, even centuries (*Figure 1*).

Geomorphological mapping can be instrumental in the solution of a wide range of problems, *from suitability and feasibility studies to site selection* for large projects; the procedure should be supported by human geographical investigations.

Hazardous waste is produced in Hungary in huge quantities (including wastes of low and intermediary radioactive level) for the safe disposal of which (at Püspökszilágy), taking into account natural conservation and environmental protection criteria, no final solution could be found yet. A problem of utmost importance is that short and medium term detrimental environmental impact (within some years and decades) upon soils, surface and subsurface waters and in the biosphere as a whole, in most cases can be estimated only approximately.

Previously detailed preliminary investigations with considerable expenditures have been performed in the environs of perspective sites of depositories for hazardous wastes of low and intermediary radioactive level (e.g. Magyaregregy, Ófalu) but finally these projects were abandoned *(Figure 2* and *3*).

Until recently, site selection procedures have been based upon limited knowledge of the study area. Investigations were not carried out in the wider geographical surroundings of the site and cause–effect relationships between the subsystems within the socio-economic environment.

At present sophisticated methods of geomorphological research is to serve site selection with a purpose of providing safe disposal in a long run; for wastes of low and intermediary radioactive level it is 1000 years (*Figure 4* and *5*).

In the catchment basin of the Tisza river extreme and recurring flood and pollution events were recorded within a short period, between 1998 and 2001. In the wake of these disasters, new expectations have emerged toward *flood prevention and water management in the Tisza Basin*.

After the adoption of the amended Vásárhelyi Scheme geomorphological analysis of the Tisza basin continued in the framework of an OTKA project, with a special reference to alluvial ridge development over the floodplain.

The amendment of the Vásárhelyi Scheme (VTT) was conceived to increase the effectivity of flood prevention through drainage over the flood bed during high water stages. According to the investigations performed so far, depressions and alluvial ridges in

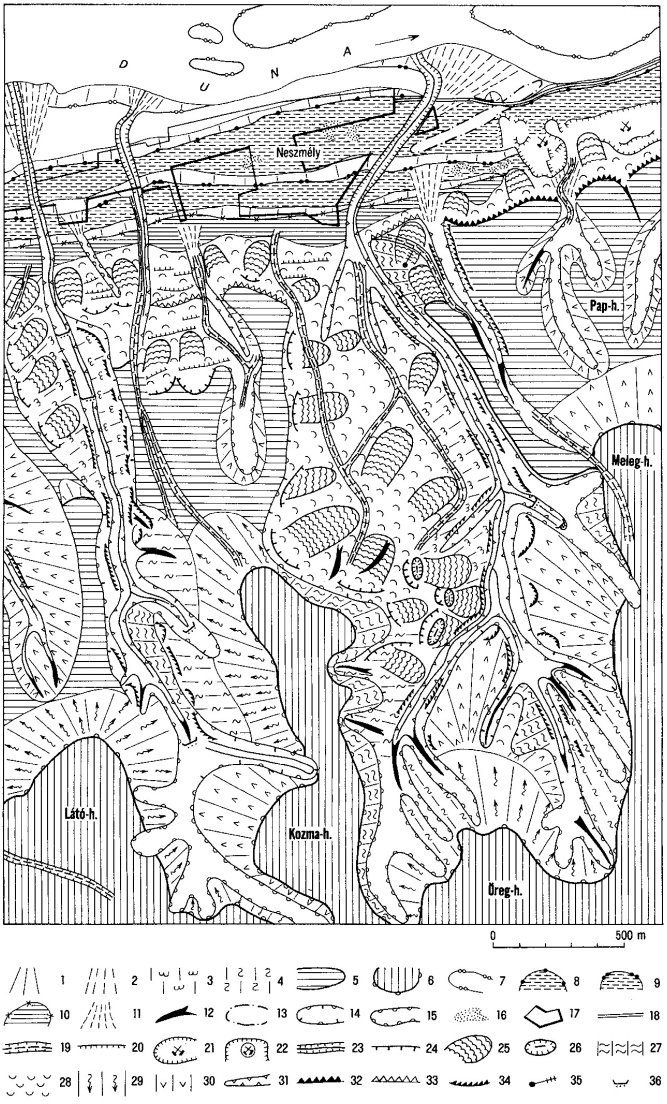

Figure 1. State of slopes: 1 = stable slope; 2 = unstable sliding slope; 3 = active sliding slope; 4 = slope with landslide hazard. Mountain landforms: 5 = interfluvial ridge; 6 = foothill, hillslope. Accumulation landforms: 7 = terrace 1.b; 8 = terrace 2.a; 9 = terrace 2.b; 10 = terrace 3; 11 = debris fan. Channels and valleys: 12 = erosional ravine; 13 = abandoned channels of minor watercourses; 14 = erosional-derasional valley; 15 = derasional valley. Sand forms: 16 = bank dune. Man-made landforms: 17 = settlement; 18 = road; 19 = road cut in loess; 20 = pseudoterrace; 21 = quarry, abandoned; 22 = quarry, upfilled; 23 = canal. Mass movement landforms: 24 = front of slicing landslip; 25 = heap of slicing landslip; 26 = heaps and minor depressions among slips and slumps; 27 = slope affected by slump, in temporary equilibrium; 28 = undulating surface of fossil landslip; 29 = slope wash; 30 = rill erosion; 31 = loess gully; 32 = unstable steep bank; 33 = stable steep bank; 34 = steep bank prone to collapse. Objects damaged by mass movements: 35 = buildings; 36 = embankments, levees

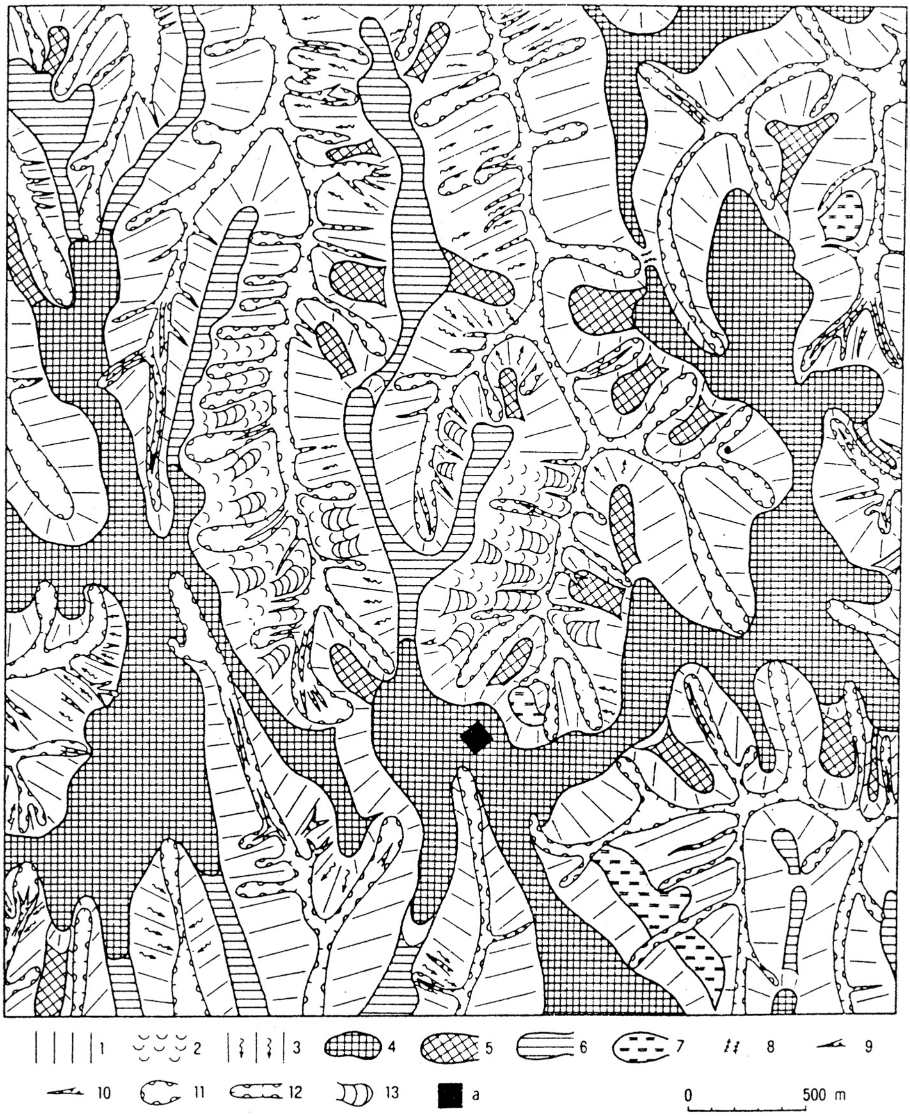

Figure 2. Geomorphological map of the environs of projected waste depository at Ófalu (Comp. by: SCHWEITZER, F., 1990). 1 = stable slope; 2 = surface of fossil landslides (slopes with landslide hazard); 3 = slope with traces of rill erosion; 4 = plateau in low position (250–300 m a.s.l.); 5 = low ridge (200–250 m a.s.l.); 6 = interfluvial ridge (230–280 m a.s.l.) 7 = gentle slope segment; 8 = col; 9 = erosional gorge (1–5 m); 10 = erosional gully (5–10 m); 11 = derasional valley 12 = erosional-derasional valley; 13 = heap of slumps; a = projected depository

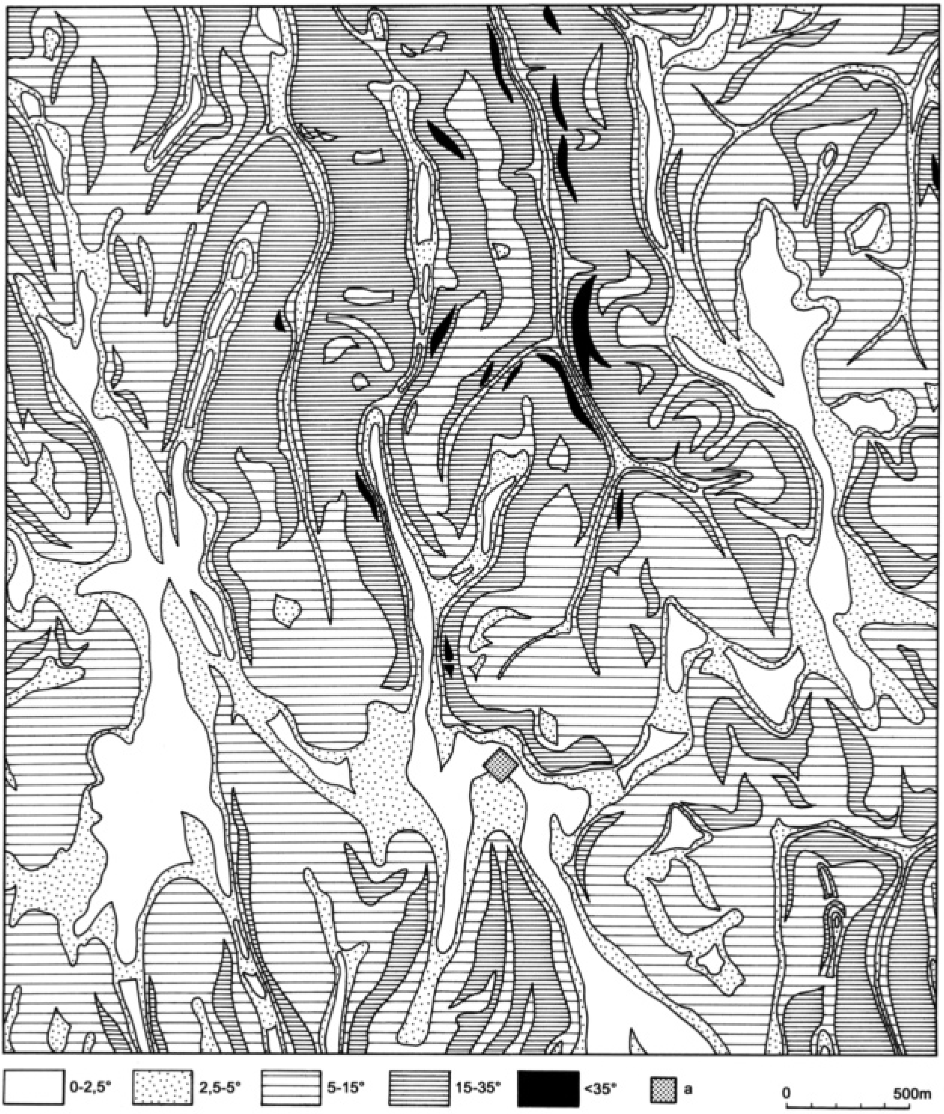

Figure 3. Map of slope categories in the environs of Ófalu (Compiled by BALOGH J. 1990).
a = projected depository

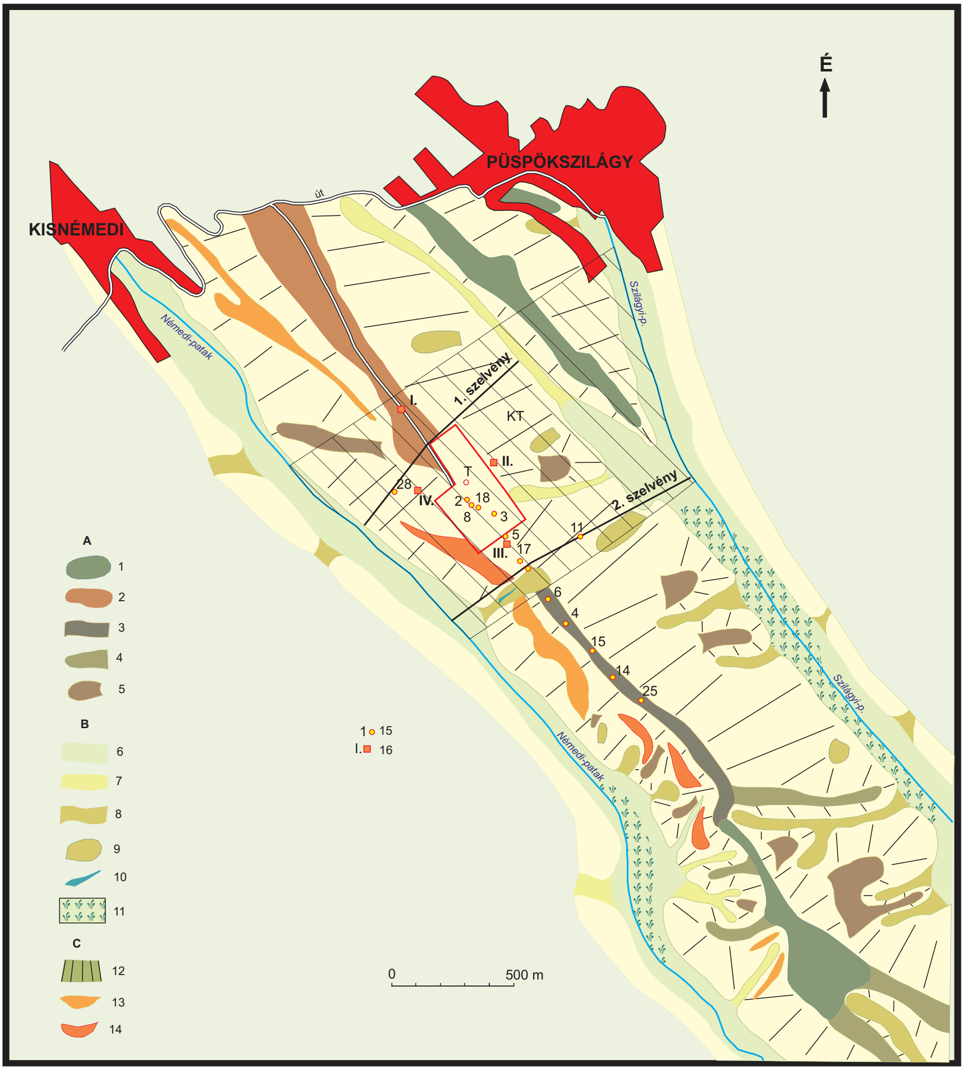

Figure 4. *Geomorphological map of the environs of waste depository at Püspökszilágy (Comp. by: BALOGH, J.–SCHWEITZER, F., 2003). A = Complex landforms: 1 = summit level (>250 m a.s.l.); 2 = summit level (200–250 m a.s.l.); 3 = ridge; 4 = interfluvial ridge; 5 = gentle slope segment; B = Erosional and accumulational landforms: 6 = erosional valley; 7 = erosional-derasional valley; 8 = derasional valley; 9 = derasional niche; 10 = ravine, gully; 11 = waterlogged talweg; C = Slopes: 12 = slope undistinguished; 13 = slope segments steeper than 25%; 14 = slope with sliding hazard; 15 = borehole; 16 = soil survey trench; T = projected site; KT = area of modelling soil erosion and slope development*

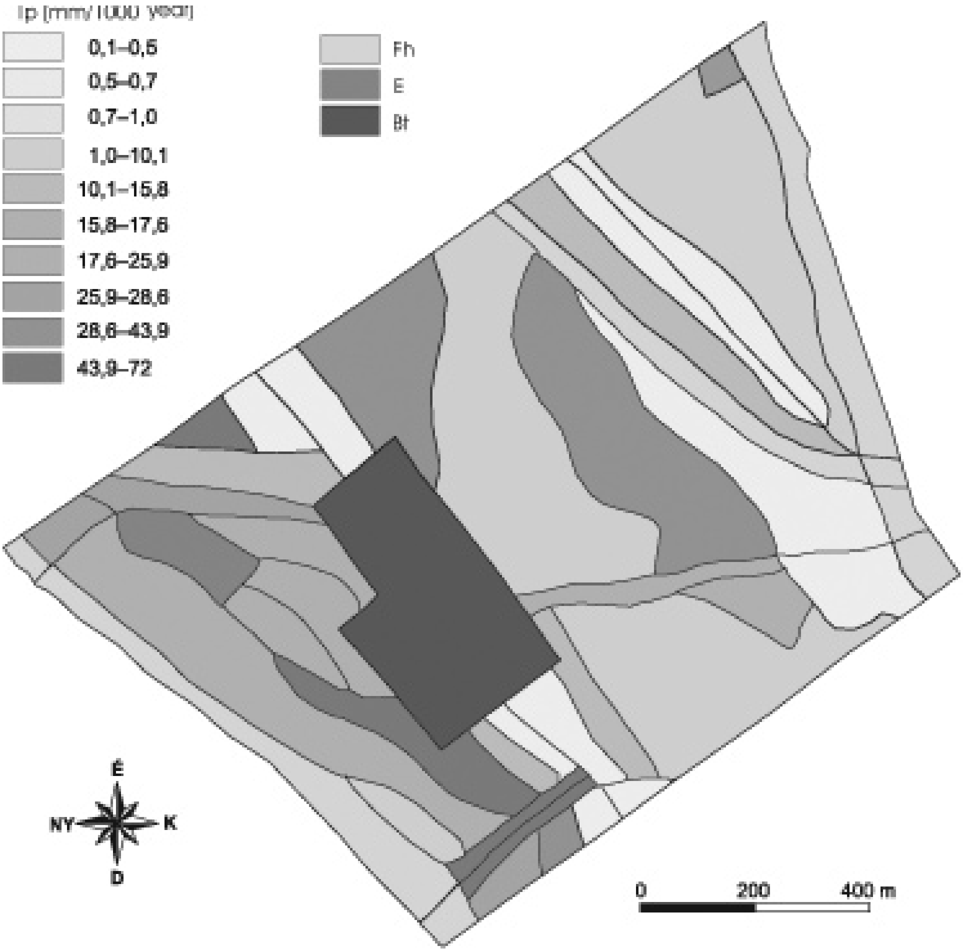

Figure 5. Thickness of eroded soil in the case of arable cultivation (100 years' simulation). (Comp. by: BALOGH, J. – HUSZÁR, T., 1999). Fh = accumulation; E = forest; Bt = built-up area; Tp = soil loss

the floodplain make an adverse impact upon drainage conditions during inundation events. Morphological changes, predominantly processes of silting up have been continuous and they are to reduce safety in the future.

For a better planning of human intervention as part of VTT and understanding of the unfavourable processes under way it seems to be necessary to focus on morphological changes such as alluvial ridge development in the bank zone and formation of point bars (*Figure 6*).

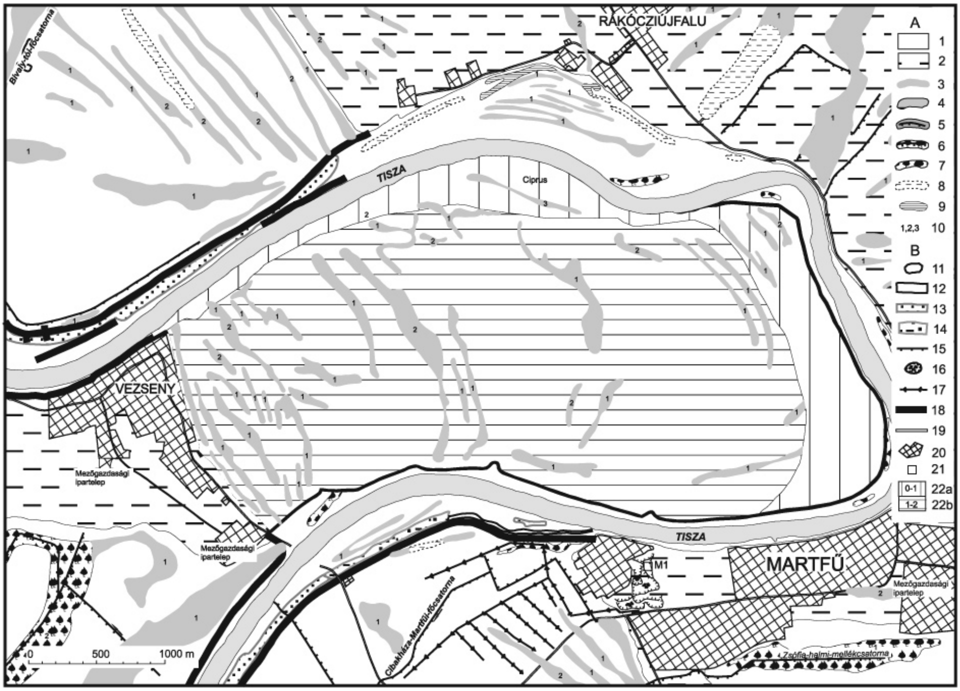

Figure 6. Geomorphological map of the Tisza section in the embayment at Vezseny. (Comp. by: BALOGH, J. – SCHWEITZER F., 2003). A = Quasi-natural landforms: 1 = Low floodplain; 2 = High floodplain; 3 = Former meander, upfilled, in ploughland cultivation; 4 = Former meander, partly upfilled, permanently inundated, in woodland; 5 = Former meander, upfilled, canalised; 6 = Former meander, upfilled, canalised, in woodland; 7 = Former meander, upfilled, in woodland; 8 = Former meander, partly upfilled, temporarily inundated; 9 = Former meander, partly upfilled, permanently inundated; 10 = Depth of upfilled meander in metres. B = Man-made landforms: 11 = Excavation pit; 12 = Row of excavation pits; 13 = Row of excavation pits, overgrown by forest; 14 = Row of excavation pits, overgrown by forest, temporarily inundated; 15 = Drainage canal; 16 = Quarry; 17 = Irrigation canal; 18 = Flood control embankment; 19 = Public road; 20 = Settlement; 21 = Soil profile; 22a = Extent of alluvial ridge development 0–1.0 m; 22b = Extent of alluvial ridge development since flood control measures 1.0–2.0 m

Conclusions

Engineering geomorphological studies in support of large projects are aimed at a site selection to reduce political and legal problems to a minimum and to promote cost effective technological solutions. Investigations carried out over the past 15–20 years revealed the aggravation of problems associated with the efficiency of construction activities. The most suitable places have already been built up and vacant areas at disposal are more or less affected by various kinds of human activities.

Experts in physical geography agree upon the idea that it is inexpedient to investigate the geographical environment from physical and human aspects separately. Although these disciplines of geographical science use different concepts and methods of study, they often have purposes in common. In our case it is to explore the potentials (i.e. the geomorphological and human geographical ones) within a given area

As in most countries, in Hungary the method of *step-by-step filtering* is applied in the procedure of investigation. As far as engineering geomorphological studies are concerned, the first step here is the exclusion of inappropriate areas, followed by the identification of the suitable places. Of the latter the preferable ones are to be analysed further with an ultimate goal of identification of sites with the highest potential to be recommended from the geographical viewpoint. Geomorphological assessment and mapping is to be carried out within these areas.

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