Association of European Geological Societies

Executive Committee Meeting

3-4 June 1994

Hungary

Guide to the Field Trip

Budapest
1994

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Guide to the Field Trip
4 June 1994

Part I. Geology

Stop 1. Budapest, Gellért Hill	General view Upper Triassic Upper Eocene Quaternary Hydrogeology
Stop 2. Érd - Diósd, exposure	Middle and Late Miocene
Stop 3. Vértesszőlős, protected site of early man	Quaternary
Stop 4. Tata, Calvary Hill, geological nature conservation area	Upper Triassic Jurassic Lower Cretaceous Neolithic chert mine
Stop 5. Gánt, abandoned bauxite pit	Upper Triassic bauxite (Paleocene) Middle Eocene

No geology proper at *Stops 6 and 7.*

Introduction

At the previous Business Meeting of the AEGS Executive Committee which took place during MAEGS-8 in Budapest, on 23 September 1993, it was decided to hold the next EC Meeting also in Hungary, and - as an innovation - to complement it with a one-day geological excursion.

The megatectonic setting (in the Carpathian Basin) and the geohistory of Hungary have been presented by J. Haas in the Excursion Guide booklets of MAEGS-8. (These are still available.) Accordingly, there is no need to elaborate on these here.

The present Field Trip will take you from Budapest to the Northeast of Transdanubia (some 250 km ride).

The sedimentary formations on display range stratigraphically from the Triassic to the Quaternary.

Cultural highlights (described separately, in the second part of this Guide) include a Neolithic chert mine, an ancient Roman settlement, the memorial of Hungary's first archbishop, the medieval residence town and necropolis of the Hungarian kings, a regional museum at Tata, the baroque-style centre of Székesfehérvár (Alba Regia), and the "Liberty Monument" in Budapest, with a large panorama of the 2-million capital cut into two parts (Buda and Pest) by the Danube.

Enjoy the trip - and come back to Hungary again!

Endre Dudich
President of the Association of
European Geological Societies

Stop 1. **Gellérthegy (Gellért Hill)**, 235 m a. s. l.
(Dr. Endre Dudich)

Gellért Hill is situated on the hilly right bank of the river Danube, facing the lowland area of the left bank (Pest), which is part of the Great Hungarian Plain. (The hills of Buda belong to the Transdanubian Central Range.)

Gellért Hill is a tectonic horst of Upper Triassic (Norian) dolomite, intensely fractured and karstified. (Eocene paleokarst and post-Eocene tectonism have been identified.) The dolomite is at some places overlain by Upper Eocene (Priabonian) sediments of a transgressive half-cycle: conglomerate and breccia, bryozoan marl (epigenetically silicified by hydrothermal processes), and by Quaternary freshwater limestone. (The latter makes up the top of Castle Hill.)

Two major fault systems could be identified, striking NNW-SSE (practically along the Danube), and E-W, respectively.

Due to stepwise ("en echelon") downfaulting of blocks, the Triassic dolomite is at a depth of 800 m below St. Marguerite island, and at 1100 m below the Municipal Park, 3 km farther to the East. The Triassic and Eocene rocks mentioned above are covered by the Eocene/Oligocene boundary Buda Marl Formation, by the Oligocene (partly euxinic) Kiscell Clay Formation and by different Miocene sediments.

The disjunctive (tensional) faults allow the upward movement of thermal waters, originating from descending karst water, heated by the anomalous geothermal gradient heat flow of the thin crust. The temperature of the sources of Gellért Bath at the foot of the Hill, is 41°C. (Those of Széchényi Bath in the Municipal Park are of 74°C.)

The abundance of hot waters along what has been called the "Buda thermal line" attracted the ancient Celts (Ak-Ink) and Romans (Aquincum). The baths were further developed by the Turkish pashas in the 16th century. Since the middle of the past century, Budapest has developed into a renowned balneological centre.

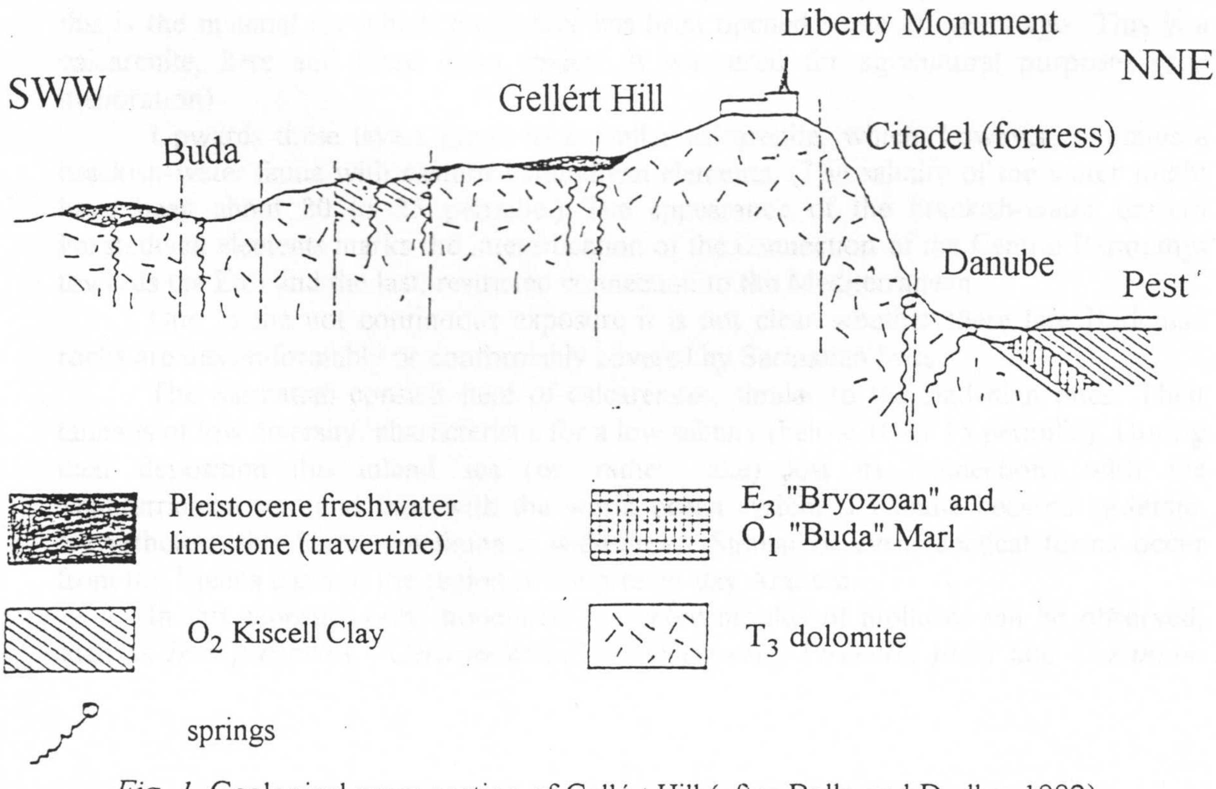

Fig. 1. Geological cross section of Gellért Hill (after Balla and Dudko, 1992)

Stop 2. **Érd - Diósd**: abandoned sandpit and quarry (Middle to Late Miocene: Badenian, Sarmatian, Pannonian)
(Dr. Pál Müller)

The exposures illustrate the late development and final closure of the Central Paratethys sea system.

Divided by a normal fault of about 30 m displacement, marine Middle Miocene and lacustrine Upper Miocene sedimentary rocks are juxtaposed.

The Badenian is represented by limestones. Near the fault a reefal structure is displayed. It is built of calcareous red algae, generally crustose in appearance. In a spot of about 20 m diameter, a coral patch reef has developed.

The coral assemblage is of low diversity, *Tarbellastrea reussiana*, *Porites cf. leptoclada* and *Porites collegniana* occur, together with red algae. The external form of the colonies is varied: massive and branching forms equally occur. Most or all colonies are embedded in an allochthonous position, probably transported and redeposited on a talus of minor size. The colonies are intensively bored, mainly by bivalves. The matrix contains an abundant fauna: molluscs, foraminifers, decapods and many other organisms of which only the crustaceans have been studied so far. These are typical of different ecological settings, but mostly littoral and shallow sublittoral. Characteristic is the presence of *Pachygrapsus*, indicating rocky littoral environment. Reef dwellers constitute about half of the assemblage. The most common forms are *Charybdis mathiasi*, *Chlorodiella mediterranea* and *Petrolisthes magnus*. The mixed composition of the fauna points to a "post mortem" transportation and mixing of skeletal elements. The transportation, however, must have been a mild one, since the fragile crab carapaces are mostly well preserved, although invariably disarticulated.

Covering, and possibly in part horizontally replacing, the reefal deposits, sediments of a shallow marine environment are exposed, containing fossils of more or less stenohaline biota. These are displayed in the NW part of the quarry. As a matter of fact, this is the material for which the quarry has been opened some 20 years ago. This is a calcarenite, here and there quite chalky. It was used for agricultural purposes (soil melioration).

Upwards these layers grade to a similar calcarenite, which, however, contains a brackish-water fauna with eastern Paratethyan elements. (The salinity of the water might have been about 20 to 25 permille.) The appearance of the brackish-water eastern Paratethyan elements marks the intensification of the connection of the Central Paratethys towards the East and the last, restricted connection to the Mediterranean.

Due to the not continuous exposure it is not clear whether these late Badenian rocks are discomformably or conformably covered by Sarmatian beds.

The Sarmatian consists here of calcarenites, similar to the Badenian ones. Their fauna is of low diversity, characteristic for a low salinity (below 10 or 15 permille). During their deposition this inland sea (or, rather, lake) lost its connections with the Mediterranean sea, and thus with the world ocean system. Its fauna became endemic. Nevertheless, this Sarmatian fauna is widespread. Similar or even identical forms occur from the Vienna basin to the region of the present-day Aral sea.

In this exposure only moderately preserved moulds of molluscs can be observed, such as *Irus gregarius*, *"Cerastoderma" vindobonensis*, *Pirenella picta* and *Cerithium* *rubiginosum*, together with tests of forams, some bryozoans, etc., all members of a low-diversity fauna.

The youngest beds in the exposure belong to the Pannonian, a stage formed in a lake that occupied a considerable part of the present-day Carpathian basin. (This lake replaced only a small, western part of the former Sarmatian lake.) The lower level is made of sands probably deposited on an alongshore bar near to a delta. It is almost depleted of fossils, although some mammal remnants have been found in the bottom layers. They are covered by dark bluish silts containing ill-preserved molluscs: limnocardiids and *Congeria*. These are the most characteristic representatives of the rich endemic fauna of the Pannonian lake.

The deposits of this exposure give an idea about the final fate of the Central Paratethys basin system.

During the history of this realm, from the early Oligocene, there were several events gradually disconnecting the basin from the world ocean system. By the late Miocene there was a major final event which led to the formation of a long-living isolated lake (from about 11 to 5.4 million years ago). In this lake an exceptionally rich endemic fauna developed, of which the ostracods and molluscs are of best known. The number of endemic mollusc species approaches one thousand. Most genera and even some subfamilies are confined to the basin.

The study of these biota gives an insight into a major evolutionary event, an adaptive radiation process. This may serve as an excellent model for cladogenesis and anagenesis, since the space of this evolution was restricted, and there is a well preserved and virtually continuous record of change and diversification of the molluscs and ostracods which inhabited the lake.

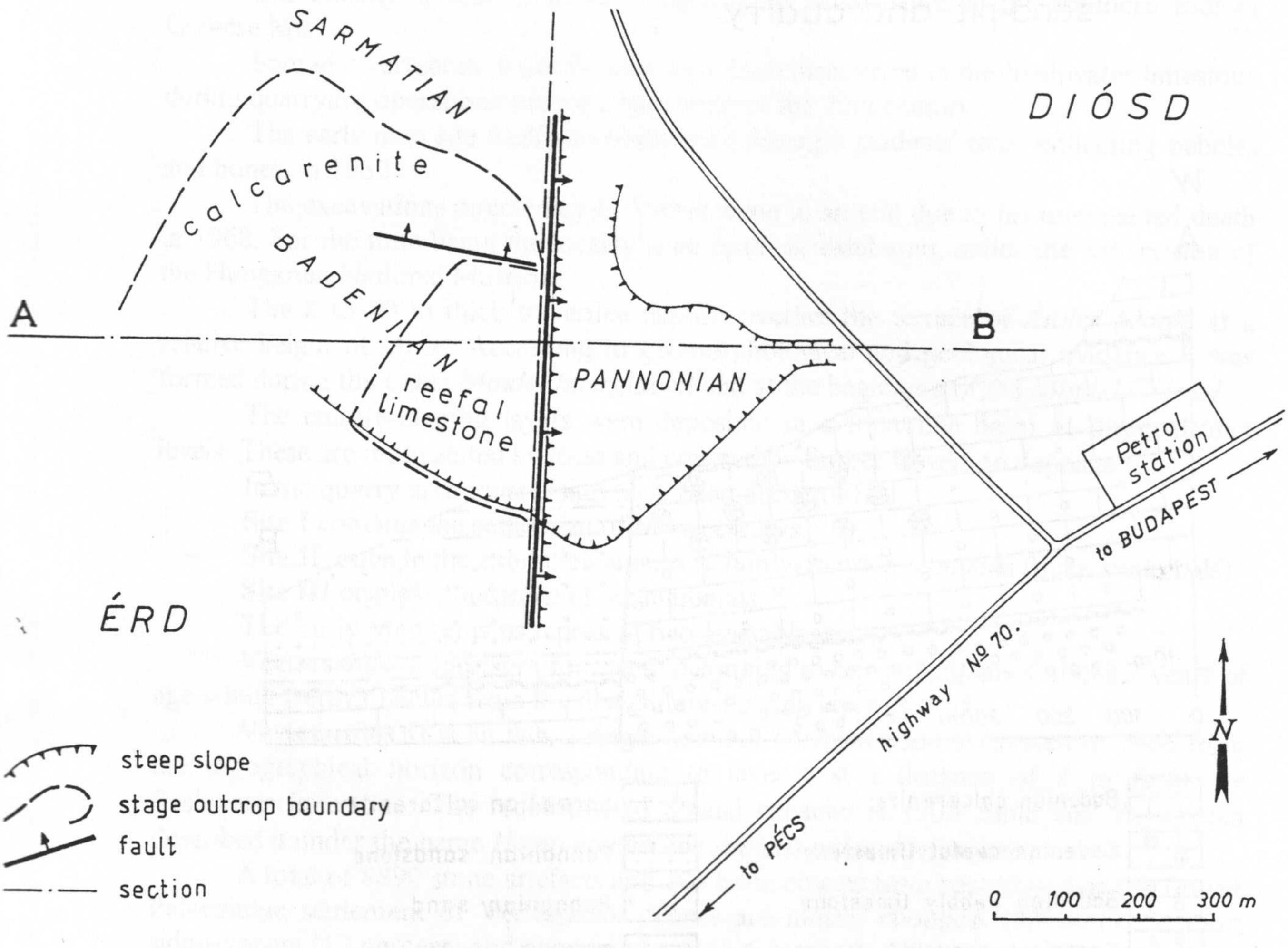

Fig. 2. Érd-Diósd. Location sketch

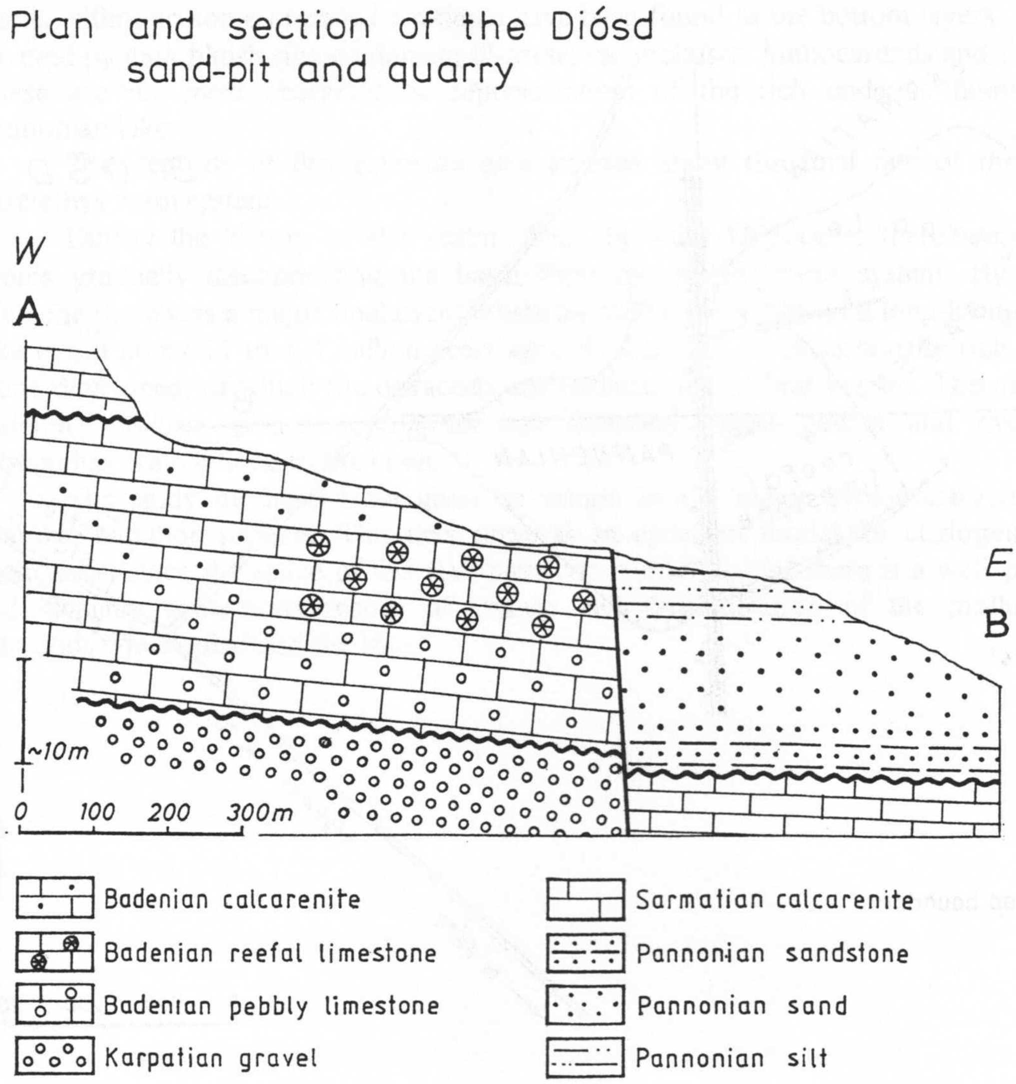

Fig. 3. Section of the Diósd sand-pit and quarry

Stop 3. - **Vértesszőlős** - a Middle Pleistocene Site of Early Man

(Dr. László Kordos)

Vértesszőlős is one of the most important sites of Early Man in Europe where hominid remains, vertebrate and mollusc faunas, footprinted tracks, plant imprints, pollens, archaeological occupation levels, as well as traces of the deliberate use of **fire** have come to light in a travertine (freshwater limestone).

The locality is situated at the village of the same name, at the southern foot of Gerecse Mts.

Sporadic vertebrate fossil remains have been discovered in the freshwater limestone during quarrying operations since the beginning of the 20th century.

The early man site itself was discovered during a students' tour, collecting pebbles and bones, in 1962.

The excavations directed by L. Vértes came to an end due to his unexpected death in 1968. For the time being the locality is an open-air exhibition, under the supervision of the Hungarian National Museum.

The 8 to 10 m thick travertine deposit overlies the terrace of *Átalér brook*, at a relative height of 60 m. According to geomorphological and geological evidence it was formed during the *Günz-Mindel Interglacial* and at the beginning of the *Mindel Glacial*.

The culture-bearing layers were deposited in a travertine basin at three distinct levels. These are intercalated by loess and covered by further travertine deposits.

In the quarry area several sites have been distinguished.

Site I contains the settlement of *Homo erectus*.

Site II, outside the exhibition area, is rich in vertebrate remnants (micromammals).

Site III displays footprints of big mammals.

The Early Man remains represent two assemblages.

Vértesszőlős I consist of four teeth belonging to one individual of about 7 years of age which were collected from the first culture-bearing layer in 1965.

Vértesszőlős II is, in fact, a single hominid occipital bone excavated in 1965 from the topographical horizon corresponding to layer I at a distance of 8 m from the freshwater limestone. The reconstructed cranial capacity is 1300 cubic cm. A. Thoma described it under the name *Homo erectus seu sapiens palaeohungaricus*.

A total of 8890 stone artefacts and 105 bone objects have been found at the Lower Palaeolithic settlement of Vértesszőlős. These are mostly choppers (23 percent), flake side-scrapers (17 percent) and chopping tools (5.6 percent). All these are attributed to the so-called *Buda Culture*, named by L. Vértes after the first find of this type material from the caves of Castle Hill in Budapest.

Vertebrate biostratigraphic correlation suggest an age of 320 to 250 thousand years for the travertine deposits of Vértesszőlős. The radiometric dating performed on different samples by several experts using various methods do not contradict this datation.

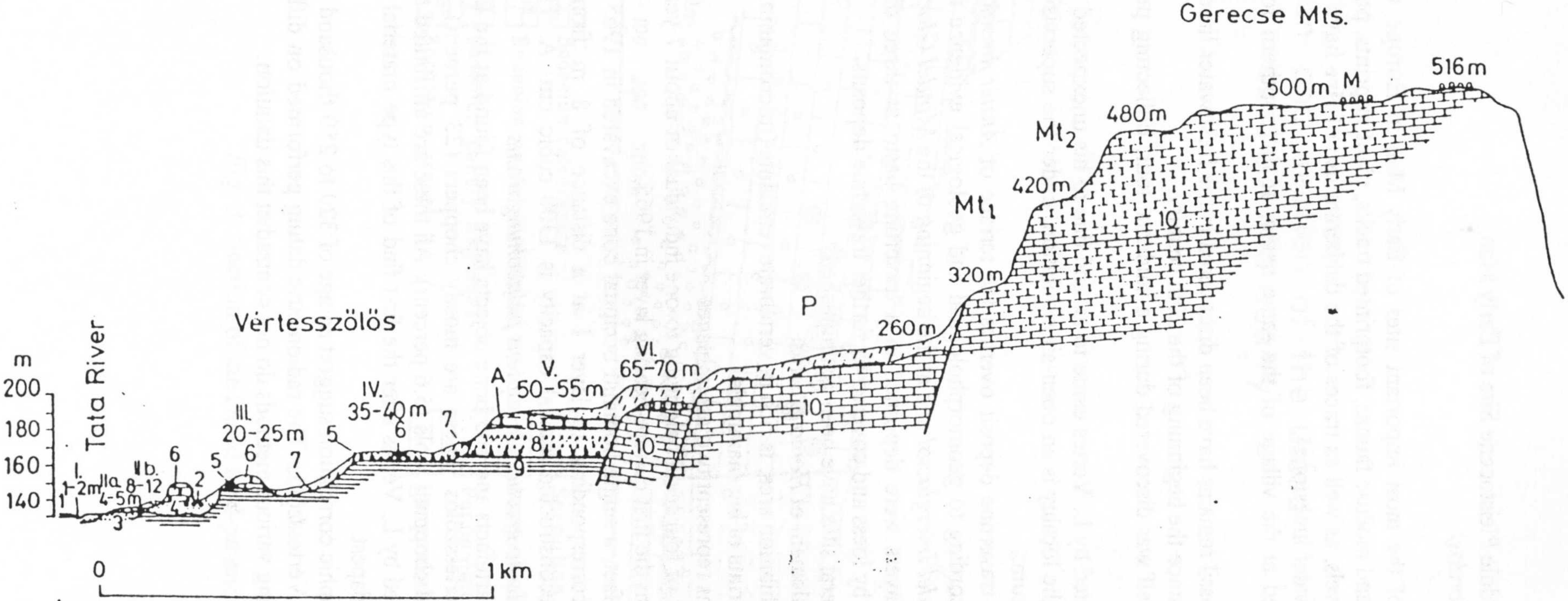

Fig. 4. Geomorphological surface of the West-Gerecse at Vértesszőlős (M. Pécsi). I. Present floodplain; IIa. First flood-free terrace (Würm); IIb. Second flood-free terrace (Riss–Würm); III. Riss (I) terrace; IV. Mindel (?) terrace; V. Günz terrace; VI. Pre-Günz terrace: P: Foothill surface; Mt_1–Mt_2: Miocene marine terraces; M: Miocene terrestrial gravels; 1. Holocene alluvium; 2. Brown forest soil; 3–4. Gravel and sand on the lower terraces; 5. Thin gravel layer on the higher terraces; 6. Travertine; 7. Loess, slope-loess; 8. Local debris fan mixed red clay; 9. Tertiary clay, sand layers; 10. Triassic limestone. x – Position of the Vértesszőlős Lower Palaeolithic site

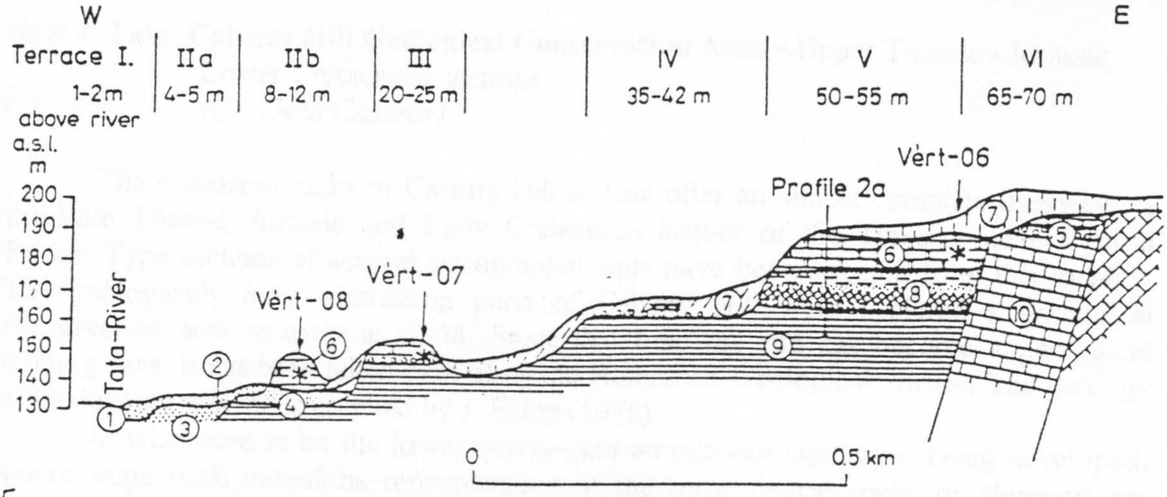

Fig. 5 Geological position and absolute age of the travertine levels on the terraces of the Átalér terraces with the Lower eolithic site at Vértesszőlős. The geological profile according to Pécsi–Scheuer–Schweitzer. For the legend to the profile see Fig. 4. Absolute chronological dating: Hennig et al. 1983.

Vért – 08 Th/U 135 $^{+12}_{-11}$ ka ESR 123 ± 25 000

Vért – 07 Th/U 248 $^{+\infty}_{-67}$ ka ESR 202 ± 20 000

Vért – 06 Th/U 227 $^{+56}_{-37}$ ka ESR 386 ± 39 000

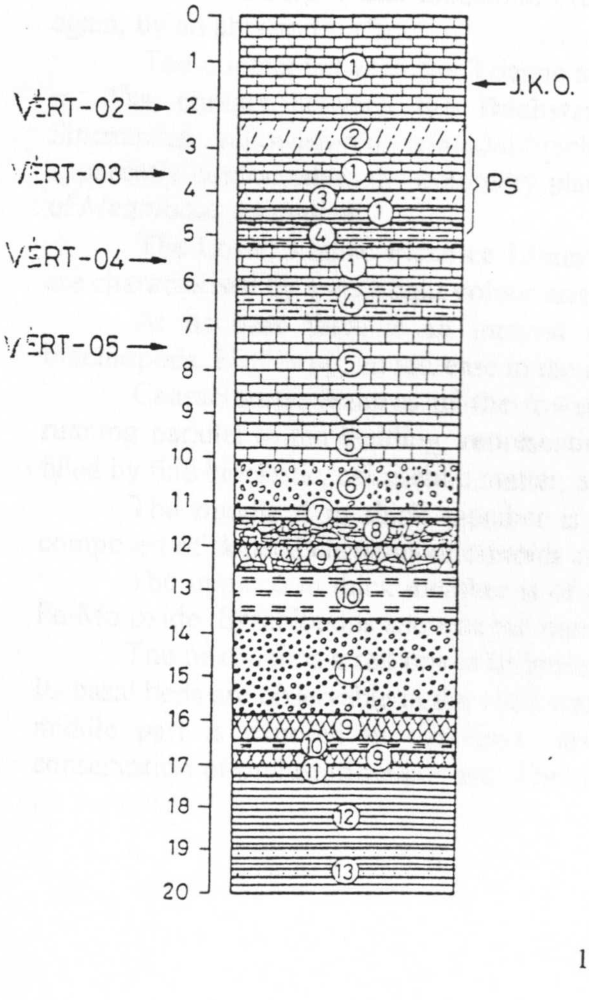

Fig. 6. Detailed profile at the Palaeolithic site I. 1. Thin layered travertine; 2. Stratified loess; 3. Fine sand with calcareous silt; 4. Calcareous silt; 5. Compact, thick-banded travertine; 6. Small pebbles with sand; 7. Ochre clay; 8. Local detritus and gravel, coarse limestone pebbles and small pebbles; 9. Red clay; 10. Mottled terrestrial clay; 11. Alluvial fine gravel with sand of the Tata river; 12. Tertiary clay; 13. Sand interbeddings: Ps—cultural layers of the Lower Palaeolithic site—pebble tools, hearth, burnt bones, bones characterised by Biharian fauna.

Th/ and ESR dating after G. J. Hennig et al. (1983):

Vért – 02	Th/U	128 $^{+20\,000*}_{-12\,000}$	ESR 127 ± 13 000*
Vért – 03	Th/U	217 $^{+40\,000*}_{-28\,000}$	ESR 245 ± 25 000*
Vért – 04	Th/U	325 $^{+\infty\,000}_{-60\,000}$	ESR 172 ± 17 000*
Vért – 05	Th/U	> 350 – 1000	ESR 333 ± 17 000

* Contaminated samples. Th/U dating after J. K. Osmond (1973). J. K. O. — 350 000 two samples were analyzed on three occasions.

Stop 4. **Tata. Calvary Hill Geological Conservation Area** - Upper Triassic - Jurassic - Lower Cretaceous sections
(Dr. Géza Császár)

The Mesozoic rocks of Calvary Hill at Tata offer an almost complete overview of the Late Triassic, Jurassic and Early Cretaceous history of the Transdanubian Central Range. Type sections of several stratigraphic units have been selected from this locality. The geologically most interesting parts of Calvary Hill were declared a geological conservation area as early as 1958. Since that time the site has become a geological training base. It has been taken care of by the Hungarian Geological Survey. The geology of the locality was monographed by J. Fülöp (1976).

In what used to be the lower quarry-yard an outdoor lapidary is being developed, where huge rock monoliths representative of the most typical rocks of Hungary are exhibited. In addition, an exhibition of the country's mineral raw materials is being assembled.

Oldest rock cropping out in the area is the Rhaetian **Dachstein Limestone** exposed in 10 to 15 m of thickness, in the wall of the lower quarry-yard in the southwest part of the hill.

In the exposed sequence, Lofer cycles characteristic of a backreef lagoon environment can be studied very well. The cyclothems, in general, show the following constitution.

An undulate abrasion surface is overlain by a yellowish-grey intertidal dolomitic limestone of wavy microlamination with algal mats which is followed by a greyish-white, calcite-speckled *Megalodus* limestone bed deposited in the subtidal zone and truncated, again, by an abrasion surface.

The contact between the Triassic and Jurassic can be studied over a length of 200 m. The contact between the **Dachstein Limestone** and the Upper Hettangian - Sinemurian yellowish-red crinoidal-brachiopodal **Pisznice Limestone** overlying it is apparently conformable, the boundary plane being even, though abounding with sections of *Megalodus* specimens.

The Lower Liassic **Pisznice Limestone Formation** is 20 m thick. Its lower 10 m are characterised by a very light colour and the lack of distinct bedding planes.

At its base there is an interval rich in crinoids, cephalopds, gastropods and brachiopods. Higher up, an increase in the amount of bioclasts is observed.

Characteristic features of the lower member are the stromatactis-type structures running parallel to the bedding, representing cavities probably produced by burrows and filled by fine bioclastic, calcipelitic matter, and coated radiaxially by calcite.

The middle 4 m thick member is strikingly well stratified with frequent lenses composed of skeletal elements of crinoids and with lots of brachiopods.

The upper 6 m thick member is of darker shade, containing tiny lumps coated by Fe-Mn oxide. Brachiopods and internal moulds of ammonites are common.

The next unit is a red crinoidal limestone that can be assigned to the Pliensbachian. Its basal beds are observable in the rock wall at the basal level of the conservation area; its middle part is exposed in the upper level, on the terrace behind the building for conservation of prehistoric mine pits. The rock is constituted by alternating calcipelite and calcarenite (crinoidite), but these rock types coalesce which is probably due to motion of unconsolidated sediment and to bioturbation.

The rock texture is generally biomicrite with rockforming *Crinoidea, Globochaete, Foraminifera, Spongia* and *Ostracoda* remains. The rich benthic assemblage is suggestive of a shallow-water paleoenvironment.

The **Kisgerecse Marl Formation** of Toarcian age overlying, with a hardground, the Pliensbachian beds is only 0.6 to 0.8 m thick. It indicates a rapid change in the shallow-water paleoenvironment and the conversion of this into a deeper-water neritic one. It is characterised by a homogeneous red marl with limestone nodules.

Of the fossils, ammonites, *Bositra* and *Radiolaria* are worthy of mention, to which benthic foraminiferal remains are added in subordinate quantities.

The **Tölgyhát Limestone Formation** of Dogger age exposed at the terrace of the upper quarry level is 5 m thick. Composed of red nodular argillaceous limestone, it abounds with Fe-Mn oxide nodules of 1 to 2 cm size. *Chondrites*-type traces of animal life are observable on the bedding surfaces. The texture is biomicrite with *Globochaete* and *Cadosina* as well as *Protoglobigerina* and *Bositra*.

In the upper part of the formation two peculiar sub-units appear: a 0.5 m thick coarse calcarenite-crinoidite bed at the base and a 0.4 m thick *Bositra* coquina layer above the former.

The Upper Dogger **Lókút Radiolarite Formation** is represented by a brown chert bed of 0.8 to 1.2 m thickness which overlies the **Pisznice Limestone** with a hardground and is heavily condensed.

Above the chert bed 0.3 to 0.8 m of greyish-white limestone bed with intraformational breccia follows which can be interpreted as talus deposit. The red micrite matrix between the breccia grains abounds with *Cadosina* and *Protoglobigerina*. On the basis of the ammonites this formation is of Oxfordian age.

The Kimmeridgian is represented by an argillaceous limestone with manganese nodules interrupted by hardgrounds and abounding with ammonites (**Pálihálás Limestone Formation**). The microfacies is characterised by a rock-forming percentage of *Lombardia*, though other planktonic microfossils (*Cadosina, Radiolaria, Protoglobigerina*) are also common.

The Tithonian-Berriasian sequence is composed of heavily condensed, purple-red and light grey cephalopodal, brachiopodal and calpionellid-bearing limestones attaining a total of only 1 to 1.5 m thickness. The comparatively higher proportion reached by the benthonic organisms here (*Foraminifera, Brachiopoda* and *Echinodermata*) is conspicuous.

Named **Szentivánhegy Limestone Formation** the unit in question is based upon the sections exposed in the conservation area and chosen as formation stratotypes.

Repeatedly rejuvenated and refilled submarine fissure systems and subsyngenetic breccious talus deposits are readily observable in the Malm formations.

The unevenly eroded surface of the Jurassic rocks was submerged again in Aptian time. It was during this transgression that the **Tata Limestone Formation**, a grey crinoidal limestone widespread in the Central Range, was formed.

The basal beds of the formation can be studied. On the one-time rocky shore a brown stromatolitic coat of 1 to 2 dm thickness was formed, frequently affecting even fossils. In the basal bed, chart, quartz, sandstone and diabase pebbles are observable and a very rich fauna of ammonites, bivalves, echinoids and gastropods is found. The roughness of the bottom is not reflected in the higher beds. The texture of the rock is extraclastic biosparite with a rock-forming proportion of skeletal elements of crinoids. The extraclasts derive primarily from the Malm sequence.

The Geological Conservation Area is important even from the archaeological viewpoint. In the chert bed there are records of Neolithic to Copper Age flint mining. The implements discovered during excavations are exhibited in the conservation building.

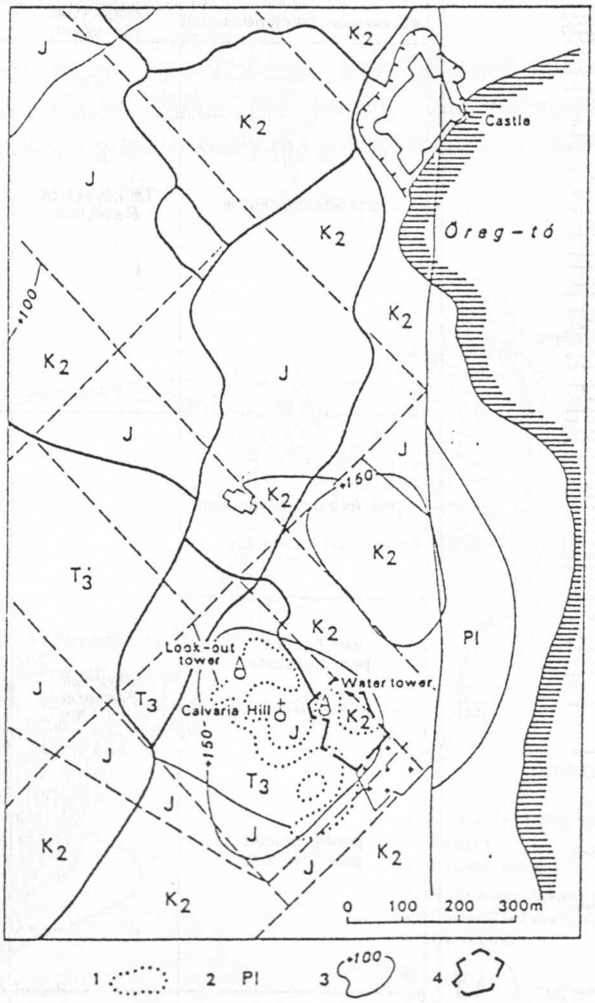

Fig. 7. Mesozoic formations at the Calvary Hill, Tata and at the adjacent areas (after Fülöp, 1976)

1. Surface outcrops of the Mesozoic formations - Subsurface formations: K_2=Middle Cretaceous (Albian silty marl, Aptian crinoidal limestone), J=Jurassic (Malm-Dogger limestones and cherts, Liassic limestones), T_3=Upper Triassic (Rhaetian Dachstein Limestone). 2. Pleistocene freshwater limestone, 3. surface contour line of the Mesozoic formations, 4. border of the Tata Nature Cónservation Area

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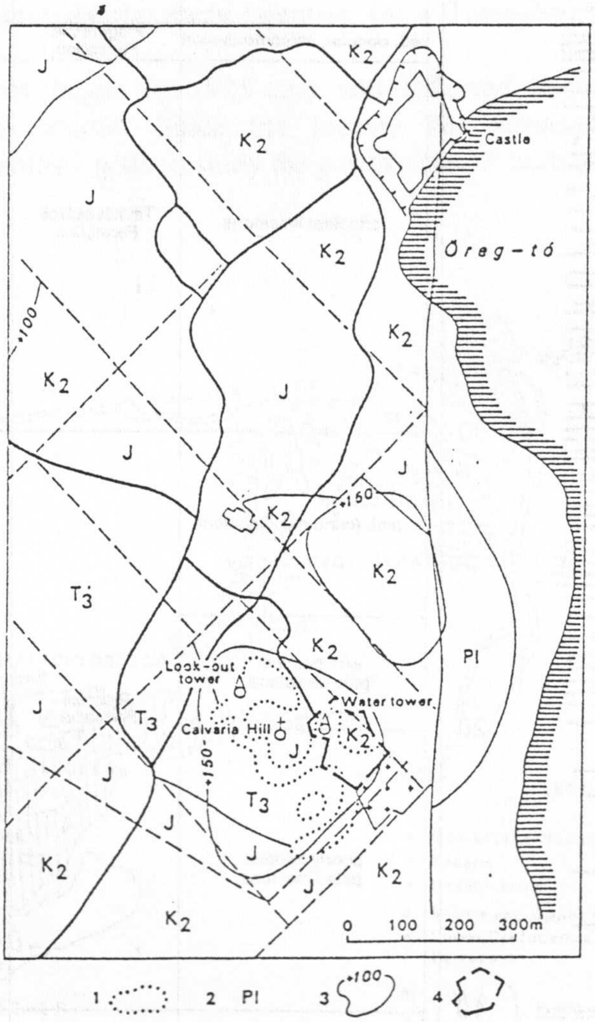

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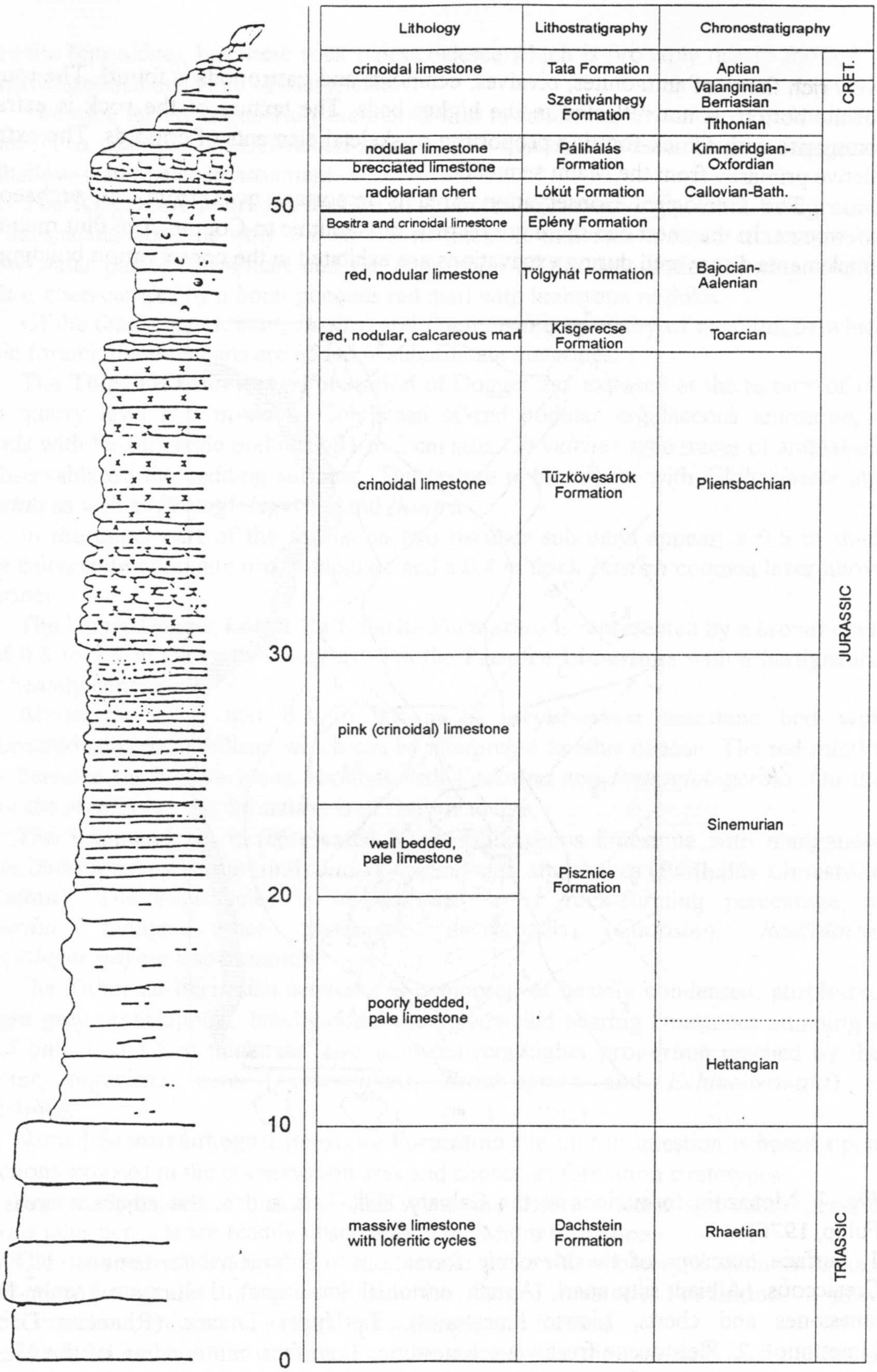

Fig. 8. Stratigraphic column of the protected quarry of Calvary Hill, Tata (modified after J. Fülöp, 1976)

Stop 5. - **Gánt** (Vértes Mts.), bauxite deposit - Open pit Bagolyhegy ("Owl Hill")
(Dr. Endre Dudich - Dr. Andrea Mindszenty)

The locality originally called "Forna" or "Fornapuszta" has been famous for its rich Eocene molluscan fauna described by Papp in 1897, and studied by generations of paleontologists.

The Eocene succession rests uncomformably on the karstified surface of Triassic dolomites. The first bauxite deposits exploited in Hungary were discovered here at the Triassic/Eocene contact, in the early twenties, by a Transylvanian mining engineer, J. Balás.

Mining activity began in 1925 and was followed soon by the first scientific descriptions of the bauxite. Since the locality has attracted many mineralogists, geochemists and paleontologists to study the peculiarities of both the bauxite and its cover.

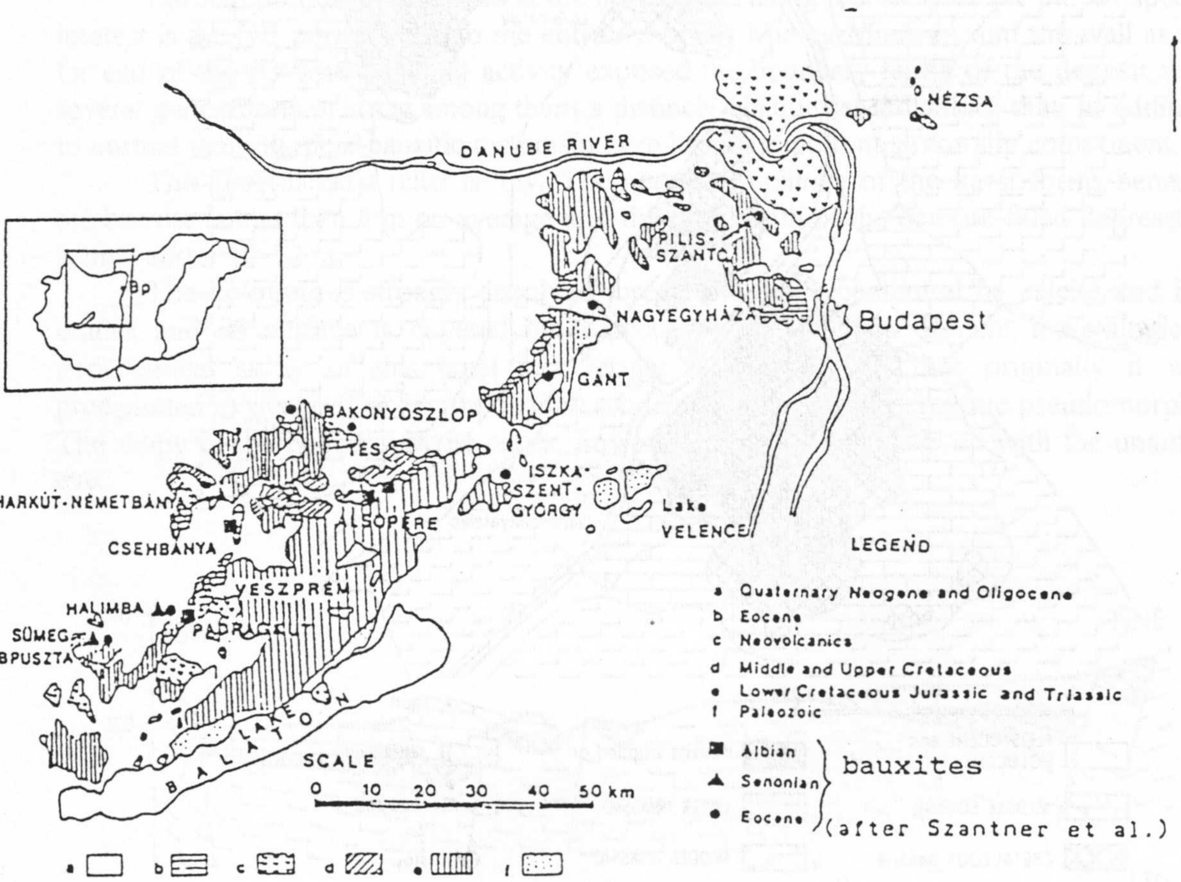

Fig. 9. Major bauxite deposits of the Transdanubian Central Range (after Mindszenty et al., 1992)

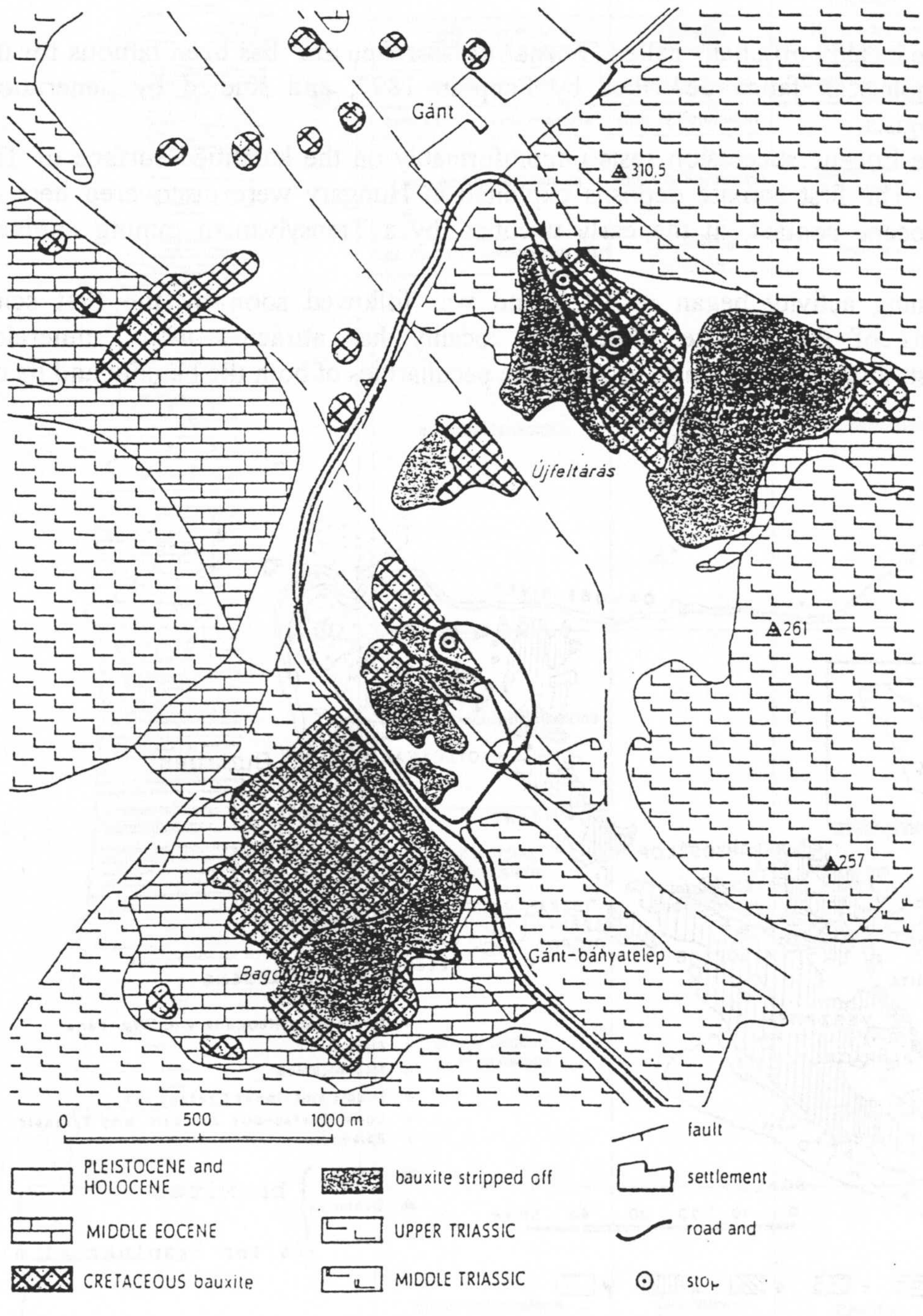

Fig. 10. The Gánt bauxite deposit (after Szantner et al., 1969)

General geology and stratigraphy

The occurrence is situated in the SE foothills of Vértes Mts. which are an asymmetric monocline slightly tilted to the NW and dissected by two major sets of faults (SSW-NNE and NNW-SSE). Most of the hilly range is built up of Triassic rocks (Ladinian dolomites, Carnian dolomites and marls). The Tertiary cover is discontinuously exposed on the surface along both the western and eastern foothills. Bauxite deposits are known from the eastern part only, where the Eocene succession reflects a stepwise transgression beginning in the latest Middle Eocene ("Marinesian" or "Bartonian" more or less equivalent to P12/14 or NP16/17, respectively, according to Bignot et al., 1985). The bauxite itself is generally considered as Palaeocene/Eocene.

Bedrock

Carnian dolomite is exposed at the bottom and along the walls of the pit. Of special interest is the NE corner close to the entrance of the Mining Museum and the wall at the far end of the pit where mining activity exposed the boundary faults of the deposit with several generations of striae among them a distincly oblique set indicating that, in addition to normal faulting, post-bauxitic tectonism here had an important strike-slip component.

The general karst relief is low. The vertical amplitude of the karst forms beneath the bauxite is less than 5 m on average and the total depth of the bauxite-filled depression is only about 10-12 m.

The dolomite is strongly dissolved, brecciated and recemented by calcite and Fe-oxides and its surface is covered by a peculiar Fe-rich crust. Recent mineralogical-geochemical study of this crust by Germán (1992) proved that originally it was precipitated as pyrite. The "pyrite" is now oxidized; it consists of hematitic pseudomorphs. The shape of the euhedral pyrite cubes, however, can be observed even with the unaided eye.

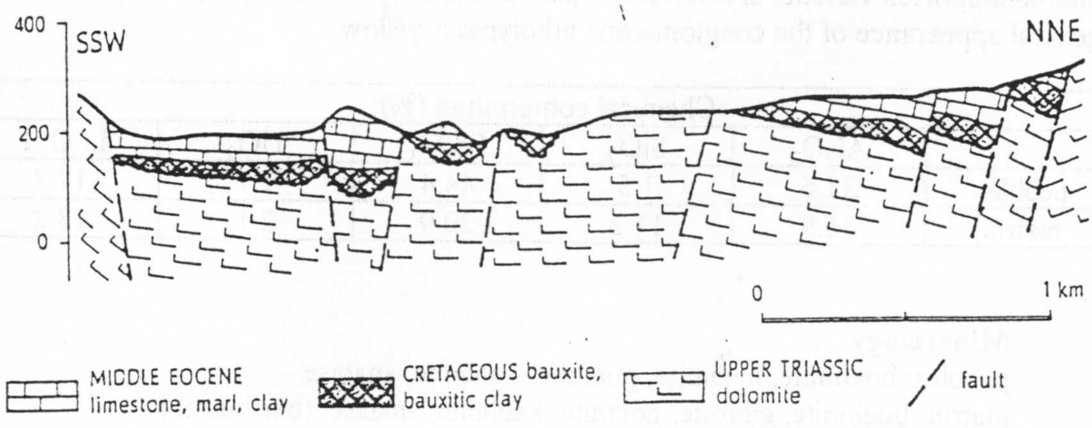

Fig. 11. Profile across the Gánt bauxite deposit (after Szantner et al., 1969)

Stable isotope analysis and cathodoluminescence study of the carbonate cement associated with the pyritic crust showed that calcite precipitated under meteoric conditions from waters rich in organically derived CO_2 and was later on partly dolomitized. The crust formed after the deposition of the bauxite but before the dissection of the beginning of the Bartonian transgression. Paleomagnetic measurements suggest that oxidation took place in the Holocene as a result of exposure and contact with downward-percolating vadose meteoric groundwater.

Bauxite

The deposit is a continuous "layer-like" body. Its irregular lower surface conforms with karstified surface of the dolomite, whereas its upper surface is rather planar.

There are two major lithotypes.

The argillaceous-bauxitic MUDSTONE is light pink or red, sometimes with a slight yellow tint, with scattered roundgrains of 1 to 2 mm diameter.

Chemical composition (%):				
Al_2O_3	SiO_2	Fe_2O_3	TiO_2	L. O. I.
49.2	10.5	20.5	2.8	16.4

Mineralogy: boehmite, gibbsite, kaolinite, goethite, anatase, rutile.

Geochemical facies: semi-vadose.

The moderately to poorly-sorted bauxite CONGLOMERATE may be matrix-supported or clast-supported. The clasts (pebbles) are rounded to subrounded, 0.5 to 2.0 cm size, reddish, russet or brown. Texture may be simple or composite pelitomorphic, pelitomorphic-intraclastic or, very rarely, oolitic. Clasts usually have a varnish-like surface coating consisting of a few thin layers of iron-oxide accretion. Since the matrix of the matrix-supported varieties is invariably a pale coloured (yellowish) pelitomorphic mud, the general appearance of the conglomeratic lithotypes is yellow.

Chemical composition (%):					
	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	L. O. I.
pebbles	31.6	1.5	44.4	1.7	17.8
matrix	46.9	11.3	20.9	2.1	18.2

Mineralogy:
pebbles: boehmite, hematite, goethite, kaolinite, anatase
matrix: boehmite, gibbsite, goethite, kaolinite, anatase, (berthierite)

Geochemical facies: semi-phreatic

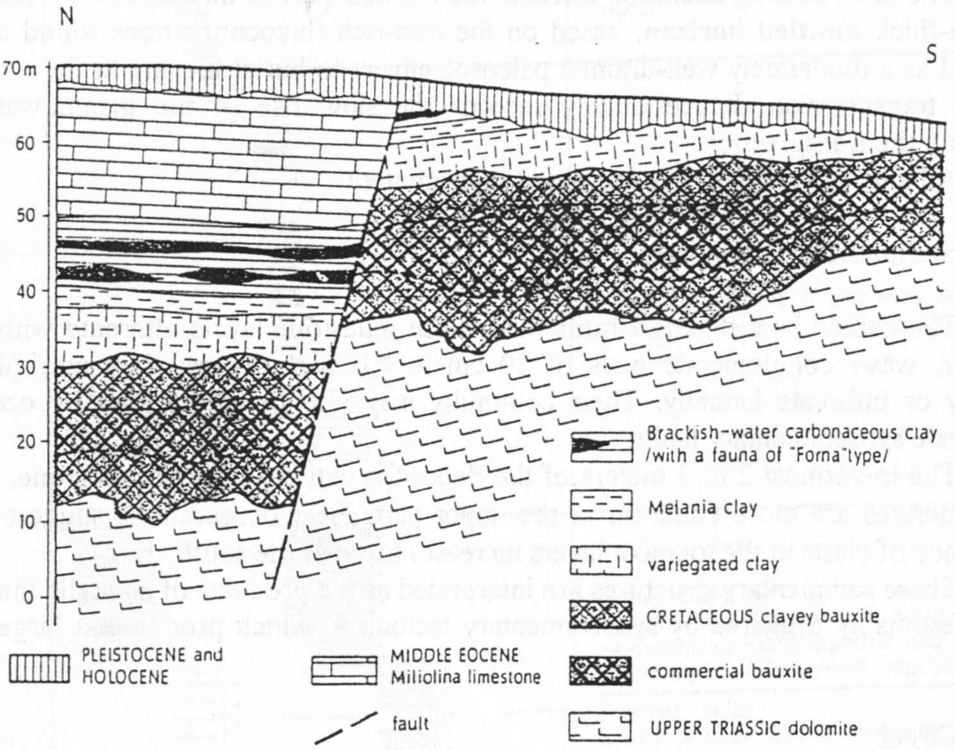

Fig. 12. Geological section of the bauxite pit of Gánt (after Szantner et al., 1969)

Alterations

The most apparent alterations are those affecting the iron-compounds. Iron oxide may be removed or concentrated, deferrificated pale coloured (white, yellow, violet, pink) or iron-impregnated (brick-red) varieties may arise.

The most striking alteration affected the topmost part of the deposit. It resulted in a ca. 2 m-thick **mottled horizon**, based on the iron-rich rhizoconcretions found in it, it is qualified as a moderately well-drained paleosol subject to burial gleying at the time of the Eocene transgression. It presumably records the slow rise of the groundwater table preceding the transgression.

All altered varieties have increased silica content.

Sedimentary structures

The bauxite is distinctly stratified. Reddish mudstone layers alternate with yellow, irregular, wavy conglomerate beds of 10 cm to >1 m thickness; they may pinch out abruptly or bifurcate laterally. Their continuity may also be interrupted by occasional, small-scale synsedimentary faults.

The lowermost 2 to 3 meters of the deposit is entirely built of mudstone, whereas conglomerates are more common in the upper part. Field observations suggest that the abundance of clasts in the topmost layers increases towards the south.

These sedimentary structures are interpreted as the products of episodic mud/debris flow presumably triggered by synsedimentary tectonism, which produced a large alluvial fan.

Cover

Immediately above the bauxite there is a 2 to 3 m thick clay/limestone/marl packet punctuated by low-grade coal seams. The limestone is rich in *Charophytes*, *Cyanophytes* and small gastropods all suggesting first a fresh-water then a schizohaline to brackish depositional environment. Higher up the occurrence of *Milliolids* indicates the establishment of a restricted marine fauna that gradually gave way to an *Alveolinid* and *Nummulitid*-rich assemblage: clear signs of more and more open-circulation in the lagoon. Repeated recurrence of low-grade coal seams may be due either to high-frequency eustatic oscillations or simply to the effect of the irregular coastal relief.

Diagenesis of the bauxite

Early diagenesis of the hematite/boehmite-rich pebbles took place at the site of their primary deposition, presumably in a vadose, oxidizing diagenetic environment. After erosion, transport and deposition in the low-level shallow karst terrain they became embedded into the fine grained pelitomorphous/intraclastic matrix. This at the time of deposition most probably consisted of a mixture of poorly cristalline or amorphous Fe-Al-Ti hydroxides and detrital clay minerals (illite, kaolinite). Alternately water-logged and moderately drained conditions provided for the precipitation of Fe-rich accretion-rings

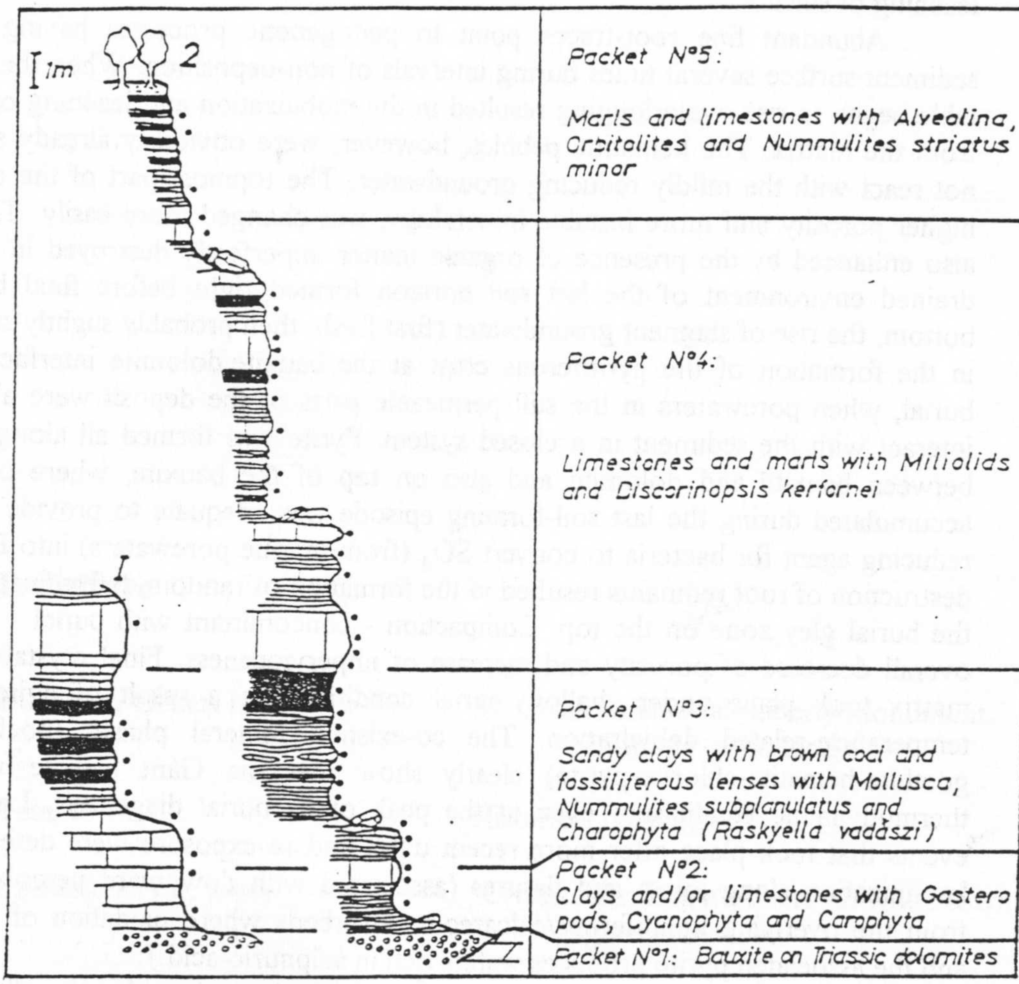

Fig. 13. Geological profiles

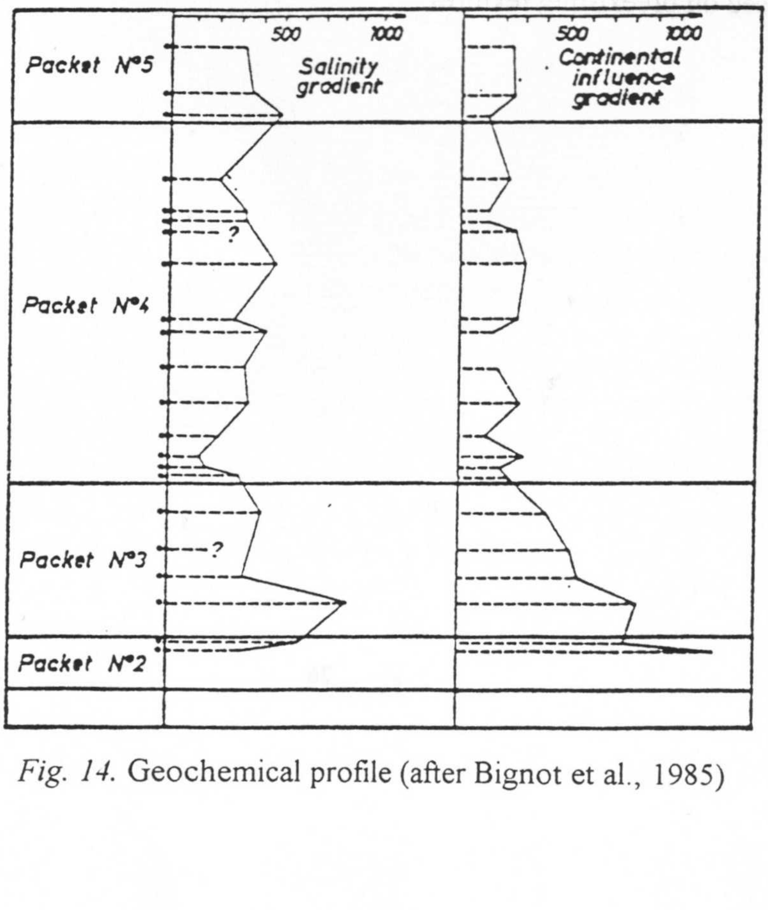

Fig. 14. Geochemical profile (after Bignot et al., 1985)

around the pebbles and - at times of episodically improved drainage - also to additional leaching of silica.

Abundant fine root-traces point to pedogenetic processes having affected the sediment surface several times during intervals of non-deposition. When the karstic water table began to rise, waterlogging resulted in the mobilization and leaching of iron, mainly from the matrix. The hematitic pebbles, however, were obviously already stable and did not react with the mildly reducing groundwater. The topmost part of the deposit, by its higher porosity and more instable mineralogy, was changed more easily. This effect was also enhanced by the presence of organic matter imperfectly destroyed in the less well-drained environment of the last soil horizon formed right before final burial. At the bottom, the rise of stagnant groundwater (first fresh, then probably slightly saline) resulted in the formation of the pyritiferous crust at the bauxite/dolomite interface. On further burial, when porewaters in the still permeable parts of the deposit were already able to interact with the sediment in a closed system. Pyrite was formed all along the interface between bauxite and dolomite and also on top of the bauxite, where organic matter accumulated during the last soil-forming episode was adequate to provide the necessary reducing agent for bacteria to convert SO_4 (from marine porewaters) into H_2S. The final destruction of root remnants resulted in the formation of random deferrification patches of the burial gley zone on the top. Compaction - concomittant with burial - resulted in an overall decrease of porosity and increase of imperviousness. Final crystallization of the matrix took place under shallow burial conditions as a result of aging rather than temperature-related dehydration. The co-existing mineral phases (boehmite-gibbsite, goethite-hematite-chlorite-pyrite) clearly show that the Gánt bauxite was far from thermodynamic equilibrium even at the peak of its burial diagenesis. Later epigenetic events that took place after more recent uplift and re-exposure were deferrification and kaolinization along joints and fissures (associated with downward percolating solutions from the overlying lignitiferous/calcareous coverbeds where oxidation of the coalseams and the associated pyrite produces waters rich in sulphuric-acid.)

Both the pyritic foot-wall crust, and the finely disseminated pyrite of the bauxite are subject to in situ epigenetic oxidation, producing abundant Liesegang-phenomena superimposed on preexisting textures.

Part II. Culture

Stop 1. Budapest, Gellért Hill	St. Gellért memorial, Liberty monument panorama of Budapest
Stop 4. Tata, town	Historical buildings
Stop 6. Székesfehérvár, town	"Civitas Alba Regia", the royal white town sightseeing walk
Stop 7. Tác village	Gorsium, excavated Roman settlement

Stop 1. **Budapest**, Gellért Hill

The Danube river separates the plain of Pest from the hilly area of Buda. The capital of Hungary (united in 1872) has slightly over 2 million inhabitants (20 percent of the country's population). It covers a ground area of 525 square kilometers. Out of this, 325 square kilometers are situated on the left bank of Danube (Pest) and 173 km on the right bank (Buda). The average width of the river is 400 m; it is the narrowest at Gellért Hill (only 285 m).

A 3rd century altar stone of the Celtic tribe of the Eraviscs has been found on the hill. It is kept in the Hungarian National Museum.

The memorial statue of St. Gellért (Gerardo) can be seen above the Rudas Bath. The latter was rebuilt in Turkish style by Pasha Sokoli Mustapha in 1566, 25 years after the occupation of Buda Castle by the Ottoman army of Sultan Soliman the Magnificent.

The Venetian-born Benedictine abbot Gellért (originally, Giorgio) was appointed by King Stephen I (the first Christian King of Hungary) the first archbishop of Hungary in 1030. He was also the tutor of King Stephen's only son, crown prince Imre, who unfortunately died in a hunting accident. After the death of Stephen I in 1038, two decades of anarchy followed. This involved also a bloody revolt of pagan Hungarians, headed by chieftain Vata. The anti-Christian rebels captured archbishop Gellért in 1046, put him into a barrel equipped with nails directed towards the interior, and rolled him down to a martyr's death from the top of the hill. He was canonized by the Roman Catholic Church in 1083. (So were, by the way, King Stephen I and Prince Imre, too). Since then, the name of the hill has been changed from Kelen Hill to Gellért Hill.

The Citadel (fortress) on the top of the hill was built by the Austrian army which suppressed the 1848-1849 Hungarian War of Independence. The idea was to intimidate the inhabitants of Pest. Its military role ended in 1897, and it was handed over to the capital. Since 1964 it has served touristic purposes (restaurant, wine cellar, tourist hostel). This is the spot from where fireworks are launched on August 20 - St. Stephen's Day.

The Liberty Monument (Zs. Kisfaludy-Stróbl) was erected in 1947. The statue of a Soviet soldier standing in front of it has recently been removed.

Stop 4. **Tata**

The attractive environment of the town Tata ("Daddy") is due to an interaction of karstic springs (22°C), lakes and woodlands.

In this area, archeologists have discovered prehistoric remains and a number of Roman constructions.

A Hungarian settlement was founded here in the 11th century. It was granted the privileges of a "royal town" by King Louis the Great (of the Anjou dynasty) in 1350.

The castle of Tata was mainly built by Sigismund, King of Hungary and Emperor of the Holy Roman-German Empire, in 1420.. King Mathias chose it as a royal resort for hunting and bathing in 1463. After the vicissitudes of the Turkish wars (16th-17th centuries) it was destroyed by the Austrians after the failure of Prince Rákóczi's insurrection, in 1711. However, it was partially restored (in Venetian neogothic style) in 1896. At present it houses the Regional Museum (named after Domokos Kuny).

The second half of the 18th century witnessed a revival of the town. The large marshes of its environs were drained by engineer S. Mikoviny. The baroque character of the town is due, to a great extent, to architect J. Fellner: the Main Church and the Monastery of the Capuchins, etc. The Watch (or Clock) Tower on Parliament Square is a masterpiece of carpenter J. Eder. The old mills of the town are important objects of the history of art and industry (Cifra mill 1587, Nepomucenus mill 1758, József mill 1770).

At present, the town of Tata has about 25 000 inhabitants. The majority of them is employed in different branches of industry developed in the 19th century. The lake, regulated by S. Mikoviny, has been developed into a popular center of recreation and water sports. (Training camp of the Hungarian Olympic team for Water sports.)

Stop 6. **Székesfehérvár**

In 1972, the town celebrated its millennium. Finds from the Copper, Bronze and early Iron Ages as well as Celtic relics indicate that people has been living in the area for several thousands of years.

The foundations of Székesfehérvár (Civitas Alba Regia, the "Royal White Town") were laid by Prince Géza (the father of King Stephen I) in 972. The first cathedral and the royal palace were built by St. Stephen.

Until 1527, 37 kings were crowned and 17 members of the ruling dynasty were buried here.

The medieval town was completely destroyed during the Turkish wars. Resettlement started only in the late 17th century.

Queen Maria Theresia set up a bishopric. Since baroque times large-scale construction work was going on in the town.

During World War II, in 1944, heavy bombardment and major battles caused considerable damage to Székesfehérvár (which was an important railroad junction).

Take a stroll from St. Stephen's Square (Szent István tér), where the most conspicuous building is the Municipal Hall, built between 1807 and 1812, in a neo-classicist style. The baroque Seminary Church stands on the corner of the nearby Petőfi Sándor Street. The arched ceiling of the church, built between 1745 and 1748, is decorated with beautiful frescoes of A. Maulbertsch. The fresco of the Oratory and the three side-altar pictures are also the handiwork of the same renowned Austrian painter.

Next to the church there is an Art Sacra Museum.

In Március 15 Street we find the baroque church of the Cistercians, as well as a rococo-style old pharmacy.

At the beginning of Arany János Street you can see the Maulbertsch decorative fountain, and around the middle of the street, the baroque Cathedral standing on top of a Hill. The sanctuary and the main altar of the church (consecrated in 1768) were designed by *F. A. Hillebrand, and the arched ceiling was decorated by Cymbal. In the crypt* there is the red marble tomb of King Béla III and his queen.

In front of the Cathedral there is only surviving medieval building of Székesfehérvár, the Chapel of St. Anne, dating from 1470.

An interesting object from the architectural viewpoint is the multistoreyed Hiemer House on the corner of Jókai Street. It was built between 1760 and 1770 for the town judge.

On the southern side of Liberty Square (Szabadság tér) there is the Municipal Hall. One of its blocks was already included in the 1698 Register as the "Stadt Rathaus". The left wing, the former Zichy Mansion, was built in the 18th century, in baroque to Louis XVI styles.

An equestrian statue, by P. Pátzay , stands in front of the building.

The Episcopal Palace is on the southern side of the square. This fine example of the Louis XVI style was built in 1801. Its Empire- and Biedermeier-style interior, as well as its library with 40 000 volumes, including medieval codices and incunabula, is of interest.

At the end of Március 15 Street you reach the Velence Hotel built in 1830. Next comes the Museum of King St. Stephen.

The Rácváros (Serbian Town) district guards the memory of Serbian merchants who called the town "Stolni Beograd". Their Orthodox Church dates from the early 18th century. Its frescoes in Byzantine style and the rococo iconostas merit attention.

Stop 7. **Tác village**, Gorsium - Roman town

The ruins of Gorsium were discovered in 1866, 17 km south of Székesfehérvár.

The first tentative excavations were executed in 1934. After 1958, systematic excavations were performed and conservation - restoration works were undertaken. Later the area has been converted into an open-air (and partly covered) archaeological exhibition and museum. More than half a million objects have been found here.

A Roman military camp was established in the middle of the first century (under Emperor Tiberius). The site was very appropriate: the crossing of two important Roman military roads. The W-E road connected Noricum and the western part of Pannonia with the capital of Pannonia inferior, Aquincum (in the north of Budapest). The S-N road led to Brigetio on the Danube river. (The Danube was at that time the frontier, the "limes", of the Roman Empire.) Somewhat later a second military camp was set up in the area.

The town itself developed in the early 2nd century (under the Emperor Traianus and Hadrianus). Soon it became the religious center of Pannonia, as testified by its "sacred area" (Area Sacra).

During the campaigns led by Emperor Marcus Aurelius against the German tribe of marcomanns (178 A. D.), including an expedition into the Vág valley north of the Danube, Gorsium was heavily damaged. It was soon rebuilt, only to be destroyed again in 260 A. D.

Gorsium was rebuilt for a second time, and it flourished in the early 4th century. Most of the excavated ruins, which can be visited, date from this period. These include a palace (Palatium), a baptismal well (Baptisterium), a public well (fons), the paved main street, a villa (Villa Leporis), and a cemetery.

Gorsium was definitively destroyed by the end of the 4th century by an invasion of nomadic tribes coming from the East.

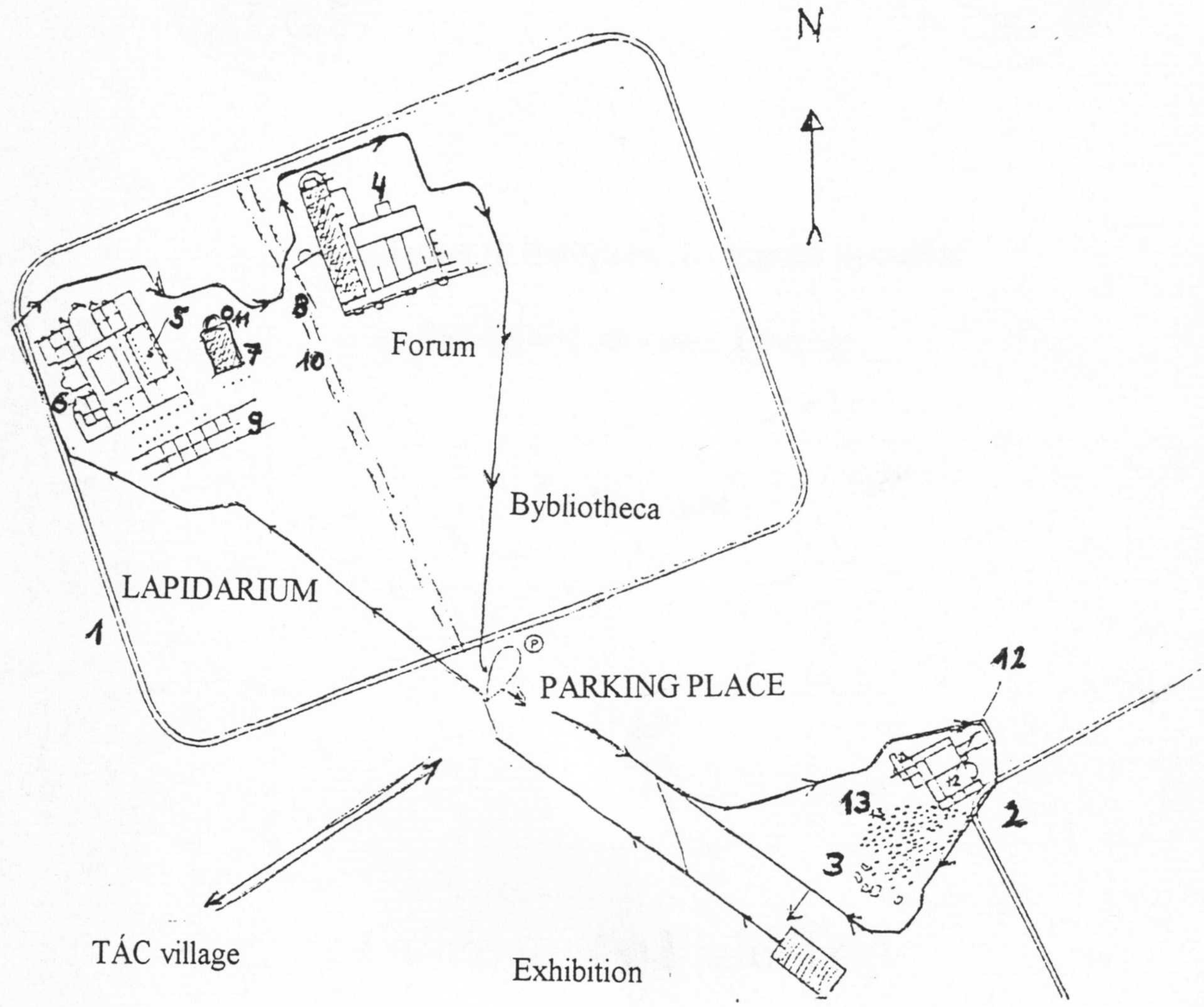

Fig. 15. Gorsium (Roman town)

Legend

1. Military camp I
2. Military camp II
3. Settlement of aborigenes
4. Sacred area (Area Sacrum)
5. Corn store house (Horreum)
6. Palace (Palatinum)
7. Basilica major
8. Basilica minor
9. Commercial buildings (Tabernae)
10. Main street
11. Public well (Fons)
12. Villa Leporis
13. 4-5th century cemetery