INQUA
INTERNATIONAL UNION
FOR QUARTERNARY RESEARCH
COMISSION ON LOESS

IGCP
INTERNATIONAL GEOLOGICAL
CORRELATION PROGRAMME
MAGNETOSTRATIGRAPHY P.128

GUIDE-BOOK FOR CONFERENCE AND FIELD-WORKSHOP ON THE STRATIGRAPHY OF LOESS AND ALLUVIAL DEPOSITS

BUDAPEST–SZEGED 26-31 August 1979

Edited by
M. PÉCSI

HUNGARY
1979

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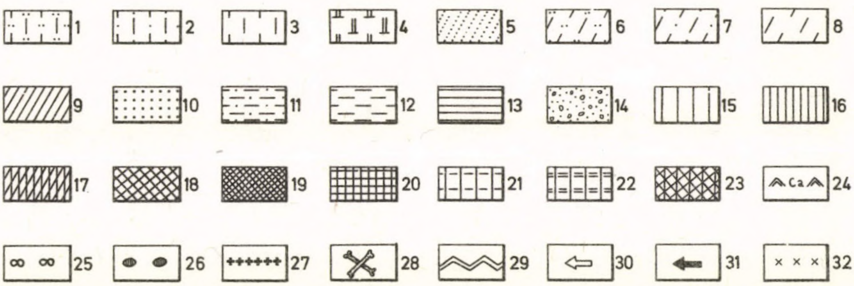

1 = loessy sand; 2 = sandy loess; 3 = loess; 4 = old loess; 5 = slope sand; 6 = loessy slope sand; 7 = sandy slope loess; 8 = slope loess; 9 = semidolite; 1o = fluvial-proluvial sand; 11 = silty sand; 12 = silt, gleyed silt; 13 = clay; 14 = sandy gravel; 15 = weak humus horizon; 16 = steppe-type soil, chernozem; 17 = forest soil altered by steppe vegetation; 18 = brown forest soil; 19 = greybrown forest soil; 2o = red clay; 21 = hydromorphic soil; 22 = alluvial meadow soil; 23 = forest soil /on floodplain/; 24 = calcium carbonate accumulation; 25 = loess doll; 26 = krotovina; 27 = charcoal; 28 = macrofauna; 29 = discontinuity in profile; 3o = traces of non-linear erosion; 31 = traces of linear erosion; 32 = volcanic ash.

Mf = "Mende-Upper" forest-steppe Soil Complex /29 8oo years B. P., Mo. 422 and HV 27 855-1599 years/; BD = "Basaharc-Double" forest steppe Soil Complex; BA = "Basaharc-Lower" charnozem soil; MB = "Mende-Base" Soil Complex /brown forest soil + forest steppe soil/; Phe = Paks sandy forest soil; Mtp = Paks marshy soil; PD = "Paks Lower Double" Soil Complex /brownish red Mediterranean-type dry forest soil/; PDK = Paks-Dunakömlőd brownish red soil; PV_1, PV_2, PV_3 = Paks red soils; Dv_1 - Dv_6 = Dunaföldvár red soils; A = clay /o.oo5/; I = silt /o.oo5 - o.o2/; L = loess /o.o2 - o.o5/; H = sand /o.o5 - 1.oo/.

PREFACE

1. In 1978 the INQUA Loess Commission has decided to hold its next meeting in August 1979 in Hungary. The conference and field workshop will be devoted to the subject of the stratigraphical correlation of loesses and alluvial deposits and this has been linked up with the IGCP Project 128 concerned with Late-cenozoic Magnetostratigraphy.

The decision to organize a meeting in this country has been reached in light of existing international cooperation between Hungarian researches of the Quaternary, Soviet and Canadian geologists and geophysicists who have studied several important loess exposures in the Danube Valley /Mende, Dunaföldvár, Paks/ and investigated two 12oo m deep cores in the alluvial basin of the Great Hungarian Plain.

The aim of the 1979 INQUA conference is to discuss problems related to the chronological correlation of loesses,alluvial deposits and ocean floor sediment cores, to compare methods of research and results of investigations. Future tasks of loess research shall also be a subject of debate. Special emphasis should be placed on those aspects of loess research concerned with problems arising in engineering practice. The program for the field workshop has been organized to serve this purpose.

2. Many institutions have provided valuable help in the preparation of the guide book. I would like to express our thanks to the Hungarian Central Geological Office for their financial assistance and collaboration in exploratory drilling projects. Our colleaques in the Soil Laboratory, Cartography and Geomorphology Departments of the Geographical Research Institute of the Hungarian Academy of Sciences also deserve praise for their cooperation at every stage of the work. The Department of the Hungarian Geological Institute concerned

with the research of the Great Hungarian Plain, the engineering geological department of the Institute of Geodesy and Geotechnics have helped in the preparation and execution of the Szeged-Algyő project and the Paks-Dunakömlőd-Dunaujváros loess projects. The Geochemistry and Geophysics Departments of the Eötvös Loránd University and the Geography Departments of the Kossuth Lajos and József Attila Universities have all actively participated in the success of this undertaking. The organizing committee of the conference was supervised personally by the secretary and by the head of the Hungarian National Committee of INQUA.

Finally our special thanks are due to the authors of the guide book, to the editors, translators, typists and printers and to those who have taken on the job of preparing the field trips and other administrative tasks.

The Hungarian Academy of Sciences provided financial assistance and moral support for our work and we have received generous help from the Executive Committee of INQUA and the IGCP Project 128 as well.

In the hope that all persons and institutions without whom the preparation of this volume would have not been possible will accept our gratitude and with the sincere hope that our efforts have been worthwhile offer the guide book for all who may be interested.

Budapest, July 1, 1979

Márton Pécsi
President of the INQUA
Loess Commission

UPPER PLEISTOCENE LITHO- AND CHRONOSTRATIGRAPHICAL TYPE PROFILE FROM THE LOESS EXPOSURE AT MENDE

M. Pécsi - M. A. - Pevzner - E. Szebényi

Thick loess blankets contain cyclically recurring strata of loess and intercalated loess-like sediments, paloesols, sand layers and similar material. From a stratigraphical point of view this sequence of strata constitutes the loess series. There are several regional, and some lithogenetic variants of loess; true loess, loessial sand, sandy loess, loess loam, clayey loess etc. A characteristic sequence of loess and paleosols are referred to as a loess complex. The term soil complex denotes two or more fossil soils lying close to each other in the same profile.

In the past twenty years several Hungarian loess profiles have been analysed and their stratigraphical sequences were correlated. Based on their specific characteristics loess and fossil soil complexes have been defined in different type localities or marked according to the position they occupy in the stratigraphical sequence /M. Pécsi 1965, 1966, 1969, 1975 and M. Pécsi et al. 1977/.

1. Geomorphological position of the loess profile at Mende

The village of Mende is located 4o kms southeast of Budapest in the central part of the Gödöllő-Monor hilly region /Fig. 1./. The hills are made up of Pliocene, Pannonian clays and sands, the so called Gödöllő Sands. They are dissected by river valleys in a NW-SE direction. The loose Pliocene sediments of the hills are situated near the wide valley of the

Fig. 1.: Map showing loess profiles in Hungary which had been analysed lithologically and pedologically. 1=type profiles studied in detail; 2=profiles referred to in literature

Danube as it flows through the Great Hungarian Plain.The hills rise 12o - 13o meters above the Danube floodplain. The tributary streams dissect the hills into elongated interfluves striking southeast. The plateaux are usually covered with a thick blanket of plateau loess, while the smooth wide southern slopes are cloathed in thick layers of slope loess. The northern slopes of the loess-covered interfluves are steeper and broader, deep dells /derasional and erosional - derasional valleys/ had formed here. These small valleys have a steep gradient, though they are only 1 - 2 kms long. In cross-section they are cylindrical or U shaped and they are the tributary valleys of the larger main erosional valleys that run in a southwestern or northwestern direction /Fig. 2./. The small dells and erosional-derasional valleys are separated from each other by loo - 2oo m wide loess hill or by narrow interfluves. The loess profile in the Mende brickyard exposes a 3o m vertical section of such a narrow interfluve /Fig. 3./.

Since the early 196o-s we have closely followed the process by which newer and newer profiles became exposed during the open cast mining of the deposits /Fig. 4./. The profiles studied in the last ten years are depicted in a generalized form on Fig. 5. Up to 1965 mining operation was not fully mechanized and the 3o m high loess exposure could be studied in broad cuts in the hill. In 1965 an 8 - lo m deep bore was drilled at the bottom of the exposure which yielded further information about the stratigraphical sequence. Below the "Mende-Base" Soil Complex which is situated at 3o - 32 m there is a thick sandy layer underlain by two poorly developed soil horizons /Fig. 4./.

2. Significance of the loess profile at Mende

The loess exposure in Mende brickyard has been considered since the 196o-s as one of the most important type profiles of

1 = river valley; 2 = erosional gully; 3 = derasional valley; 4 = flat, trough shaped derasional valley; 5 = loess gully; 6 = loess doline due to karstic and suffosional processes; 7 = road; 8 = embankment, cut; 9 = brickyard pits. A = location of loess profile; B = active mine; C = abandoned pit; 1o = exposures; 11 = deep bore; 12 = dam; 13 = marshy area; 14 = ephemeral lake; 15 = ersoional-derasional slopes to 5^{o}; 16 = erosional-derasional slopes betwoen 5 - 15^{o}; 17 = erosional-derasional slopes greater than 15^{o}; 18 = debris fan of derasional valley; 19 = erosional-derasional interfluves; 2o = erosional-derasional remnant; 21 = derasional remnant; 22 = erosional meander scar /Umlaufberg/; 23 = derasional ridge; 24 = derasional step or terrace; 25 = derasional bench.

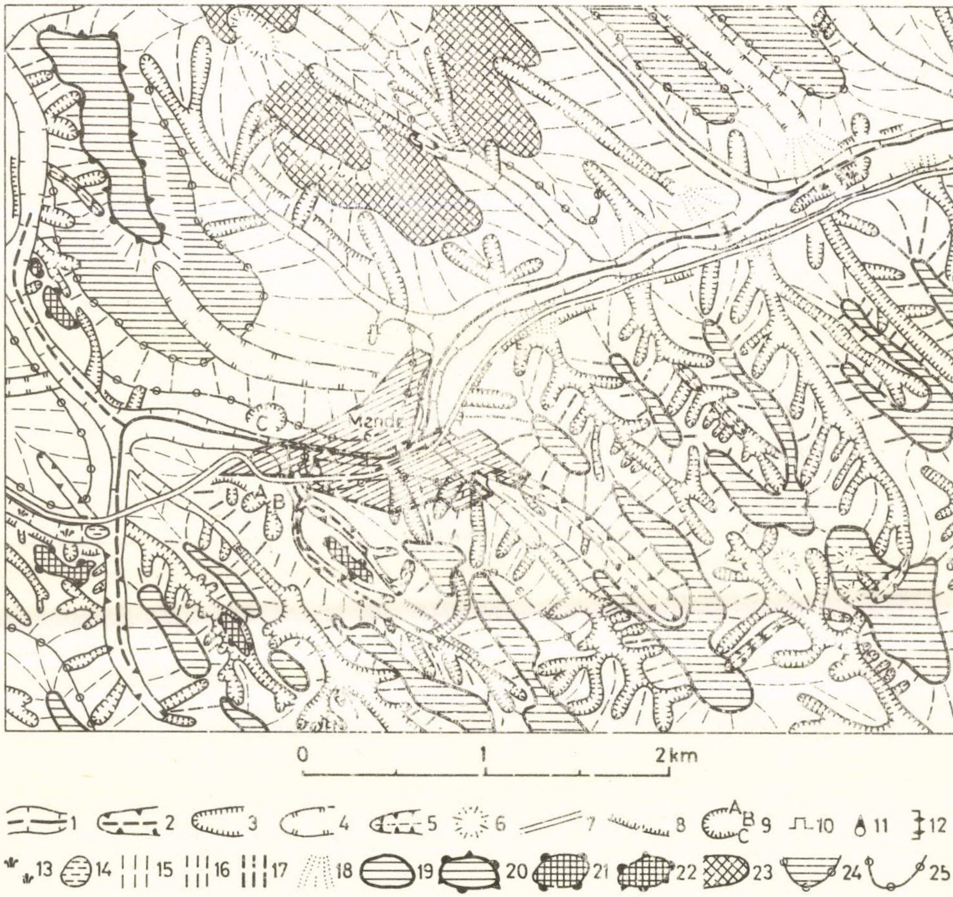

Fig. 2.: Geomorphological map of Mende and its environs /after Gy. Hahn/

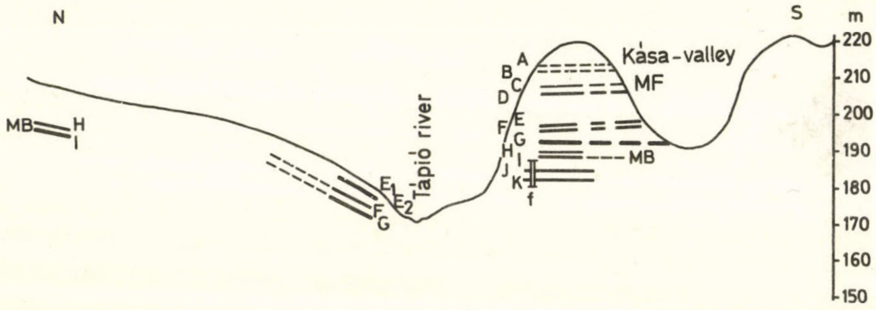

Fig. 3.: Cross-section of the loess exposures in Mende brickyard /after Gy. Hahn/
A., K and E_1, E_2 are humus horizons and fossil soils; f = borehole, see legend for Fig. 2. too.

the Upper Pleistocene loess series in Hungary and in the Carpathian Basin /M. Pécsi 1965, 1966/. A number of loess exposures /Basaharc, Dunaujváros, Tápiósüly etc./ have been examined in an attempt to record the stratigraphical sequences of the young loess, and to correlate the fossil soil horizons. The loess profile at Mende proved to be the most typical. The complete sequence of the stratigraphical series known as the young loess is present in this profile. Although the profile in the Basaharc brickyard near the town of Esztergom is also fairly complete, the profile at Mende is probably the more reliable source. The cycles of loess and fossil soil formation can be traced at Mende without major interruptions, hence it is ideal for subdividing litho- and chronostratigraphically the Upper Pleistocene loesses in Hungary. The two soil com-

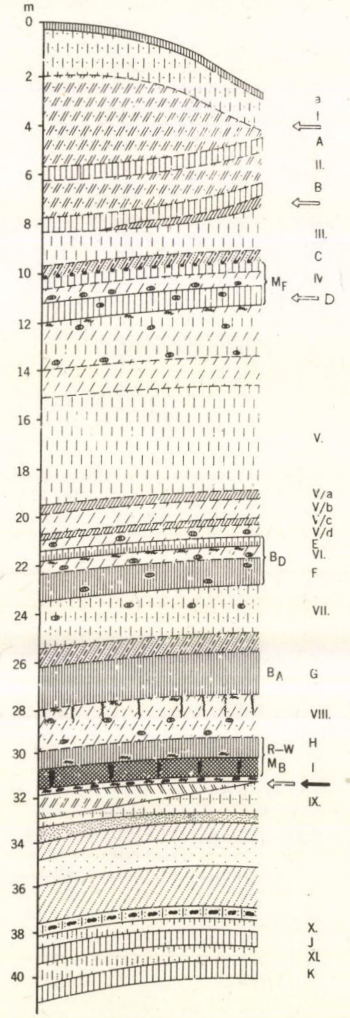

Fig. 4.: Generalized profile of the loess exposure in Mende brickyard /1965/

a = recent chernozem; A--K = fossil soils; I--XI = serial number of loess and loess-like formations

➡ traces of derasional processes

⇨ traces of erosional processes

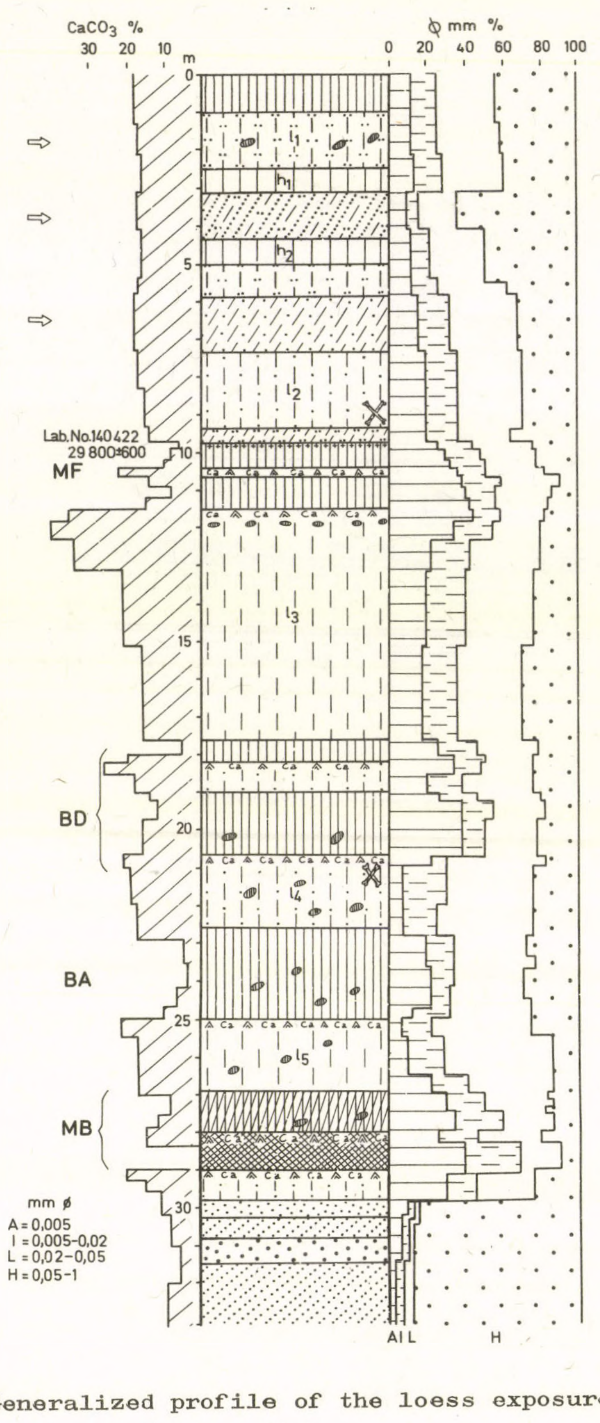

Fig. 5.: Generalized profile of the loess exposure in Mende brickyard /1969 - 74/

plexes of the Mende profile, the "Mende-Upper" Soil Complex /MF/ and the "Mende-Base" Soil Complex /MB/ have been interpreted as significant stratotypes of fossil soils in the young loess. The MF Soil Complex is a stratotype that separates the Middle Würm from the Upper Würm. The MB fossil Soil Complex is a stratotype that marks the last interglacial /R-W/. /M. Pécsi 1965; Gy. Hahn 1975; M. Pécsi and others 1977./

3. Stratigraphical and pedological analysis of the Mende loess profile

3.1. The upper lo m thick loess series

Today the upper sequences of the exposure can only be observed with some difficulty in situ. The 4 - 5 m topmost layers[x] were largely destroyed by the newer method of mining operation. Elsewhere, a young forest was planted on the hillside which has overgrown the abandoned pits.

The lo m thick upper series of loess contain two poorly developed humus soils /loess serjozem/ /H_1, H_2 horizons/ in both of which charcoal remains have been found. The upper humus horizon in the Tápiósüly profile /located nearby/ was so rich in charcoal fragments /Betula, Pinus cembra and Larix picea/ that they were sufficient for radiocarbon analysis. The age of the charcoals was fixed /Hv 1615/ 16 75o ± 4oo years B. P. In the second humus horizon and in the overlying loess strata many bone fragments of Rangifer tarandus shovels have been discovered. The second humus horizon of the Mende profile is located in a similar stratigraphical position in several other loess profiles in Hungary /Tápiósüly, Dunaujváros, Dunaszekcső and Balatonszabadi-Sóstó/. The radiocarbon age of charcoal remains is

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[x]This is the youngest loess; it is usually 8-lo m thick and contains a relatively high sand ratio. It can be best studied in the exposure at Tápiósüly, located nearby.

2o ooo years B. P. in this stratigraphic horizon. In the so called "Dunaujváros-Tápiósüly" Loess Complex the humus horizons usually contain molluscan fauna that prefer cold and humid climatic conditions. In the sandy loess and loess layers those molluscs prevail that thrive in cold, dry climatic phases. Thus the upper lo m thick sequence of the Mende profile had accumulated during very cold and dry climatic conditions,occasionally interrupted by shorter spells of cold and relatively humid climates. Two phases of both dell erosion accumulation, or infilling, have been recorded. The accumulation of material in the dells probably took place under cold humid climatic conditions, hence the higher humus content of the deposits and the fine-stratification of layers.

The whole skeleton of a young mammoth has been collected from the base of the typical /true/ loess sequence between 8 - lo m in the profile. We are of the opinion that the Dunaujváros-Tápiósüly Loess Complex had accumulated during the cold maximum of the last glacial period. The cold, dry arctic loess-tundra climatic phases were interrupted by 2 - 3 shorter cold and humid phases during which taiga forests could grow. In the loess relics of the Eastern Gravetti man are known from several sites /e. g. Ságvár/. These men were probably reindeer hunters /Mrs. Gábori, Vera Csánk, 1967/.

3.2. <u>The young loess between lo - 3o m in the Mende brickyard</u>

In the loess profile at Mende down to the bottom of the exposure we find yet another young loess series in which well developed fossil soils are interbedded /Fig. 5./. The Mende-Basaharc Complex consists of four fossil soil horizons that enclose three significant loess packets. The latter are mostly typical loesses ,stratified and sandy loess layers are less common. Calcareous concretions /loess dolls/ are not characteristic, they occur more frequently in the old loess series.

- The "Mende-Upper" Soil Complex

The first well developed double fossil soil in the Mende profile is situated between 1o - 12 m /Fig. 5./. The two horizons of this forest-steppe type soil can be recognized with ease in several other loess profiles in the Carpathian Basin. The upper part /MF_1/ of the soil complex is poorly developed chernozem-like soil with krotovinas and charcoal, dated consistently by three laboratories 27 - 28 ooo years B. P. /M. Pécsi 1965; Seppäla 1971; M. Pécsi 1975/[1].

The lower part of the "Mende-Upper" Soil Complex /MF_2/is a well developed forest-steppe type chernozem /brown forest soil/. Its pedological characteristics are shown in Fig. 6. and Table 1. Soil formations of similar age like the "Mende-Upper" Soil Complex have been described in several sections in Europe. These are known by their local names: Stillfried B. in Austria; Kesselt in Belgium, France and West Germany; Gleina-Böden in East Germany; PK 1 in Czechoslovakia and Roumania; Vitachev and Brjansk in the Soviet Union.

- The "Basaharc-Double" Soil Complex /BD/ in the Mende profile

Underlying the MF soil complex there is a 6 m thick almost homogeneous loess packet /Fig. 5./. The underlying forest-steppe type double soil is remarkably well developed at Mende. This soil complex is consqpicuously present in many loess eyposures in Hungary. The pedological characteristics of the "Basaharc-Double" Soil at Mende are shown in Fig. 7. and Table 2. From the slightly sandy loess layer underlyin the BD soil bone fragments, molars and pieces of an Elephas primigenius's tusk have

---

1. 29 8oo ± 6oo Lb. No. 14o 422 /M. Pécsi 1966/
   27 2oo ± 14oo Lb. No. I. 313o /M. Seppäla 1971/
   27 855 ± 1589 Lb. No. HV 5422 /M. Pécsi 1975/

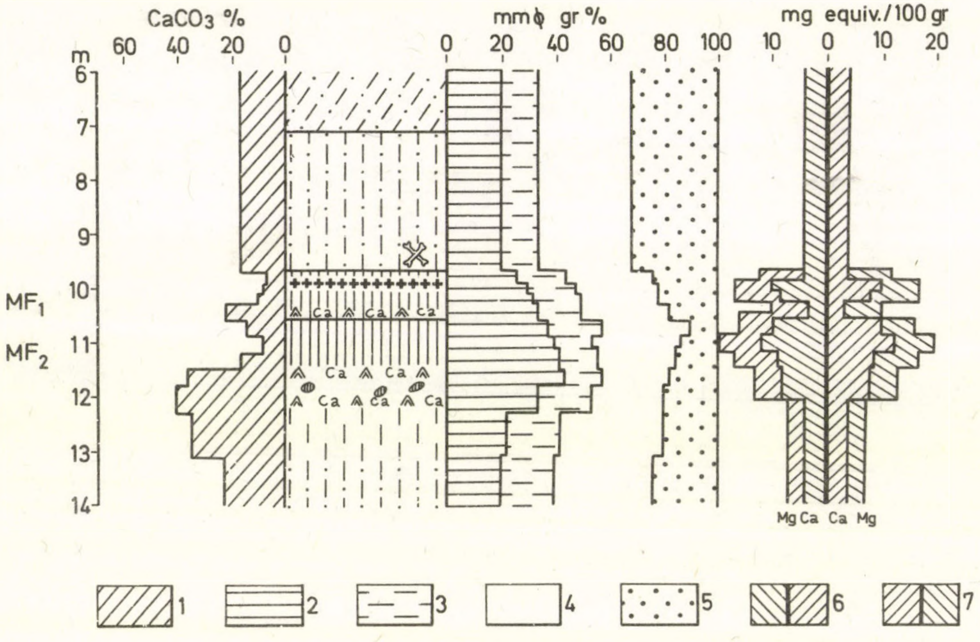

Fig. 6.: Pedological section of the "Mende-Upper" Soil Complex in the profile at Mende brickyard /1968/ /after M. Pécsi - E. Szebényi/
1 = $CaCO_3$; 2 = clay fraction /up to o.oo5 mm Ø/; 3 = silt fraction /o.oo5 - o.o2 mm Ø/; 4 = loess fraction /o.o2 - o.o5 mm Ø/; 5 = sand fraction /greater than o.o5 mm Ø/; 6 = exchangeable Ca mg equiv /loo gr ; 7 = exchangable Mg mg equiv/loo gr; MF_1 = upper soil of the "Mende-Upper" Soil Complex; MF_2 = lower soil of the "Mende-Upper" Soil Complex

Table 1. Results of pedological analysis of the "Mende-Upper" Soil Complex /1968/ in a profile at Mende Brickyard

Depth m	$CaCO_3$ %	humus %	hy %	clay A	silt I	loess L	sand H	Ca	Mg	Colour
				mm ø gr %				mg equiv/1oo g		
5,85- 9,75	15,9	o,27	1,24	19,1	15,8	32,8	32,3	4,2o	o,o	2,5YR 5/4 yellow loess
9,75- 9,9o	6,3	o,86	1,65	25,7	19,o	31,6	23,6	3,7o	3,75	2,5YR 5/4 MF_1 A_1 horizon
9,9o-1o,15	7,6	1,29	1,97	29,4	18,1	3o,5	22,2	9,6o	7,63	10YR 5/3 A_2 horizon
1o,15-1o,35	1o,1	1,23	1,82	31,9	18,1	27,o	22,3	7,5o	9,82	10YR 5/3 AC horizon
1o,35-1o,6o	22,o	o,55	1,5o	33,7	16,7	31,1	18,1	3,oo	7,63	2,5YR 6/4 C horizon
1o,6o-1o,9o	13,9	o,86	2,42	38,3	2o,o	3o,7	1o,o	1o,oo	6,54	10YR 5/4 MF_2 A_1 horizon
1o,9o-11,25	7,6	1,24	2,83	39,9	15,4	3o,2	14,o	11,8o	8,73	10YR 4/3 A_2 horizon
11,25-11,5o	15,2	o,86	2,41	41,7	15,2	26,5	16,2	8,6o	8,73	10YR 4/4 AC horizon
11,5o-11,8o	36,1	o,43	1,26	44,7	14,1	23,2	18,3	7,7o	5,45	10YR 7/3 C horizon
11,8o-12,3o	39,7	o,27	1,1o	33,2	19,8	26,7	2o,1			10YR 8/4 C horizon
12,3o-13,1o	34,2	o,27	o,95	21,1	2o,3	38,9	19,7			2,5YR 7/4 yellow loess
13,1o-15,1o	21,1	o,17	1,o8	2o,2	2o,o	35,o	24,8	3,39	3,27	2,5YR 6/4 yellow sandy loess

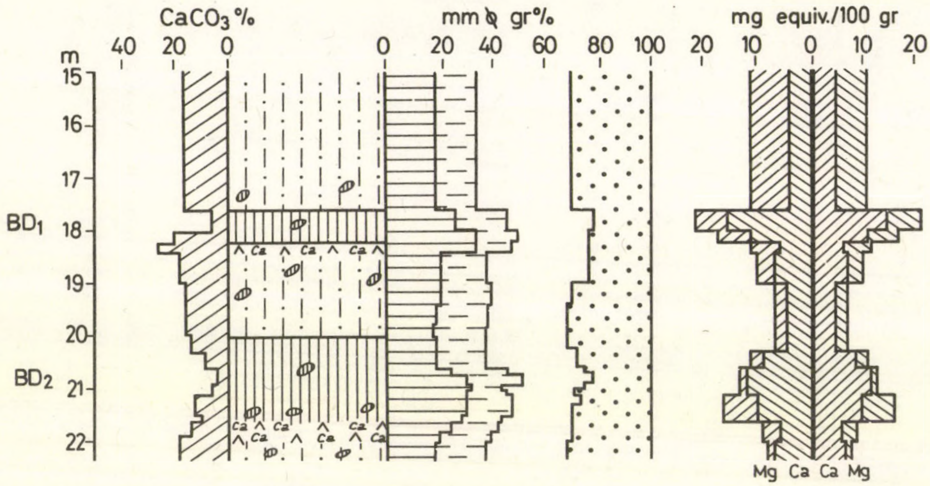

Fig. 7.: Pedological profile of the "Basaharc-Double" Soil Complex /after M. Pécsi - E. Szebényi/ in the profile at Mende brickyard /1968 - 76/. See legend for Fig. 6. also.

been recovered, the radiocarbon dating of the bones is in progress.

We described the BD fossil soils in the loess exposure in Basaharc brickyard, near Esztergom and named it "Basaharc-Double" Soil Complex /M. Pécsi 1964, 1965/. It was probably formed during a warm interval in the Middle Würm. In Basaharc we had collected charcoal samples from the BD_1 soil. The charcoal remains are older than 32 1oo ± 72o years B. P. /Hannover 8116/. According to our earlier investigations the rate of sedimentation of young loess in Hungary was 1m/2ooo years. In the

Table 2. Results of pedological analysis of the "Basaharc-Double" Soil Complex in the Mende brickyard exposure /1968—1976/

Depth m	Thick-ness of strata	$CaCO_3$ %	hu-mus %	hy %	clay mm ø	silt gr	loess %	sand	Ca mg equiv/100 g	Mg mg equiv/100 g	colour
15,10-17,60	2,50	16,5	0,27	1,12	18,4	16,8	36,3	29,0	14,20	6,54	2,5YR 6/4 yellow loess
17,60-18,00	0,40	5,5	0,62	1,79	25,8	19,5	32,5	21,6	14,90	6,54	10YR 6/3 A horizon
18,00-18,20	0,20	19,8	0,62	1,61	34,7	15,7	24,0	24,8	10,90	6,54	10YR 7/3 A/C horizon
18,20-18,45	0,25	26,1	0,27	1,28	33,2	14,0	28,3	24,3	6,00	5,45	10YR 7/3 C horizon
18,45-19,00		18,1	0,21	1,12	20,7	17,2	38,1	23,3	7,40	3,27	5YR 7/3 yellow loess
19,00-19,20		16,6	0,21	1,13	19,4	20,8	30,6	29,8			10YR 6/3 yellow loess
19,20-19,40		16,4	0,21	1,09	19,5	19,4	30,1	31,1			10YR 6/3 yellow loess
19,40-19,60		16,7	0,21	1,08	18,5	19,0	30,8	32,7			10YR 6/3 yellow loess
19,60-19,80		17,0	0,21	1,00	17,4	19,0	30,5	33,0			10YR 6/3 yellow loess
19,80-20,00	1,55	16,5	0,21	1,08	17,8	21,2	30,0	31,2			10YR 6/3 yellow loess
20,00-20,30		13,8	0,32	1,13	18,1	19,7	30,6	32,5	5,32	2,06	10YR 6/3 A1 horizon
20,30-20,60		8,4	1,21	1,29	18,4	18,9	32,8	28,9	8,80	2,06	10YR 6/3 A1 horizon
20,60-20,75		3,8	0,21	1,40	23,1	21,2	30,2	26,0	12,32	2,06	10YR 6/3 A2 horizon
20,75-20,90		4,2	0,32	1,72	29,6	21,3	27,0	24,3	11,87	1,03	10YR 5/4 A2 horizon
20,90-21,05		5,8	0,32	1,79	31,7	13,7	27,7	26,7	11,87	1,03	10YR 5/4 A2 horizon
21,05-21,15	1,15	5,4	0,32	1,83	30,9	16,3	25,7	29,2	11,87	1,03	10YR 5/4 A2 horizon
21,15-21,30		12,9	0,21	1,49	30,3	17,7	25,2	27,6	9,80	5,68	10YR 6/4 AC horizon
21,30-21,50		12,5	0,21	1,33	30,8	17,5	22,4	30,1	9,80	5,68	10YR 6/4 AC horizon
21,50-21,65		10,4	0,21	1,36	27,5	15,4	26,0	30,8	9,80	5,68	10YR 6/3 AC horizon
21,65-21,83	0,78	13,4	0,21	1,56	23,5	17,2	29,2	30,8	5,60	3,10	10YR 6/3 AC horizon
21,83-22,03	0,20	17,1	0,21	1,17	20,7	19,0	29,7	30,5	5,60	3,10	10YR 6/3 C horizon
22,03-22,18	0,15	17,9	0,21	1,05	18,4	20,0	31,9	31,6	7,77	1,03	10YR 7/3 yellow loess

knowledge of these calculations if we add the time needed for the formation of fossil soils in the profile we would suggest that the "Basaharc-Double" Soil Complex is probably 42 - 45 ooo years old /M. Pécsi 1972/.

- <u>The "Basaharc-Base" Soil /BA/ in the Mende profile</u>

The BA soil in the Mende profile is a remarkably well developed dark coloured compact chernozem-type /chernozem-meadow/ soil /Fig. 5./. It is mostly rich in krotovinas. Its pedological characterics are shown in Fig. 8. and Table 3. /M. Pécsi and other 1977/. Direct evidence about the absolute age of this soil is not available at present. Relying on our calculations about the rate of sedimentation and /fossil/ steppe soil formation we may estimate the age of the BA soil to be 6o - 64 ooo years. In the Mende profile below the Basaharc-Base Soil there is a 2 m thick somewhat stratified loess stratum, the lower part of which is solifluction loess /Fig. 4./. Teeth of Equus Sp. have been found here which are most likely of Würmian type.

- <u>The "Mende-Base" Soil Complex /MB/</u>

This double soil consists of a fossil brown forest soil and a forest-steppe-type chernozem soil. The upper unit, the forest-steppe-type soil /MB_1/ directly overlies the lower, a reddish brown brown forest soil /MB_2; Fig. 9., Table 4./.The stratigraphical position of the "Mende-Base" Soil Complex in Hungary and in the Carpathian Basin is is such, that it may be regarded as a stratotype that separates the young loess from the old loess. This was first described by M. Pécsi /1965/ and the pedological analysis was done by P. Stefanovits /1965/.

M. Pécsi suggested that this soil complex had probably formed during the second half of the last interglacial /R-W/.

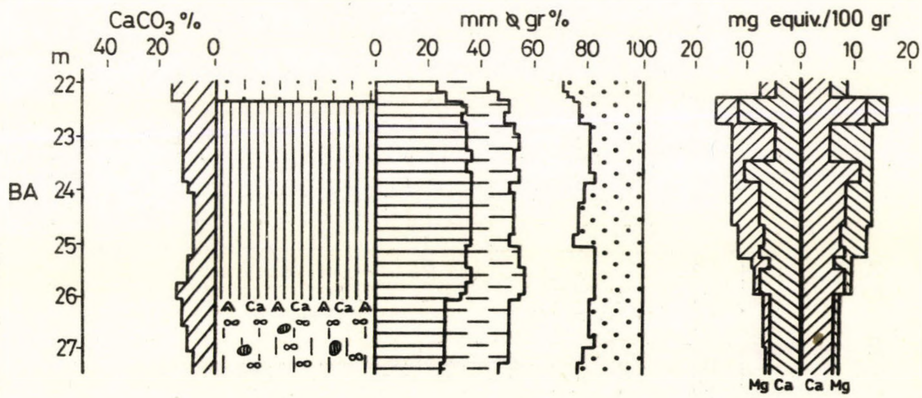

Fig. 8.:Pedological profile of the "Basaharc-Lower" Soil Complex /after M. Pécsi - E. Szebényi/ in a profile at Mende brickyard /1976/. See legend for Fig. 6. also.

He cited as supporting evidence the following facts: the vertebrate and molluscan fauna, recovered from the overlying young loess were all formations of the last glacial, while the chernozem-type soil horizons /MF, BD, BA/ interbedded in these young loess series indicate the warmer intervals within the Würm glacial. In the continental climatic regime of the Carpathian Basin during the last interglacial, climatic conditions were favourable for the formation of brown forest soils. Hence the development of forest soils. Further paleonthological, lithostratigraphical and geomorphological evidence was found to support our assumption that the MB Soil Complex had been formed during an interglacial.

Table 3. Results of pedological analysis of the "Basaharc-Lower" Soil Complex in a profile at Mende brickyard /1976/

Depth m	$CaCO_3$ %	humus %	hy %	clay	silt	loess	sand	Ca	Mg	Colour	
				A	I	L	H				
				mm Ø gr%				mg equiv/100 g			
22,18-22,31	15,6	0,32	1,18	21,1	20,7	28,9	29,1	5,10	3,71	10YR 6/3	sandy yellow loess
22,31-22,4o	15,0	0,43	1,35	25,4	19,3	26,5	28,9	5,10	3,71	10YR 6/3	sandy yellow loess
22,4o-22,49	15,0	0,43	1,40	26,3	19,0	27,8	26,6	12,90	4,18	10YR 6/3	sandy yellow loess
22,49-22,61	12,9	0,43	1,70	32,1	17,3	27,3	23,9	12,90	4,18	10YR 5/4	A horizon
22,61-22,72	11,3	0,43	1,94	34,8	15,1	27,0	23,3	12,90	4,18	10YR 5/2	A horizon
22,72-22,89	11,6	0,43	2,02	32,9	16,7	26,2	24,1	12,90	4,18	10YR 5/2	A horizon
22,89-23,10	11,6	0,43	1,72	34,6	17,8	27,9	20,2	5,16	8,77	10YR 5/3	A horizon
23,10-23,45	10,4	0,43	2,02	34,4	19,0	27,0	17,4	5,16	8,77	10YR 4/4	A horizon
23,45-23,65	11,2	0,43	2,09	36,2	15,8	29,4	19,2	5,16	8,77	10YR 4/4	A horizon
23,65-23,85	12,5	0,43	1,95	34,3	18,7	27,8	19,1	11,35	2,58	10YR 4/4	A horizon
23,85-24,05	13,7	0,43	1,91	35,2	18,5	27,2	18,1	11,35	2,58	10YR 4/3	A_1 horizon
24,05-24,25	9,6	0,43	1,88	35,9	15,0	26,3	7,96	22,5	5,16	10YR 4/4	A_2 horizon
24,25-24,45	8,7	0,43	2,04	36,2	15,8	24,0	22,8	8,56	5,16	10YR 4/3	A_2 horizon
24,45-24,65	8,7	0,43	2,14	36,8	17,6	23,6	22,8	8,56	5,16	10YR 4/3	A horizon
24,65-24,85	8,3	0,43	2,13	35,6	17,1	23,8	23,9	8,56	5,16	10YR 4/3	A horizon
24,85-25,05	7,5	0,43	2,07	36,7	18,0	20,3	25,0	6,71	5,16	10YR 4/4	A horizon
25,05-25,25	8,3	0,43	2,06	35,1	14,6	21,6	27,2	6,71	5,16	10YR 4/3	A_3 horizon
25,25-25,45	7,5	0,43	1,96	34,4	20,5	26,5	18,6	8,56	4,13	10YR 4/3	A_3 horizon
25,45-25,65	8,3	0,43	1,86	33,0	20,2	28,2	18,7	6,71	3,10	10YR 4/4	AC horizon
25,65-25,80	11,2	0,43	1,48	35,3	20,8	26,8	17,3	8,77	1,55	10YR 4/3	AC horizon
25,80-25,95	9,5	0,43	1,50	35,7	20,6	26,9	17,2	8,77	1,55	10YR 4/3	AC horizon
25,95-26,10	14,6	0,21	1,35	33,7	21,2	26,7	17,5	8,77	1,55	10YR 4/4	C horizon
26,10-26,25	13,3	0,21	1,32	31,0	22,0	27,7	18,4	6,10	1,55	10YR 5/3	C horizon
26,25-26,40	12,5	0,21	1,07	26,8	23,0	30,6	19,1	6,30	1,55	2,5Y 6/4	C horizon
26,40-26,55	12,5	0,21	1,12	26,3	23,3	30,4	20,0	6,30	1,55	2,5S 6/4	C horizon
26,55-26,75	11,2	0,21	1,05	26,3	21,6	31,6	20,4	6,30	1,55	2,5Y 5/4	C horizon
26,75-26,95	10,0	0,21	1,05	25,8	21,4	32,2	20,5			2,5Y 5/4	C horizon
26,95-27,15	10,4	0,21	1,16	26,6	21,2	30,3	21,7			2,5Y 5/4	yellow loess
27,15-27,3o	7,9	0,21	1,22	26,0	23,5	29,8	20,7			2,5Y 5/4	loess
27,30-27,45	9,1	0,21	0,99	25,9	23,2	30,4	22,0			10,YR 6/4	loess
27,45-27,65	8,3	0,21	1,15	24,9	22,0	30,2	23,2				loess

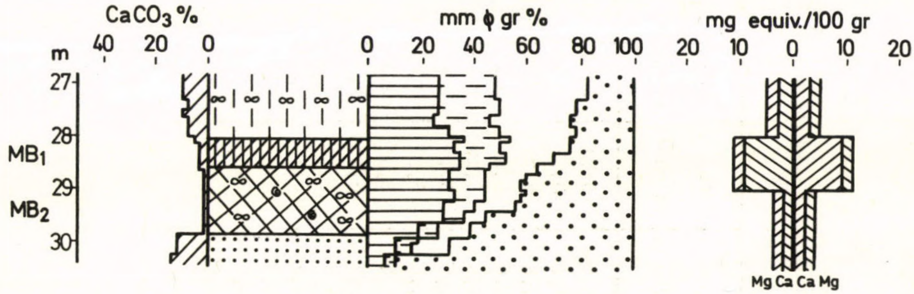

Fig. 9.: Pedological profile of the "Mende-Base" Soil Complex /after M. Pécsi - E. Szebényi/ in a profile at Mende brickyard /1976/. See legend for Fig. 6. also.

There is little doubt that the MB soil is an interglacial formation, but was it indeed formed during the last interglacial? Paleomagnetic investigation of these horizons may yield more reliable evidence.

Table 4. Results of pedological analysis of the "Mende-Base" Soil Complex in a profile at Mende brickyard /1976/

Depth m	$CaCO_3$ %	humus %	hy %	clay A	silt I	loess L	sand H	Ca	Mg	Colour
				mm Ø gr %				mg equiv/1oo g		
27,65-27,8o	7,5o	o,-	1,3o	3o,4	2o,9	26,4	22,2	3,71	2,13	10YR 5/2 yellow loess
27,8o-27,95	6,25	o,-	1,5o	35,6	18,8	21,8	24,1	8,77	2,13	7,5 YR 5/4 "
27,95-28,1o	4,17	o,-	1,63	32,6	17,1	25,6	24,8	8,77	2,13	7,5 YR 4/4 MB soil
28,1o-28,25	5,oo	o,-	1,63	34,6	16,7	17,9	3o,8	8,17	2,13	7,5 YR 4/4
28,25-28,4o	5,oo	o,21	1,61	33,4	13,5	17,o	35,6	8,17	2,13	5 YR 4/6
28,4o-28,55	o,83	o,21	1,5o	3o,3	14,1	18,7	36,3	8,77	2,13	5 YR 4/3
28,55-28,6o	1,25	o,-	1,36	29,2	13,o	18,7	39,5	8,77	2,13	5 YR 4/3
28,6o-28,7o	1,25	o,-	1,88	29,4	12,9	15,8	42,4	8,58	2,o3	5 YR 4/4
28,7o-28,8o	o,83	o,-	2,o3	29,3	12,8	16,5	42,3	8,58	2,o3	5 YR 5/4
28,8o-28,9o	o,83	o,-	2,4o	32,8	11,5	15,2	4o,5	2,o6	2,o3	5 YR 4/4 B horizon
28,9o-28,95	2,92	o,-	2,55	33,2	11,5	14,5	4o,3	2,58	2,o3	5 YR 5/4 B horizon
28,95-29,o5	o,83	o,-	2,6o	32,3	11,o	14,8	41,9	2,58	2,o3	7,5 YR 5/6 B horizon
29,o5-29,2o	2,o8	o,-	2,35	27,1	12,4	15,o	44,5	2,58	2,o3	7,5 YR 5/6 BC horizon
29,2o-29,4o	o,83	o,-	2,21	28,6	8,o	13,6	5o,o			yellow loess
29,4o-29,6o	2,5o	o,-	1,77	18,3	7,3	11,4	62,7			

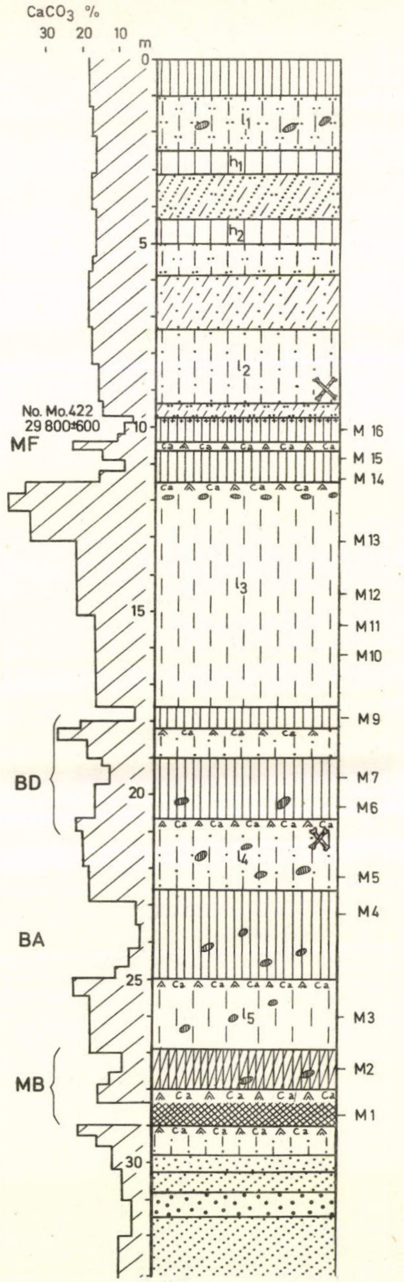

Fig. lo.: Location of samples taken for paleomagnetic analysis illustrated on a generalized profile of the Mende loess exposure /1965-1974/. - M_1 - M_{16} sample numbers according to M. A. Pevzner; all samples have normal magnetic polarity.

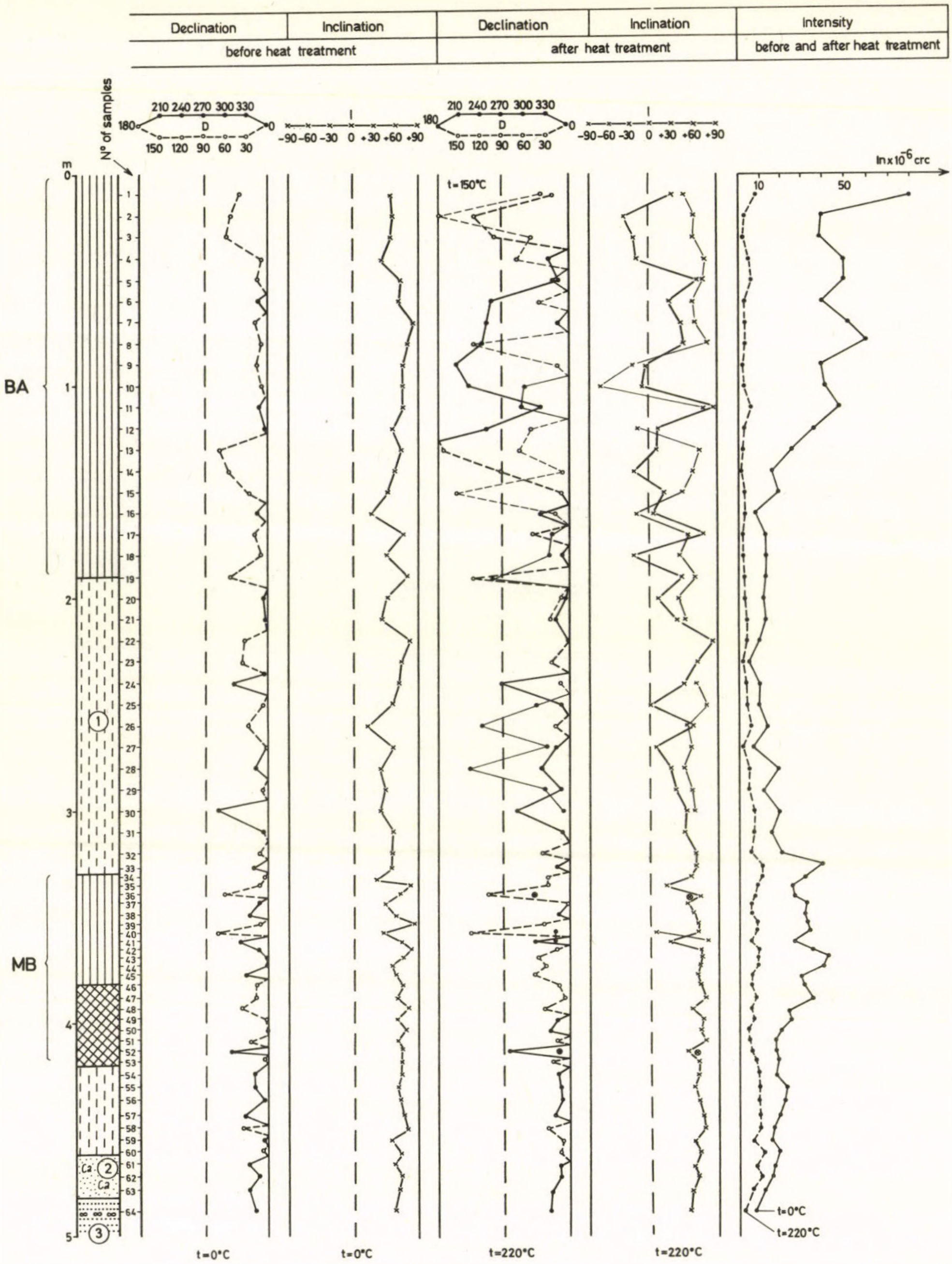

Fig. 11.: Detailed paleomagnetic analysis /1976/ of the lower part of the Mende brickyard exposure /M.A.Pevzner/. Sampling was done at 5 cm or 1o cm interval in an attempt to locate the Blake Event. - 1=loess; 2=sand with carbonate content; 3= stratified fluvial sand.

Paleomagnetic analysis of the loess complex of the Mende profile

The duration of the Würm and Riss-Würm interglacial are dated differently on the absolute time-scale by various authors. The climatic optimum of the Riss-Würm interglacial was dated as between 8o - 9o ooo years B. P. by B. Evans /1972/, based on maximum solar radiation during this time. C. Emiliani /1969/ and others examined deep sea sediments and consider the climatic optimum to have been reached between 9o - 1oo ooo years B. P. A. Dreimanis and A. Raukas /1975/ put this phase between 11o - 13o ooo years B. P., while W. S. Broecker and J. Donk /197o/ after analysing the cyclic changes in the O^{18}/O^{16} isotope ratios in the deep sea sediments dated the optimum of the Riss-Würm interglacial as 127 ooo ± 6 ooo years B. P. The age of the Blake Event in the Upper Pleistocene sediments was paleomagnetically determined as 1o7 ooo years B. P.

J. Kukla and J. Fink have suggested that we must look for the evidence of the Blake Event in the young loess, in the upper part of the Riss-Würm soil formation and in the overlying loess strata. In order to determine wether the Blake Event is represented, we carried out paleomagnetic analyses of the whole loess profile; the first was done in 1973 /Fig. 1./

In the past year two geophysical laboratories have analysed by different methods some critical sections of the Mende loess profile, its specific stratotypes. M. A. Pevzner /see Fig. 1o., 11./ has completed the paleomagnetic investigation of the lower part of the profile in the Geophysical Laboratory of the Geological Institute of the Soviet Academy of Sciences. Recently P. Márton of the Geophysical Department of the Eötvös Loránd University, Budapest has also analysed these stratigraphical sequences in detail /see his report in this volume/.

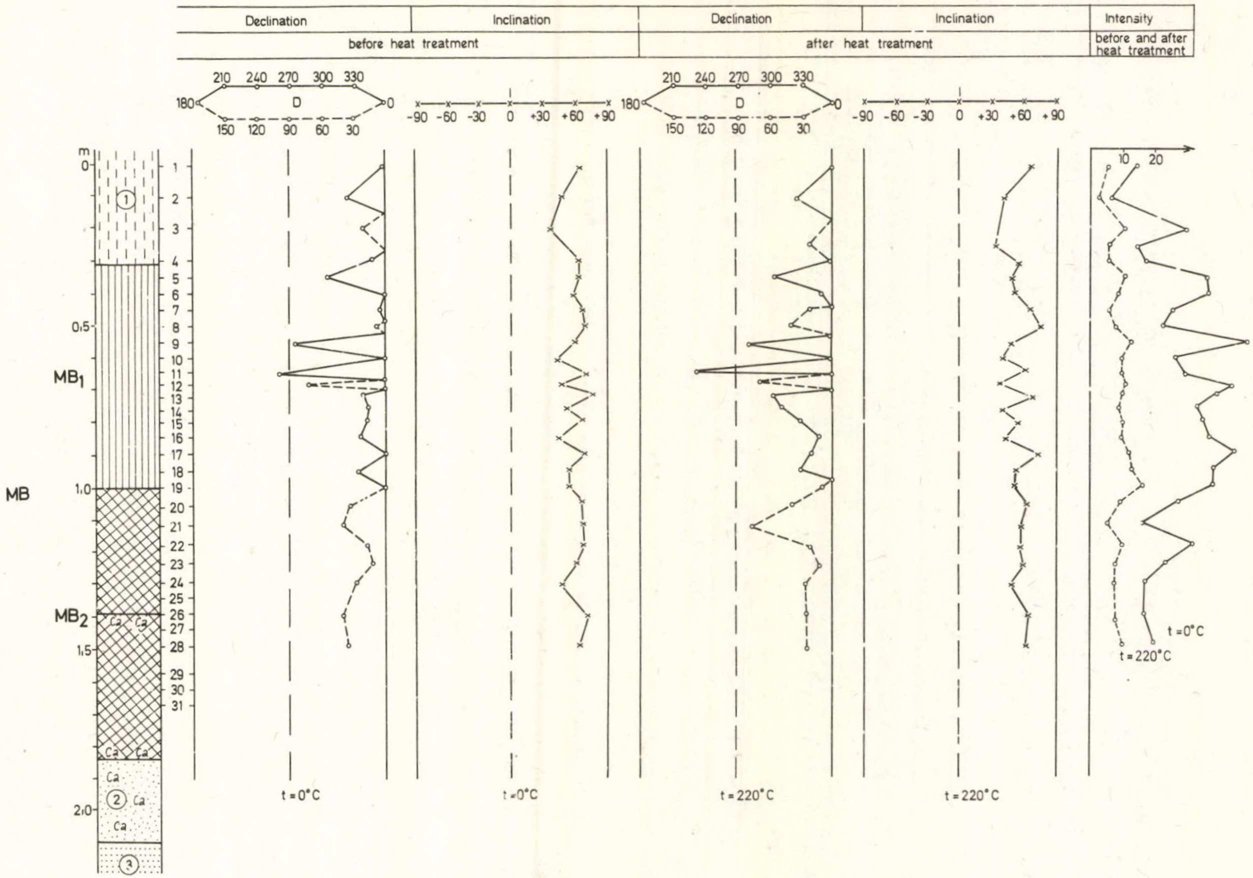

Fig. 12.: Paleomagnetic analysis of the "Mende-Base" Soil Complex in the Mende brickyard exposure /1978; M.A. Pevzner/. - Monolit samples for paleomagnetic analysis were taken at 5 cm interval. - 1=loess; 2=sand with carbonate content; 3=stratified fluvial sand. MB_1=dark brown steppe soil with friable structure; MB_2=B and BC horizon of brown forest soil.

Thermal cleaning of samples /see Fig. 11., 12./ was carried out at 22o°C and in some cases at 15o°C to define the stable magnetic component. Samples from both profiles carried secondary /probably viscous/ magnetization in addition to the primary magnetization, but the contribution to NRM of secondary magnetization in fossil soil horizons was significantly greater than in the loesses.

Secondary magnetization is destroyed by thermal cleaning but when it is relatively strong with respect to total magnetization, the stable component cannot be defined with sufficient accurancy. After thermal cleaning at 22o°C stabil magnetization of samples /No. 1 - 14/ from the upper part of the first profile /see Fig. 11./ exhibited 5 - 1o per cent of the initial magnetization /NRM/, while samples from the middle part of the profile showed 2o - 3o per cent of the NRM, and in the lower part of the profile 5o - 6o per cent of the NRM was present in samples /No. 5o - 6o/.

Since the secondary magnetization of the upper part of the profile had been significantly greater than the primary magnetization, it was not possible to determine the direction of the latter. Samples from the deeper horizon are normally magnetized. Similarly a definite statement about the magnetic direction of samples No. 24, 26, 28, 3o, 31, 4o, 41, 52 cannot be made, because in these cores the pair of specimens showed inconsistency in their magnetic direction. This inconsistency may be due to the presence of unstable large ferro-magnetic grains or to errors in sampling.

In the second profile /Fig. 12./ the significance of secondary magnetization is less. Here 3o per cent of the initial magnetization was preserved after thermal clearing. All samples with the exception of No. 9, 11, 12, 22 possess normal magnetization.

In both profiles of the Mende exposure all those samples that showed stable behaviour on cleaning carry only normal magnetization. The absence of any reversed magnetization may either be accounted for by the extreme shortness of the Blake Event or by its older age[1]. Another explanation may be that the Blake Event was restricted to certain regions and is not a global phenomenon, or the strata carrying reversed magnetization in this profile had been removed by erosion.

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1. The latest results obtained by thermoluminescene analysis /by Borsy et al. 1979. to be published/ give the age of the "Mende-Base" Soil Complex as 9o - 1oo ooo years B.P.

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THERMAL ANALYSIS OF THE MENDE LOESS PROFILE

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Our investigations focused primarily on the analysis of fossil soils in the Mende loess profile with an aim to describe fossil soil stratotypes. Lithologically and lithostratigraphically five main loess bands /l_1 - l_5/ could be distinguished in the profile, and these were thermally analysed /Fig. 1./.

1. In the Mende brickyard profile the "Dunaujváros-Tápiósüly" Loess Complex is 1 - 9 m thick, its sandy loess and loessy sand strata contain on the average 2o per cent clay. In the second band of the complex total clay mineral content is higher than average /25 - 3o per cent/. Among the clay minerals in the l_1 and l_2 loess bands, illite predominates /12 - 18 per cent/ compared to montmorillonite /6 - 12 per cent/. Kaolinite on the other hand, occurs only in 1 - 2 per cent.

Unlike in the loesses in the deeper lying layers, here it was not possible to find indications of chlorite. In the loess samples dolomite and carbonate minerals were detected /on average 18 per cent/; in the lower part of the l_2 loess band, situated close to the MF_1 fossil soil, the samples contained some dolomite and kalcite /16 per cent/. Samples collected from the 1 - 9 m thick loess did not indicate the presence of pyrite, chlorite and of hydrous oxides of iron, however, organic matter content could be found /o.2 - o.4 per cent/. It must be noted that the pyrite appeared in the sample from the layer overlying the MF_1 soil and humus content also increased /o.6 per cent/.

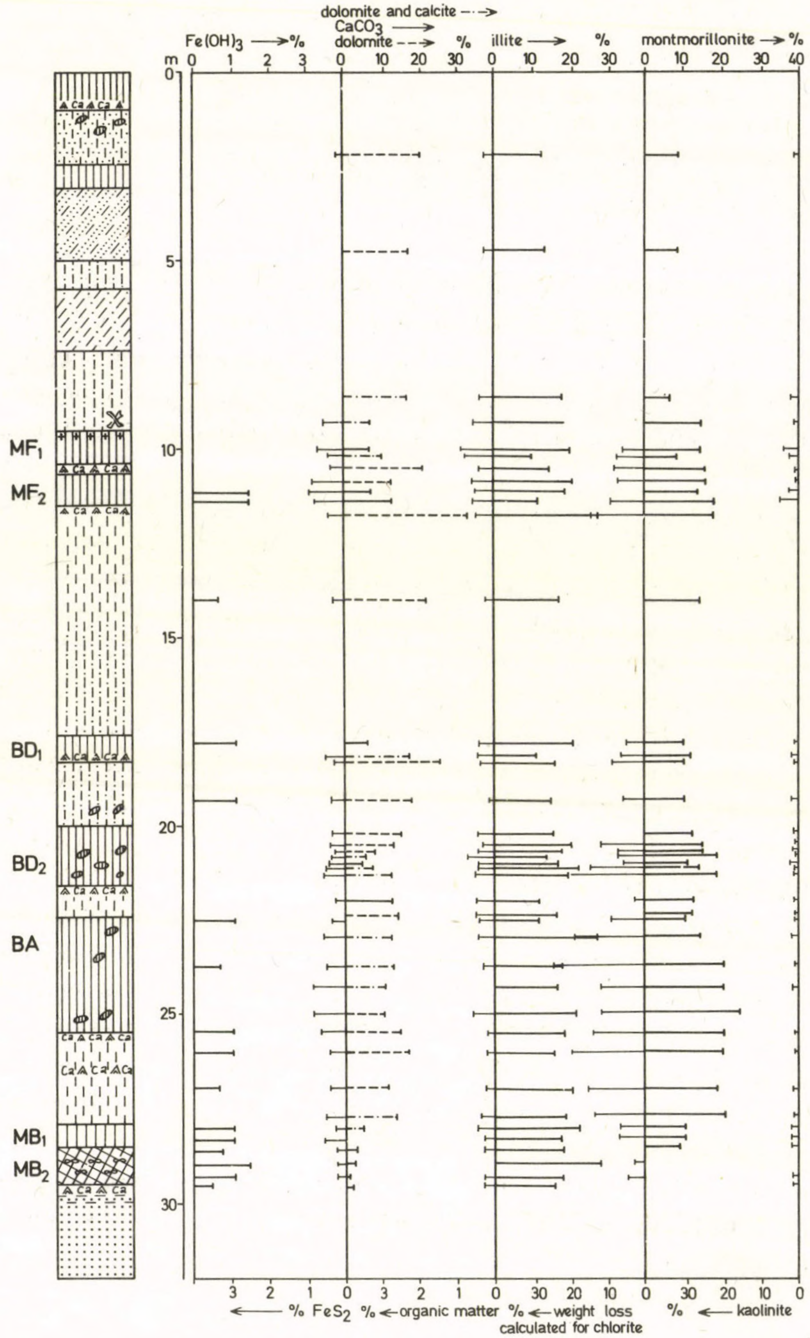

Fig. 1.: Results of thermal analysis of the Mende loess profile /1976/

In the loess samples l_3 - l_4 /between lo - 3o m/which be long lithologically to the so called "Mende-Basaharc" Loess Complex, total clay mineral content is in similar quantity like in l_2, however, in the fifth band /l_5/ overlying the MB soil it is significantly greater /35 per cent/. In the loess strata l_3 - l_5 illite is the dominant clay mineral. In the layers l_4 - l_5 the presence of chlorite was also indicated.Th amount of carbonate minerals in l_3 is well above average /23 per cent/. Hydrous oxides of iron appear in this layer their average content is o.7 per cent. In the fourth loess band /l_4/ organic matter content increases to o.5 per cent. The fre quent occurence of krotovinas or animal burrows in the layer could account for this phenomenon. Pyrite, in small quantity is found in all samples.

2. The total clay mineral content of fossil soils compared to the loess strata is significantly greater. A characteristic increase of phyrite and chlorite could also be observed. While in the loess layers dolomite represent the carbonate minerals, in the soils, kalcite plays a more important role. The humus content - as it should be expected, increased to o.5 - o.9 percent.

The following typical characteristics of the different fossil soils may be noted.

2.1. "Mende-Upper" Soil stratotype is a double steppe soil /MF_1, MF_2/. The humus content of the A_2 horizon of the MF_1 soil is the highest /o.9 per cent/ compared to all other fossil soils. Total clay mineral content is 37 per cent /plus the chlorite/; of those illite is 19 per cent, montmorillonit 14 per cent, kaolinite 4 per cent and some chlorite. Weight loss for chlorite is o.6 per cent. Kalcite is also present in this horizon. Hydrous oxides of iron could not be detected, however, pyrite content is o.7 per cent.

The total quantity of clay minerals decreases in the A/C horizon /2o per cent plus chlorite/ and the amcunt of carbonate minerals increases /o.7 per cent/. This latter consists mainly of dolomite and kalcite, while pyrite content decreases /o.4 per cent/.

The MF_2 soil directly underlies the Cca horizon of the MF_1 soil. The amount and distribution of clay minerals is basically the same in the samples collected from the MF_2 soil like in the overlying MF_1 soil /Fig. 1./. Differences can only be noted by the presence of significant quantities of hydrous oxides of iron in the A_2/B - A/C, B/C horizon of the MF_2 soil. Pyrite content also increases /o.9 per cent/ in these horizons. A remarkable amount of dolomite could be found /33 per cent/ in the Cca horizon of this soil and the total clay mineral content is also high /44 per cent plus chlorite/. Kaolinite could not be detected.

Thermal analysis together with pedological investigations seem to indicate resemblance to forest-steppe soils /chernozem, degraded chernozem, chernozem brown forest soil/.

2.2. The thickest loess band of the Middle Würm /5 m/ is situated in between the BD_1 soil and the "Mende-Upper" Soil Complex, it was formed during the glacial 3o - 4o thousand years ago. The clay and other mineral content /both in quantity and quality/ of the A_2 horizon of the BD soil is similar to the corresponding upper horizon of the MF soil /Fig. 1./, the only difference being that in the BD_1 soil hydrous oxides of iron in the upper horizon.

The total clay mineral content of the BD_1 soil is 5 per cent more than that of the underlying loess.

In the 1976 exposure at Mende a 2 m thick loess layer was found interbedded in between the BD_1 and BD_2 soils. Earlier in other profiles examined at Mende this layer was only o.5 m thick. In the profile presently described the BD_2 soil is separated from the "Basaharc-Base" soil /BA/ with an o.5 m thick loess stratum. The BD_2 soil is exceptionally thick in this profile. Total clay mineral content - with slight variations - is 34 per cent /plus chlorite/ in this soil, while in the A_2/B horizon is even higher /38 per cent plus chlorite/.

Compared to the underlying loess total clay mineral content has increased by lo per cent in this soil. Pyrite content increases slightly downwards /o.3 - o.6 per cent/ while organic matter content shows an even distribution /o.4 per cent/, though in the A_2 /B/ horizon it increases to o.8 per cent. Among the carbonate minerals kalcite and dolomite amount to only 5 - 6 per cent. In the A_2 and A/C horizons dolomite is the carbonate mineral once more, while hydrous oxides of iron could not be detected in sufficient quantity.

2.3. In the profile investigated, the BA soil is 3 m thick, its total clay mineral content reaches 4o - 45 per cent /plus chlorite/. Chlorite plays an important role in this soil but kaolinite content is lower than in the other soils discussed above.

Compared to the clay mineral content of the underlying loess layer /l_5/ the ratio of clay minerals in the BA soil is 8 - lo per cent higher. Distribution of these minerals is fairly even, a maximum quantity has accumulated in the A_2 /B/ soil horizon /44 per cent plus chlorite/; illite is 28 per cent, montmorillonite 14 per cent, kaolinite 2 per cent and weight loss for chlorite 2 per cent.

The amount of carbonate minerals - with slight variation - is around 7 per cent in the A_2 horizon it is present in the form of dolomite and kalcite, while in the Cca horizon it is dolomite once more. Pyrite content is the A/C horizon /o.9 per cent/. Distribution of humus content is uneven, on the average o.6 per cent. Unlike in the BD_2 soil hydrous oxides of iron is found here /o.7 - 1.1. per cent/. Differentiation between the BD_2 and BA soils was possible on the basis of a ıigher clay mineral content and the presence of hydrous oxides ›f iron in the latter soil. Although the carbonate horizons ›f the BA and BD_2 soils are important, it is significantly .ess than is the case of the MF and BD forest steppe soils.It ıay be supposed therefore that the BD_2 and BA soils were form- ›d under somewhat moister conditions and the carbonates were 'ashed out in solution.

2.4. The "Mende-Base" Soil Gomplex was 1.5 m thick in the 976 profile, while in the 1974 profile it had been more than m thick and the double horizon had been more marked. Under- ying the soil complex stratified alluvial sand with medium rain-size was found. In the sandy horizon of the soil the arbonate accumulation had cemented the sand. The clay content f the sand is small, only a few per cent, in comparison the otal clay mineral content of the soil it has increased to 2o- 2 per cent. The upper o.5 m thick part of the MB soil marked B_1 contains illite /18 - 21 per cent/, montmorillonite /8 - o per cent/ and kaolinite /2 -3 per cent/. The B_2 horizon nderlying it, is less rich in clay minerals, apart from a mall amount of kaolinite only illite was found, its quantity ecreases downwards /28 - 15 per cent/ towards the sandy base.

In addition to differences in soil structure between the B_1 and MB_2 soils an abrupt change in the clay mineral assem- lage also occurs. A significant amount of montmorillonite is resent in the MB_1 soil just like in the above discussed for- st-steppe soils of the Mende profile. In the B horizon of the edbrown forest soil of the MB_2 soil on the other hand, mont- orillonite is absent.

The quantity of carbonate minerals in the MB soil complex s generally low. While in the MB_1 soil the quantity of dolo- ite and kalcite is 5 per cent, in the MB_2 soil only kalcite as found in 1 - 2 per cent. However, it is characteristic hat the B/C horizon in the MB_2 soil is rich in plant roots and vertically oriented carbonate concretions are situated along microfissures. The concretions are cylindrical shaped forms calles loess doll.

The MB_1 horizon is richer in organic matter /o.5 per cent/ than the MB_2 soil /o.3 per cent/. The amount of hydrous oxides of iron is also significant in this latter soil.

On the basis of these investigations and the pedological characteristics of the MB soil complex it may be considered a poligenetic formation, developed on sand. The MB_2 soil is a clayey brown forest soil, the overlying MB_1 soil is a forest-steppe soil; this latter is incomplete.

The clay mineralogical composition of the MB_2 soil greatly resembles the fossil soils in a similar stratigraphical position in the Dunaföldvár and Dunaujváros loess profile.

MOLLUSCAN FAUNA OF THE MENDE LOESS PROFILE

M. Wagner

Molluscan fauna was collected on two occasions from the Mende profile. Our aim was to investigate the ecological requirements of the species recovered from the different strata of the exposure. In 1968 we had analysed the upper 18.5o m thick section of the profile, and later in 1976 we attempted to determine the former ecological environment of the molluscan assemblages between 18 - 32 m in the same profile. On the first occasion fewer samples were collected. In 1976, however, sampling was done at 1o cm, occasionally 2o cm interval without interruption. A sample usually consisted of 1 dm^3 of material. Molluscs were obtained from the samples by washing.

Terrestrial molluscs could be classified into five ecological groups:

1. hygrophile species of moist woodlands /riparian forests on flood plains/;
2. thermophile species, dry tolerant;
3. hygrophile species of open country /in general/;
4. ubiquitous species;
5. water species /in general/.

In our classification we have relied on similar results by Horváth /1954/, Lozek /1963/ and Krolopp /1963/. In an other paper M. Wagner /1977/ we argued that former climatic conditions and ecological environments may be succesfully reconstructed by comparing the relative abundance of various molluscs. An evaluation based on such quantitative ratios became somewhat difficult in the case of samples from this profile. The majority of molluscs were ubiquitous species and because of these characteristics they are unsuitable for the

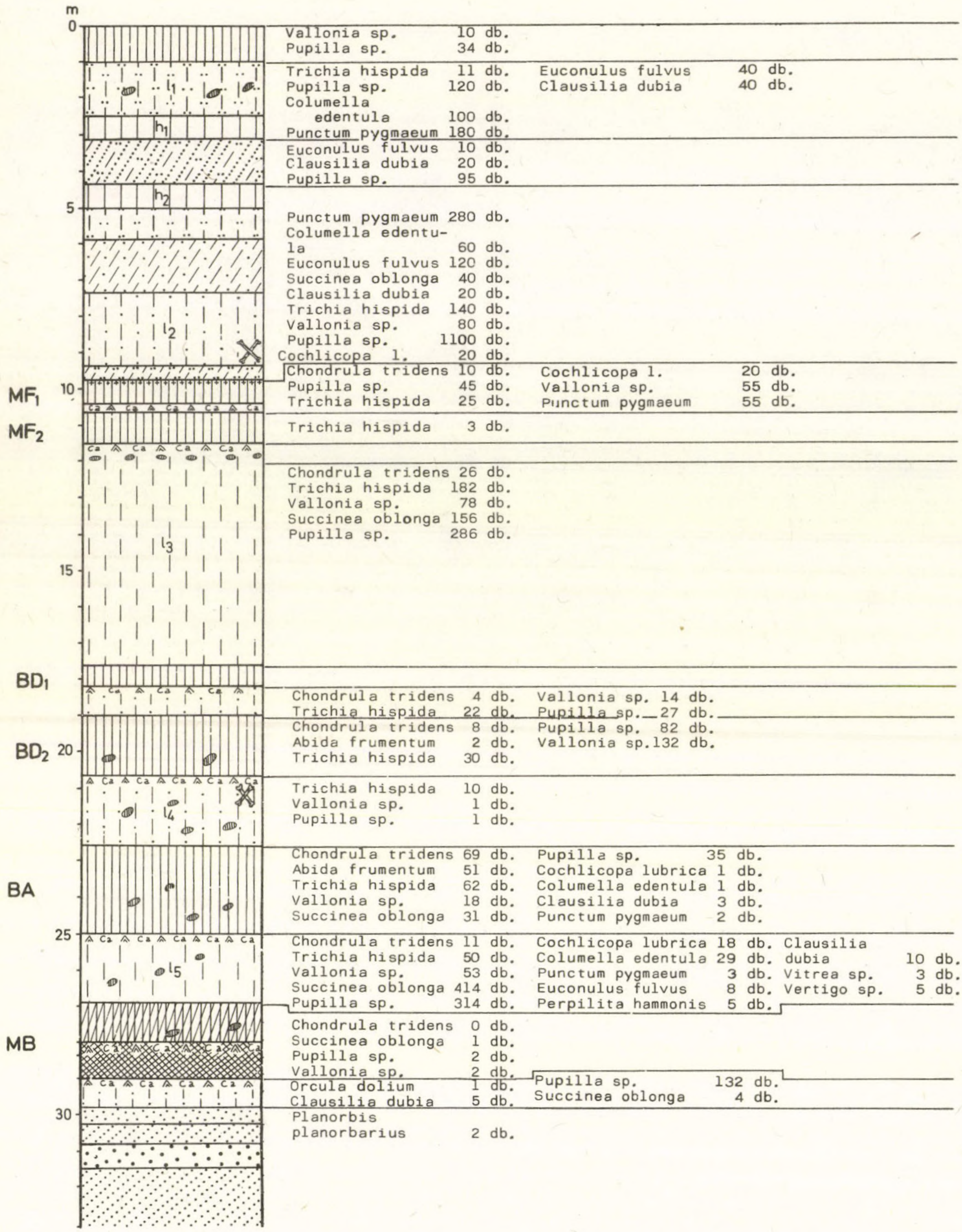

Fig. 1.: Molluscan fauna of the Mende loess profile

determination of prevailing climatic conditions. The percentage ratio of other gastropods was so small that their assessment by this method was not possible.

A total of 2o98 gastropods[x] were found in the samples taken at Mende, of these 1475 were ubiquitous species. From a repeated analysis of these latter species the conclusion was drawn that the ecological requirements of various ubiquitous species are different. Differences may be demonstrated by the preference of a species for a specific climate. The predominance of a species indicates that ecological conditions are optimal for the development of that particular species.

Fig. 1. shows the stratigraphical distribution of molluscs from the Mende profile. Between 18.5o - 32 m the total of molluscs are given, while the number of molluscs between 18.5o - o.o m were calculated and partly estimated. They indicate the probable number of gastropods that would have been found, if sampling had been continuous throughout the whole length of the section.

<u>Location of the molluscan fauna in the stratigraphical sequence of the loess profile</u> /Fig. 1./

In the sandy strata between 31.oo - 29.8o m 2 specimens of water snails /Planorbis planorbarius/ were found /Fig. 1./.

In the layers between 29.8o - 29 m apart from other species, individuals of Orcula dolium, Clausilia dubia and Succinea oblonga were discovered. These snails prefer a forest environment. The exceptionally high number of Pupilla specimen were probably washed down from the overlying soil. It is interesting to note that in sediment with a high ratio of sand particles the Pupilla species are preserved as a rule

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[x] The total number of molluscs /2o98/ represent the shells found in the whole profile. On Fig. 1. in the first 18.5 m the number of gastropods were calculated.

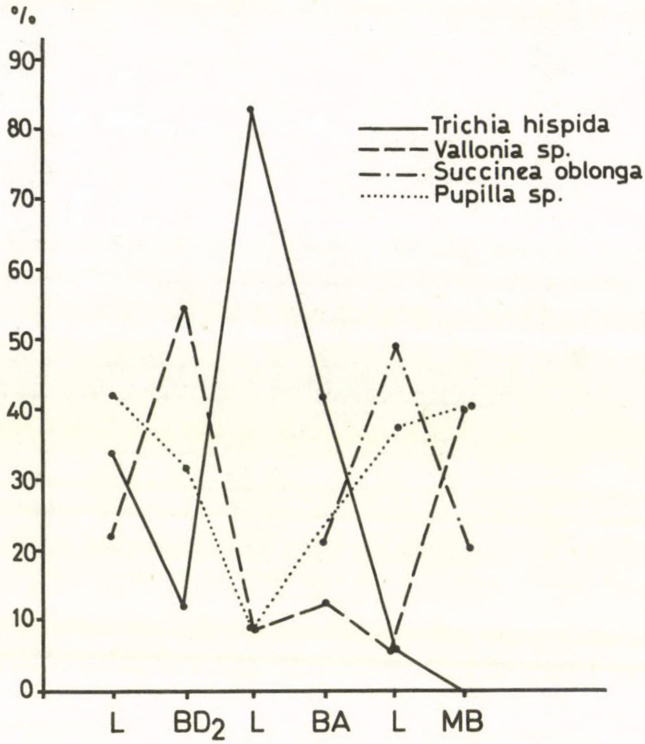

Fig. 2.: Percentage distribution of ubiquitous molluscs in each layer for the lower part of the profile

in a much greater quantity than the other molluscs. The reason for this is not known, probably the composition of the shell is different.

The "Mende-Base" Soil Complex /MB/ between 29 - 26.95 m contained only a few ubiquitous species. The maximum development of thermopile species /Vallonia, Pupilla/ is clearly demonstrated on Fig. 2.

The loess band between 26.95 - 25.oo m had the richest selection of molluscan fauna both in terms of species and individuals. It must be noted that the consistency of the shells is the least impaired in this band, if compared to the rest of the profile. Furthermore the individual specimen have a larger size and are better developed than in the other layers. This latter may indicate a richer quality food for these snails. The percentage ratio of Succinea specimen that prefer a moist and cold climate is exceptionally high, while the occurrence of a large number of Columella edentula marks colder conditions. The other snails that were found in the loess also favour a moist, forested environment.

A high percentage ratio of Vallonia and Pupilla species may be observed in between 25.oo - 22.4o m in the chernozem-type /forest-steppe/ soil of the "Basaharc-Base" Soil. Chondrula and Abida species, both thermophilous, also occur in relatively large number. Among the fossil soils in the profile, this soil contained the richest supply of molluscan fauna.

The loess layer interbedded in between the "Basaharc-Double" Soil Complex and "Basaharc-Base" Soil /22.4o - 2o.6o m/ had fewer species and specimen, than the "Basaharc-Base" Soil. The ratio of Trichia individuals is high and these animals generally prefer cold, dry ecological conditions.

The "Basaharc-Double" Soil Complex /BD_2/ is situated between 2o.6o - 19.oo m contains fewer species and individuals than the "Basaharc-Base" Soil. The percentage ratio of the various types of ubiquitous gastropods in this soil clearly indicates a maximum for the Pupilla and Vallonia species. A few Chondrula and Abida specimen also occur. A study of present-day species indicates that all these animals prefer a warm and dry environment.

Between 19.o - 18.3o m Trichia hispida, Chondrula tridens, Vallonia and Pupilla species were found. The evaluation of the faunistic evidence in the loess proved to be a difficult task, since the relatively high ratio of sand particles in the loess seems to indicate the operation of slope-wash processes. This appears to be the only tentative explanation for the dominance of both thermophile Pupilla species and of Trichia species together. These latter are known to thrive in a cold environment.

The upper horizons /BD_1/ of the "Basaharc-Double" Soil Complex had no molluscs between 18.3o - 17.6o m.

The thickest band of the "Mende-Basaharc" Loess Complex is situated between 17.6o - 11.6o m in the profile. Together with ubiquitous species some thermophile Chondrula tridens were also found.

The specimen are generally few in the loess, which may indicate drier climatic conditions than had been characteristic during the deposition of the loess band between the "Basaharc-Base" /BA/ and the "Mende-Base" Soil Complex /MB/.

In the layer between 11.6o - 1o.7o m no gastropods were discovered. So few snails were recovered from the "Mende-Upper" Soil /MF_2/ that an analysis of the molluscan fauna was not possible.

The upper horizon /MF_1/ of the "Mende-Upper" Double Soil is rich in molluscs /1o.7o - 9.7o m/. Both Cochlicopa lubrica and Punctum pygmaeum prefer a moist environment, while the Chondrula tridens is typically a thermophile species.

The loess interbedding between 9.7o - 1.3o m may be subdivided into three part on the basis of faunistic evidence. The lowest section between 9.35 - 4.35 m is rich in Columella edentula species that prefer a cold climate while the large number of Eucolunus fulvus, Clausilia dubia, Punctum pygmaeum specimen prefer a forested cool and moist environment.

In between 4.35 - 3.1o m in the loess only three types of molluscs were found. Pupilla sp., Euconulus fulvus, Clausilia dubia species. Although the latter two species still prefer a moist environment, the fact that much fewer specimen are present in this horizon compared to the underlying one, may signal the arrival of a slighty drier climate.

In between 3.1o - 1.3o m the number of Columella edentula species greatly increases, hence the climate once more became moister and colder.

The layer between 1.3o - o.7o m contained thermophile Pupilla sp. and Vallonia sp. ubiquitous species. These may signal the existence of a somewhat warmer climate.

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PALEOMAGNETISM OF THE MENDE BRICKYARD EXPOSURE

P. Márton

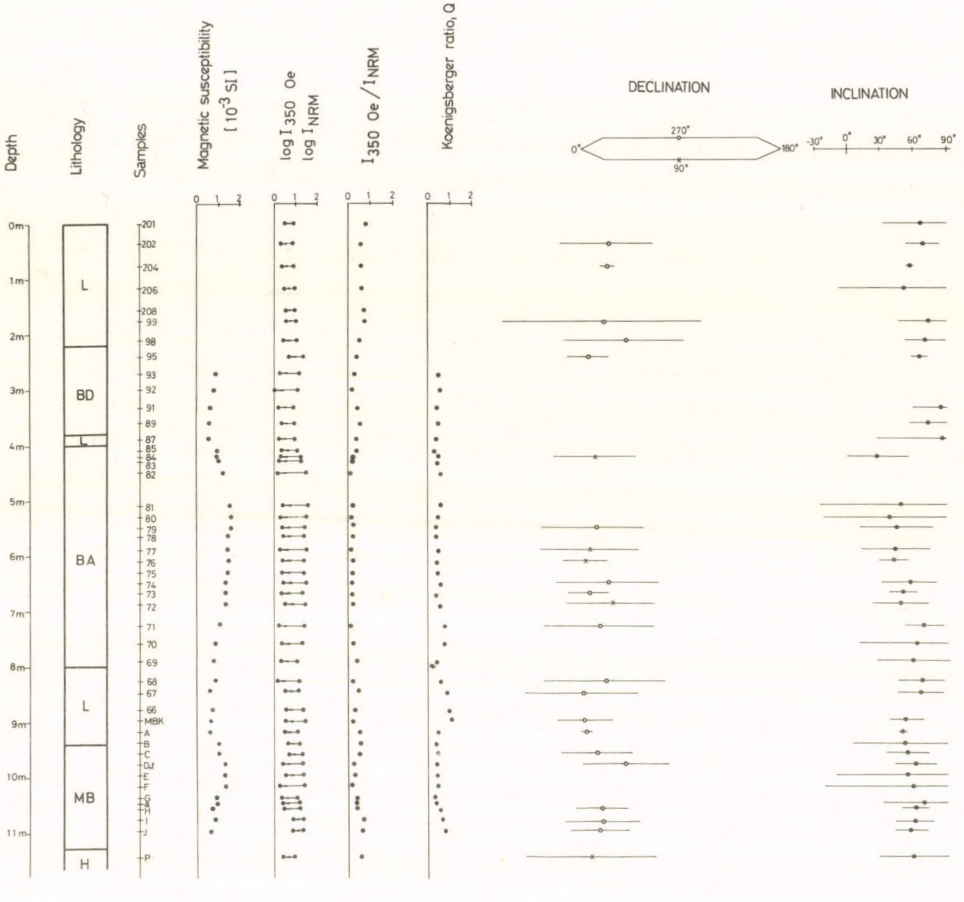
Method

Forty-six pairs of specimen were taken from the lower 11 m thick section of one of the exposures in the Mende brickyard. The susceptibility at each sampling spot was also determined.

The specimens were measured using the technique of AF-demagnetization. One specimen from each sample was demagnetized in 1o - 15 mT steps up to a peak field of 4o - 55 mT. The viscous component disappeared usually at 25 mT and further demagnetization in higher fields revealed the stable magnetization. The second specimen was demagnetized in one step /4o mT/ and the direction of this cleaned magnetization was compared with those measured in the first specimen. If these were found consistent then their mean direction was computed and taken as the direction of stable magnetization of the sample /D, I/. A confidence interval both for D and I was also computed /dD, dI/ from α_{95}, Fisher's measure of confidence.

Results

Results of the paleomagnetic measurements are presented in Fig. 1. the depth scale and lithological column are drawn according to Mrs Szebényi's personal communication. Declinations and inclinations are plotted with confidence intervals /horizontal bars/. Where both D and I are missing, the magnetization of the respective sample was found unstable or inconsistent in the two specimens. If only D is missing it is because of its total uncertainty.



<u>Fig. 1.</u>: Paleomagnetic profile of the Mende brickyard exposure. Mean direction /D, I/ of stable remanence for the Mende brickyard profile. Horizontal bars indicate 95 per cent confidence intervals /dD, dI/. Other parameters are explained in the heading.

On Fig. 1. all magnetizations are of normal polarity. The overall mean value of susceptibilities in the profile is equal to o.97 x 10^{-3} SI units. In the loess layers susceptibilities are smaller than in the fossil soils. The intensity of initial magnetization shows a positive correlation /o.o6 < R < o.73/ and that of "cleaned" magnetization /at 35 mT/, an essentially a negative /-o.65 < R < o.18/ correlation with suspectibility, where R is the correlation coefficient. These correlations are generally quite poor as shown by the large confidence intervals of R. Nevertheless, there is a tendency that the greater the initial magnetization of a sample, the greater the soft VRM component of the magnetization. This can also be seen from the variations of the respective intensities /I_{NRM}, I_{35o}/.

The carrier of magnetization is thought to be magnetite on the basis of IRM acquisition curves saturation showing in relatively low magnetic fields. Fig. 2. illustrates this for a loess and a soil sample. Thus, it was possible to estimate the magnetic content of the formations from the measured susceptibilities /Stacey, 1974; Parry, 1965/. Loesses were found to contain o.o2 and fossil soils o.o4 - o.o5 volume per cent of magnetite /Márton, 1977/.

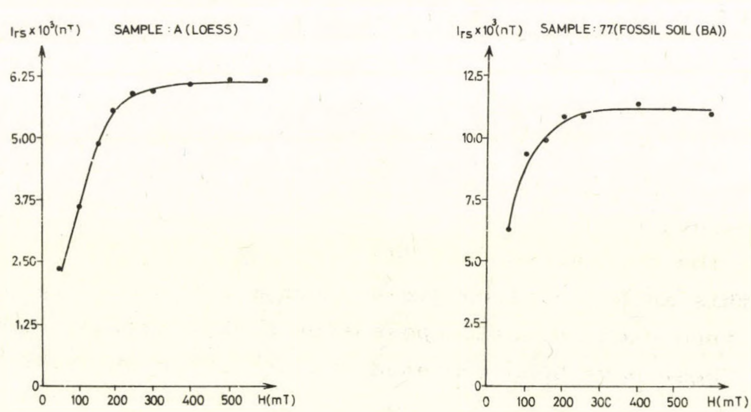


Fig. 2.: IRM acquisition curves for a loess and a chernozem fossil soil specimen from Mende brickyard

Discussion

As it has been shown in the first part of this paper the loesses and loess-like deposits of the Mende exposure examined paleomagnetically, were formed in the period between 3o ooo and cca. 11o ooo years ago, i. e. during a normal polarity interval of the Earth's magnetic field. All stable magnetizations measured are of normal polarity and align in the direction of the present geomagnetic field.

The stable magnetization of the loess is believed to be contemporaneous with its ultimate deposition i. e. characteristic of the direction of the ambient field during the formation of the sediment. Since magnetization is stable and parallel to the present field direction, it is also believed that dislocations of these loesses by gravitational transport has been negligible.

The magnetization of the fossil soil in the profile must also be linked with soil formation. Physical processes taking place in the bedrock /loess/ during soil formation probably destroy primary magnetization. As a result of chemical processes new magnetic phases develop. This point is illustrated by the variation of susceptibility in the BA- and MB-soils /Fig. 1./ both being sufficiently thick to show that secondary magnetite has precipitated mostly in the lower part of the A-horizon and in the entire B-horizon. It is believed that the stable fossil magnetization of the Mende soils originates from the small magnetite grains that precipitated in form of individual crystals, while the larger grains, having grown bigger during soil formation, are the carriers of the VRM component.

If this interpretation for the origin of magnetization is correct, then each formation possesses a characteristic magnetization. These have been computed and are shown on Table 1. and Fig. 3.

Table 1. Characteristics of the mean magnetic directions and statistical parameters of the different strata of the Mende loess profile

	Depth m	Formation	Number of samples	Mean: Declination	Mean: Inclination	Statistical parameters: K	$\alpha_{95}=dI^o$	$dD^o=\frac{\alpha_{95}}{\cos I}$
1.	0.0—2.2	L	7	338.46	64.10	75.23	7.0	16.03
2.	2.2—3.8	T /BD/	5	342.31	75.62	59.27	16.16	
3.	4.0—8.0	T /BA/	15	4.65	51.70	27.59	7.41	11.96
4.	8.0—9.4	L	5	352.92	58.31	76.45	8.31	16.77
5.	9.4—11.2	T /MB/	9	336.52	59.61	51.73	7.23	14.29
				mean value				
6.	0.0—11.2		41	350.33	59.62	24.94	4.56	9.02

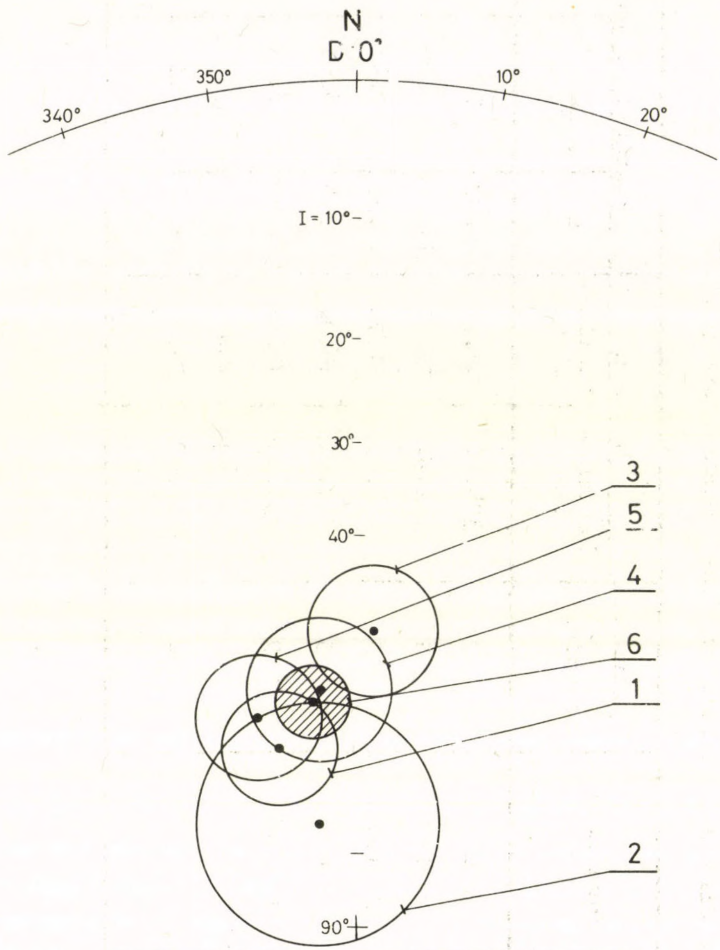


Fig. 3.:Mean magnetic directions /D, I/ of the different strata of the Mende exposure /1 - 5/ with 95 per cent confidence circles. No.6. illustrates the mean magnetic direction of the whole profile.

A statistical comparison of the mean direction of magnetization of the BA-soil revealed that it differs significantly from that of both the underlying MB- and the overlying BD-soils at 95 per cent the level of significance. From among the loess layers the one interbedded in between the BA and MB-soils has a mean paleomagnetic direction which is transitional between that of the two soils. The loess layer overlying the BA-soils is too thin, but the third above the BD soil exhibits a paleomagnetic direction statistically equal to that of the MB-soil. The overall average direction of magnetization of the whole sequence does not differ significantly from the present geomagnetic field direction.

M. Pécsi suggested /personal communication/ that the MB-soil might have been formed during the Blake-/reversed/ event 1o7 ooo years ago. However, magnetization has turned out to be normal so that either the MB-soil was not formed during that period or if it was, its magnetization was not characteristic of the Blake-event.

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PALEOMAGNETIC INVESTIGATION OF THE 1110 M SEDIMENT CORE FROM THE DÉVAVÁNYA SCIENTIFIC EXPLORATION BOREHOLE

A. Rónai and A. Szemethy

The year 1976 was a milestone in the research of the Great Hungarian Plain. The drilling project at Dévaványa was begun in the middle part of the Körös basin /Fig. 1./.

The time correlation of the sedimentary sequences of the different Quaternary basins in Hungary proved impossible by classical geological methods. Differences in the rate of subsidence of the basins presented great difficulties. The molluscs are inadequate for subdividing such relatively short period of time, the same applies for the Ostracod-fauna and for the vertebrate-remains. Only the pollens have provided sufficient data for a stratigraphic subdivision in a few boreholes. The climatic history of the basin could thus be explained but correlation with other boreholes could not be performed. An attempt was made to establish a time scale from level changes recorded by repeated geodetic measurements taking into consideration the rate of sinking and the composition and thickness of the correlative sediments. After the recognition of fluvial sedimentary cycles the knowledge of these served as a tool in the determination of major erosional gaps in sedimentation.

The Dévaványa core samples were the first on which paleomagnetic measurement were carried out besides other classical geological analysis. We had hoped that it would be possible to obtain an absolute time scale for the process of lowland sedimentation. In Hungary paleomagnetic investigations were made in the past on hard, oriented rock specimens, but not on loess sediments. The method of testing samples of

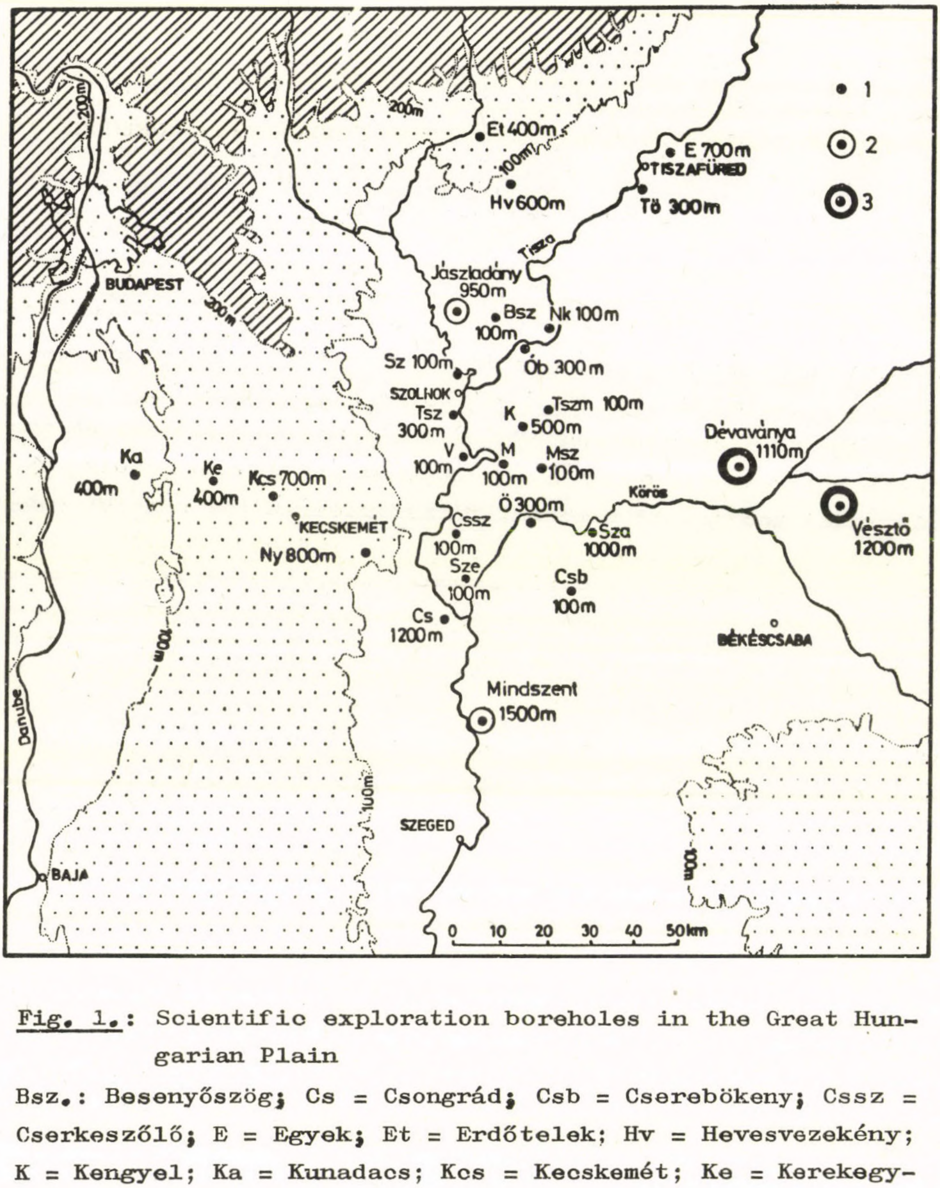


Fig. 1.: Scientific exploration boreholes in the Great Hungarian Plain

Bsz.: Besenyőszög; Cs = Csongrád; Csb = Cserebökeny; Cssz = Cserkeszőlő; E = Egyek; Et = Erdőtelek; Hv = Hevesvezekény; K = Kengyel; Ka = Kunadacs; Kcs = Kecskemét; Ke = Kerekegyháza; M = Martfü; Msz = Mesterszállás? Ób = Óballa; Ö = Ösöd; Sz = Szolnok; Sza = Szarvas; Tö = Tiszaörs; Tsz = Tószeg; Tszm = Törökszentmiklós; V = Vezseny

1 = Site of boreholes /depth in meter/; 2 = Boreholes treated in the literature /see references/; 3 = Borehole analysed paleomagnetically.

this kind was worked out only about two decades ago and it is used by a few laboratories throughout the world. The samples taken from the Dévaványa borehole were tested by courtesy of the Paleomagnetic Laboratory of Dalhousie University, Halifax, Nova Scotia, Canada.

Results are as follows: all polarity changes obtained from the core samples of Dévaványa borehole could be identified on the internationally accepted polarity time scale and the time-intervals of the sedimentary cycles could be established with great accuracy.

The paleomagnetic measurements in Dévaványa borehole have special international importance because it was the first series of measurements in the world, where samples were taken at every meter from a more than one thousand meter thick sedimentary sequence, in which the sedimentation was continuous in the last five-six million years, probably without any considerable interruption.

The Dévaványa borehole was planned to be drilled to the depth of 12oo meters, but the drilling had to be terminated at the depth of 1116 meters, thus we have reliable core samples from this part of the borehole.

It penetrated into fine grained sediments from top to bottom. Macroscopically the sediments are similar to the so called variegated clay known from the Upper Pliocene, but in this area this formation extends through the whole Quaternary and the Upper Pliocene and changes to the known Upper Pannonian formation only at the depth of about 114o meters. Coarse grained layers were not found from the borehole as far as the depth of 65o meters, and there was a small amount of medium grained and fine grained sands as well. The argillaceous character is more significant from the top down to the depth of 6oo meters, from then on the ratio of the sand gradually increases. The distribution of rudaceous and argillaceous sediments by 2oo meters was as follows:

	Clay	Silt	Sand
	distribution in per cent		
o - 2oo m	4o	55	5
2oo - 4oo m	63	25	12
4oo - 6oo m	61	34	6
6oo - 8oo m	43	49	9
8oo -1ooo m	35	48	17
o -1ooo m	48	42	1o

Paleomagnetic measurements /Fig. 2./ detected the Brunhes-Matuyama boundary at the depth of 12o meters. It means that the deposition of the upper, 12o meter thick part of sediments lasted 7oo ooo years. The thickness of sediments deposited in a year is o,171 mm and 5833 years were needed to form a one meter thick layer.

In the international geological literature the lower boundary of the Quaternary period, the Pleistocene - Pliocene boundary is dated at 1.8 or 2.4 My. Both data are in connection with paleomagnetic transitions. The boundary at 1.8 My corresponds to the beginning of the Olduvai normal polarity event within the Matuyama reversed polarity epoch. But the Pliocene - Pleistocene boundary is correlated more often to the Matuyama - Gauss paleomagnetic transition at 2.4 My,when the Gauss normal polarity epoch had changed to the Matuyama reversed polarity epoch.

In Dévaványa borehole the beginning of the Olduvai event was found at the depth of 32o meters and the Matuyama - Gauss transition at the depth of 42o meters. For the sediments between 12o and 32o meters the rate of deposition, calculated from the data mentioned above, gives the value of o,18 mm per year, which is close to the sedimentation rate of Upper Pleis-

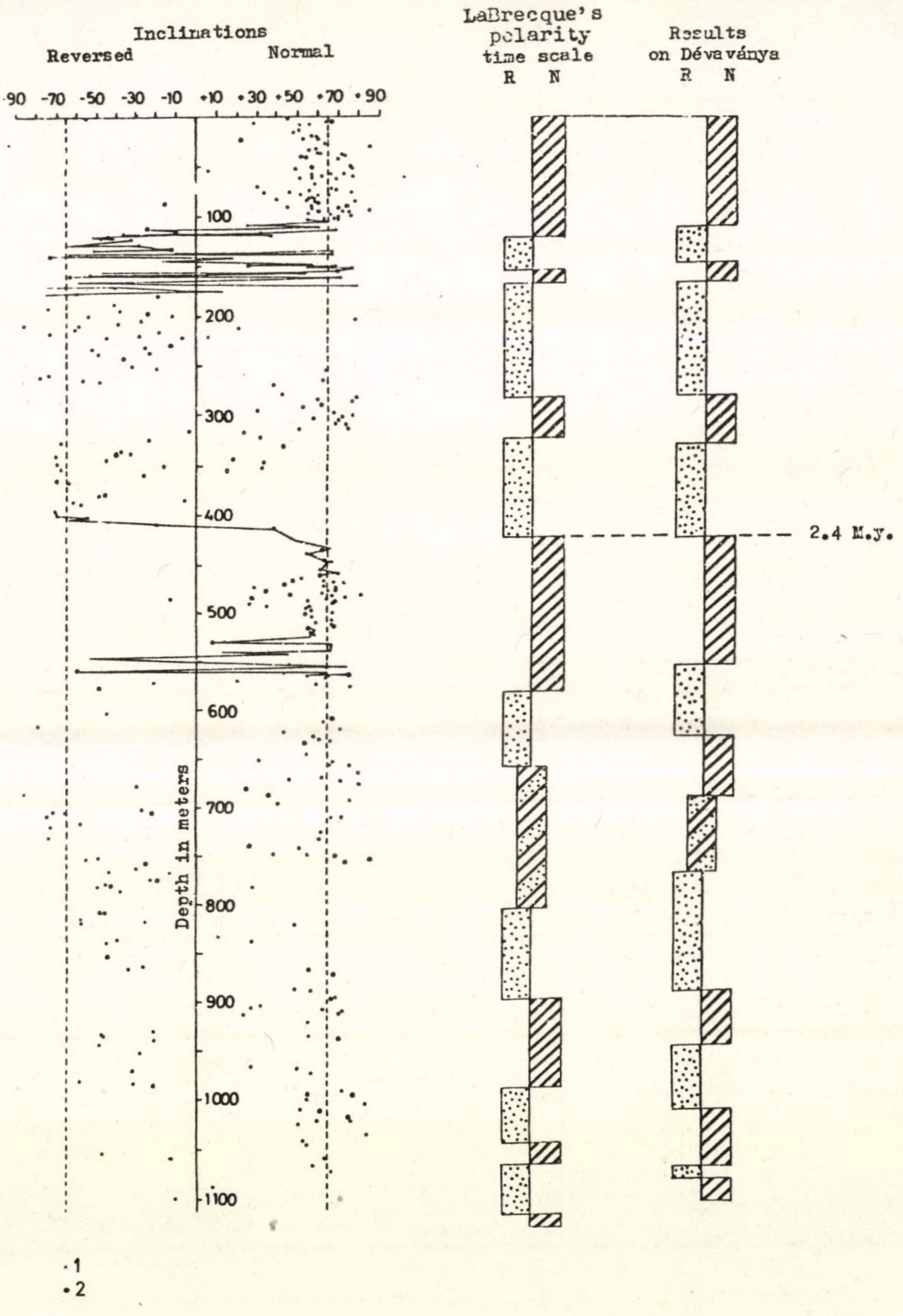


Fig. 2.: Paleomagnetic inclination values of the Dévaványa borehole sample - 1 = well defined stable inclination; 2 = weakly defined stable inclination

tocene. This calculation is supported by the similarity of the sediments.

Between 1.8 and 2.4 My, i. e. 320 and 420 meters 100 meter thick sediment deposited in c.6 My, which correspond to 0.17 mm thickness per year; the deposition of 1 meter thick sediment lasted 6000 years. This value is also very similar to that of the two others mentioned earlier, and might be explained with the similar grainsize distribution of sediments.

After the Pliocene limnic sedimentation the beginning of the river sedimentary cycles was found at the depth of 490 meters by both granulometrical and macroscopical investigation. Mineralogical investigation of sands and trace element analysis shows a remarkable change between 416 and 430 meters. The Pliocene - Pleistocene boundary was considered to be at about 430 meters by Ostracod-studies. Pollen analysis showed significant climate changes at the depths of 321 and 482 meters. The Matuyama - Gauss paleomagnetic boundary is close to these values, so it is confirmed by various aspects. However, it is to be noted that the beginning of the Olduvai event appears markedly in the sequence and can be detected both mineralogically and paleontologically. The lower boundary of Quaternary can be taken at 1.8 My. The more thoroughly the history of the last 1-3 million years is investigated the more it can be seen that the transition from the Pliocene to the Pleistocene was gradual with several oscillation.

If we accept the paleomagnetic transition Gauss - Matuyama as the Pliocene - Pleistocene boundary, i. e. the upper 420 meter thick part of the drilling is taken as Quaternary, this data is very close to that of the Pliocene - Pleistocene boundary found in the Jászladány borehole at the depth of 432 meters. The sequence, the paleontological features and sedimentary cycles of the two boreholes can also be well correlated. The similarity of Quaternary sequence at Dévaványa and Jászladány

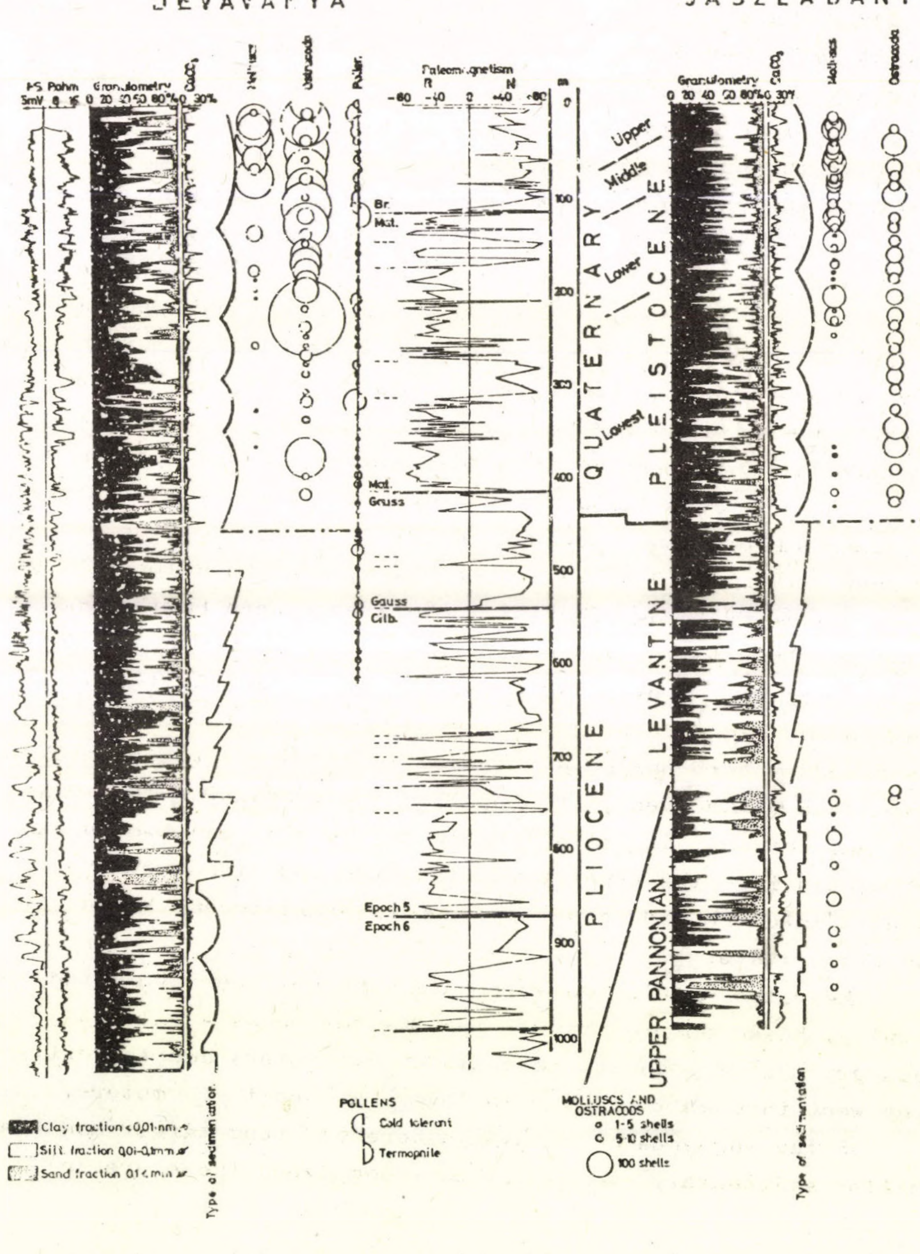


Fig. 3.: Geological profiles of two test wells in Hungary

/Fig. 3./ can be shown by the data as follows: the ratio of the clay-layers in Dévaványa is 52 per cent, while in Jászladány it is 5o per cent. The Pliocene - Quaternary boundary, found at the depth of about 3oo meters in the Kengyel borehole drilled in tectonically uplifted Nagykunság, correlates well with the base of Pleistocene at the depth of 52o - 65o meters in the Csongrád and Mindszent Quaternary basins, which sink faster and are infilled with coarse sediments.

Having accepted the Pliocene - Quaternary boundary at 42o meters, we must regard the upper 12o meters as Upper and Middle Pleistocene, because according to the Alpine terminology and age determinations, the whole Mindel - Riss - Würm glacial and interglacial belong to this interval. Only the Günz and Pre-Günz periods with the Tegelen and Pre-Tegelen periods can be correlated to the interval of 12o - 14o meters. The Early-Pleistocene lasted from 2.4 My to o.7 My. the Late-Pleistocene from o.7 My to 12 ooo years, and the Holocene from 12 ooo years till now. The Early-Pleistocene can further be divided into two parts, the boundary between them is about the end of the Olduvai event at about 1.6 My. Similarly the Late-Pleistocene can also be divided into upper and lower parts. The boundary here can be a reversed event inside the Brunhes epoch, the Blake event, at about 11o ooo years. The last glacial, and the last interglacial, i. e. the Würm and Eemian can be counted into the Upper part, the Riss and Mindel can be counted into the Middle part. The Lower-Pleistocene began with the Cromer interval.

The paleomagnetic measurements have not been evaluated totally. Based on preliminary results the Gauss - Gilbert boundary /3.4 My/ is at the depth of 62o meters and the drilling went through the 5 My old layers at about 92o meters.

In the sequence of Dévaványa borehole four larger and ten smaller sedimentary cycles can be recognized. These are in correlation with the cycles known in Jászladány borehole and with the sedimentary intervals that could be established in other drillings which penetrated the total Quaternary sedimentary sequence. The cycles, began with coarse sediments becoming finer and finer gradually upwards. In the middle of the cycle there are fine clays. Then the process reverses and the cycle finishes with coarse grained sediments again. There are cycles in the mineralogical composition too.

Remarkable changes can be found between 29 and 74 meters, and from 416 to 43o meters. The four major stages of step-faulted sinking during the Quaternary period in this area can also be recognized from mineralogical studies. The conclusion which can be drawn from the data is that the Körös Basin had become a separate sedimentary basin from the beginning of the Pleistocene period. It had no connection with the source areas of the Danube or the Northern Hungarian Basin.

The distribution of magnetic-ilmenite and biotite grains in the o.1 - o.2 mm fraction of the Dévaványa samples is shown in the folloving table /see later/:

In addition to these important minerals the pyroxenes and amphiboles also represent significant ratio to the depth of 45o meters 1o to 2o per cent in some cases. But from the depth of 45o meters and especially from 55o meters they occur only occasionally.

The method of paleomagnetic measurements

The paleomagnetic method is based on the recognition that rocks magnetize in the direction of the ambient geomagnetic field during rock formation. The magnetic minerals are the minerals of iron, especially iron oxides. As sediments and sedimentary rocks respectively contain a small amount of magnetic minerals, the paleomagnetic investigations have been ex-

Table

Depth range /m/	Magnetite-Ilmenite	Biotite
	/extreme values in per cent/	
o - 5o	12 - 25	1 - 6
5o - 1oo	4 - 1o	5 - 8
1oo - 15o	4 - 23	1 - 2o
15o - 2oo	7	11 - 22
2oo - 25o	6 - 1o	1 - 3
25o - 3oo	4 - 18	1 - 7
3oo - 35o	2 - 23	1o - 16
35o - 4oo	9 - 13	o - 4
4oo - 45o	9 - 21	o - 1
45o - 5oo	2 - 14	1 - 31
5oo - 55o	3 - 1o	3 - 18
55o - 6oo	5 - 18	-
6oo - 65o	5 - 18	o - 1
65o - 7oo	11 - 21	o - 2
7oo - 75o	16 - 17	1 - 3
75o - 8oo	-	-
8oo - 85o	13 - 28	o - 1
85o - 9oo	7 - 21	1 - 2
9oo - 95o	12 - 3o	1 - 6
95o - 1ooo	5	2
1ooo - 1o5o	1 - 12	1 - 3
1o5o - 11oo	29	1
11oo - 115o	3 - 17	1 - 3

tended to these rocks only for the last decades, when the measurement of magnetic moments, 2-3 orders of magnitude less than that of the igneous rocks, has become possible with sensitive equipment developed in recent years.

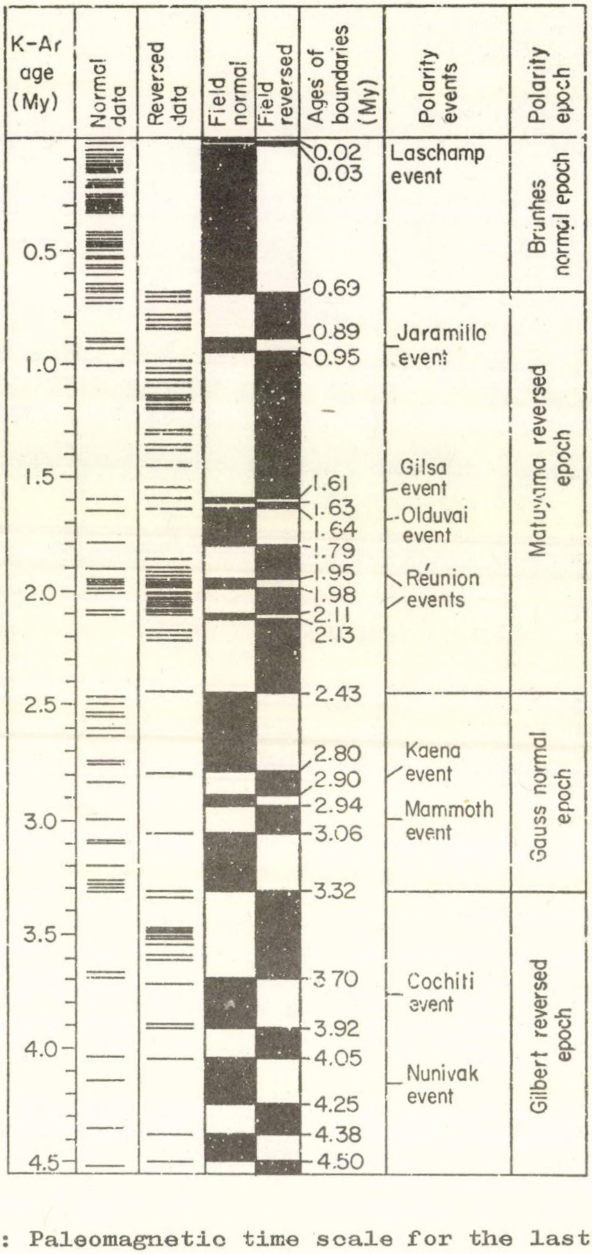
In sedimentary rocks the moment and direction of the detrital remanent magnetization /DRM/ should be determined. As a rule primary DRM is masked by viscous remanent magnetization acquired after the rock had been formed. This can be removed by using different cleaning techniques.

The polarity of earth's magnetic field had reversed several times in the geological past. A Cox's /1969/ reversal scale based on paleomagnetic and K-Ar measurements contains the normal and reversed polarity epochs and events for the last 4.5 My /Fig. 4./. The most recent summary of the polarity data based on the measurements of ocean floor basalts is published by LaBrecque et al. /1977/ /Fig. 5./, and we used their time scale for correlation of our data.

In the paleomagnetic measurements the absolute value and direction of the remanent magnetization were determined. The measurements were made in the Paleomagnetic Laboratory of Dalhousie University, using a DSM-1 spinner magnetometer. In this equipment the specimen spins about a horizontal axis, the vertical component and the eastern or northern components of the horizontal vector are measured. The specimen should be placed into the sample holder in six positions so that finally four data can be obtained for each component. The value of magnetic moment is given by

$$F = \sqrt{H^2 + V^2}$$

where H is the horizontal and V is the vertical component of the magnetic vector. The DSM-1 was connected to a small computer and the declination, the inclination and the magnetic moment were calculated from the data of the six position measurements. The sensitivity of the equipment is 3×10^{-8} emu,



<u>Fig. 4.</u>: Paleomagnetic time scale for the last 4.5 My. /Cox, 1969/.

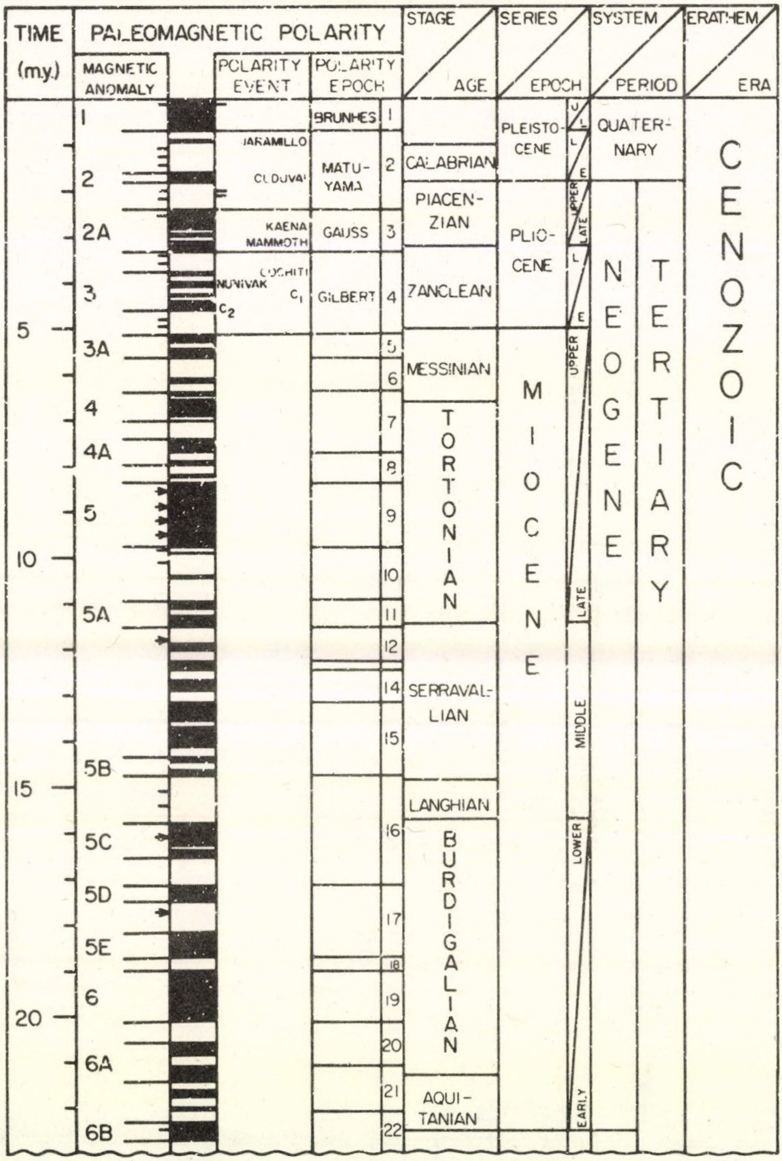
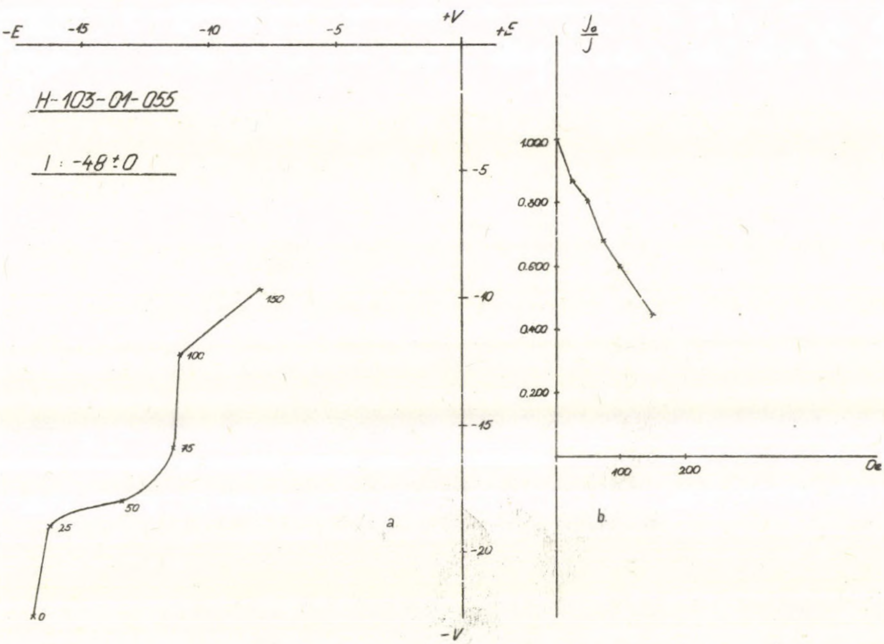


Fig. 5.: Paleomagnetic time scale for the Neogene /after La Brecque et al. 1977/.

thus the value of 10^{-5} - 10^{-6} emu which is characteristic for sedimentary rocks in general, can be measured easily. Along with the calculation of the magnetic parameters the program provided statistical estimates of precision and reliability.

The sampling for our measurements was made by pressing plastic sleeve /diameter and length of 2.5 cm/ into the core cut along its longitudinal axis. The sample was measured together with the plastic sleeve planned to be fit into the sample holder directly. The sample orientation was fixed by reference lines marked on the tubes and the samples. Of course from cores only vertically oriented samples can be obtained because the rotation of the core could not be avoided. Thus the vertical orientation of the samples was known and the bedding plane was parallel to the longitudinal axis of the sleeves. In this sampling method pressing the tubes into the core must be made with great care to avoid disturbance which may cause inaccuracy in measurements.

The magnetic cleaning of the specimens were made by progressive AF. demagnetization in an equipment constructed by J. Hall at Dalhousie University. All specimens were demagnetized in at least a peak field of 150 Oe. The amplitudes of the demagnetizing field were as follows: 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500 Oe. In some cases the peak value of 150 Oe was large enough to destroy the soft magnetization and to reach stable inclination. When the inclination values, obtained in the last three demagnetization steps, differed from each other less than 10 degrees, the mean value of the last three inclinations was calculated and accepted as stable inclination. In some other cases the stable inclination could not be reached even after 500 Oe demagnetization, especially in samples from transition zones, and hence possessing smaller primary magnetic moments. Changes of the magnetic moments during demagnetization can be detected and shown by demagnetization curves. The changes of the vertical component plotted against one of the horizontal component can also be detected in order to control the optimum value of demagnetization because reaching stable inclination the values of the components align along a straight line /Figs. 6., 7./.



<u>Fig. 6.</u>: Demagnetization graphs of a core sample from Dévaványa /H-1o3-o1 - o55/

a/ Variation of the vertical component plotted against the eastern/northern component

b/ Demagnetization curve of the sample

V = vertical component; E = eastern component;

N = northern component

$\frac{J_o}{J}$ = Ratio of the magnetic moments

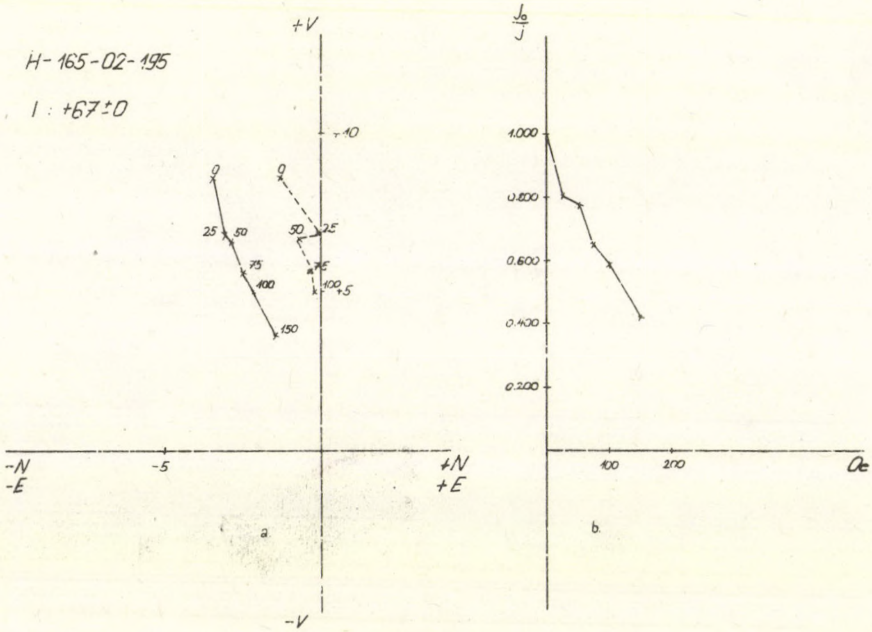


Fig. 7.: Demagnetization graphs of a core sample from Dévavá-nya /H-165-o2-195/

a/ Variation of the vertical component plotted against the eastern/northern component

b/ Demagnetization curve of sample

Legend: V = vertical component; E = eastern component; N = northern component

$\frac{J_o}{J}$ = Ratio of magnetic moments

Inclination for each sample was computed from subsequent measurements of the direction of stable magnetization. Inclinations were grouped into four categories for further evaluation:

A/: Well defined stable inclination:
/N = 2, SD < 2, or N > 2, SD ≤ 1/

B/: Weakly defined stable inclination
/N = 2, 5 $\geq$ SD $\geq$ 2/

C/: No stable inclination, polarity can be identified
/N > 2, SD $\geq$ 5/

D/: No stable inclination, no polarity

/N: number of data used for calculation, SD: standard deviation./

In the evaluation only the data marked A or B were taken into consideration /Fig. 2./.

From the inclination values plotted against depth the intervals of normal and reversed polarity periods were determined. Using the data obtained from the paleomagnetic measurements the polarity changes of the earth's magnetic field, i.e. the boundaries between the paleomagnetic events could be identified in the profile of the borehole. Having compared this profile with the latest paleomagnetic time scale based on the data of ocean floor investigations, we found a very good correlation. Even the short events, as that of the Jaramillo or Olduvai events within the Matuyama reversed epoch, could be detected well. Some inclinations were found to be opposite to the prevailing direction. It can be assumed that these samples may indicate those very short events or excursions which could not be identified perfectly in ocean floor sediments because of the small sedimentation rates. These magnetic excursions can be detected in sedimentary sequences where the deposition was steady with relatively fast sedimentation rate as it had occurred in the Körös Basin. Of course the existence of these short events and excursions should be proved by making other paleomagnetic measurements in this area. Furthermore, these internationally unique results correlated well with the latest paleomagnetic time scale have proved that magnetostratigraphy should be considered as a new and useful method in the further research of the Great Hungarian Plain.

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ALLUVIAL LOESS /INFUSION LOESS/ ON THE GREAT HUNGARIAN PLAIN – ITS LITHOLOGICAL, PEDOLOGICAL, STRATIGRAPHICAL AND PALEOMAGNETIC ANALYSIS IN THE HÓDMEZŐVÁSÁRHELY BRICKYARD EXPOSURES

P. Márton, M. Pécsi, E. Szebényi, M. Wagner

1. Does "infusion loess" originate from eolian dust or from alluvial silt?

More than half of the area of the Great Hungarian Plain in the Middle Danubian Basin is covered by specific loess-like formations. They form an almost continuous cover on the high flood plains of the Danube and particularly of the Tisza river and normally occur a few meters above the present-day flood plain on alluvial plains. These latter were formed by the coalescence of extensive, relatively low, alluvial fans. The present-day surface soils are meadow chernozems, different types of meadow soils, alluvial and alkaline soils. Below the soil profiles of the steppe, or meadow type soils, the 1 - 2 m thick "yellow earth" exhibits loess-like characteristics. In some places it is only o.5 m thick, while in other areas it may reach a thickness of 3 m. In the past few years the brickyards and new building foundations exposed the strata underlying these loess-like formations to a depth of 6 - 1o m. This sedimentary sequence is made up of horizontally layered silt, clay and sand strata occuring alternately, and originated from flood plain, fluvial and from marshy deposits.

Formally the clay pits on the Great Hungarian Plain were mined without machines, generally to a depth of 2 - 3 m. Below the o.5 - 1 m thick soil profile 1.5 - 2 m thick unstratified yellow loess-like sediments were visible. Most experts believed that the material of this loess-like formation accumulated from the eolian dust deposited on the flood-plain by the wind during those climatic phases of the Pleistocene when loess formation was typical.

The genetic interpretation of the loessial deposits on the Great Hungarian Plain was a subject of discussion and of frequent debate among Hungarian specialists during the past hundred years. The different names by which this formation has been referred to, show signs of the controversy: "marshy loess", "water loess", "redeposited loess", "hydroeolite", "infusion loess" /dust that fell on moist flood plains/ alluvial loess silt etc. In 1944 J. Sümeghy classified all eolian deposits as /Alföld loess/ "plain loess" found on the Hungarian plains, particularly in the region east of the Tisza river. However, he distinguished the eolian plain loesses of Pleistocene age from the more clayey plain loesses of the early Holocene. These latter were deposited by floods either on top of the Pleistocene loess, or replaced them.

A study of several loess profiles on the Great Hungarian Plain including the one at Hódmezővásárhely brickyard /M. Pécsi, 1965, 1966, 1967/a, 1967/b/ enabled us to arrive at the conclusion that the widespread "infusion" loess blanket on the plain may be classified in terms of deposition as loess silt; as a result of meadow or chernozem soil formation it has acquired a loess structure by diagenesis to a depth of 1.5 - 2 m.

Many of our colleagues share this view and others had insisted earlier on the fluvial deposition of "infusion loess" albeit by different arguments /J. Sümeghy, 1944; L. Kádár, H. Horusitzky, P. Treitz/. Others are of the opinion that the thin loess blankets on the low interfluves on the left bank of the Tisza river are eolian deposits. Undoubtedly in many places on the low alluvial fan surfaces dunes or dust fields are found near or farther away from the river channels; the last agent of deposition was the wind and <u>in such cases</u> the loess on the sand bars was formed from material of eolian origin.

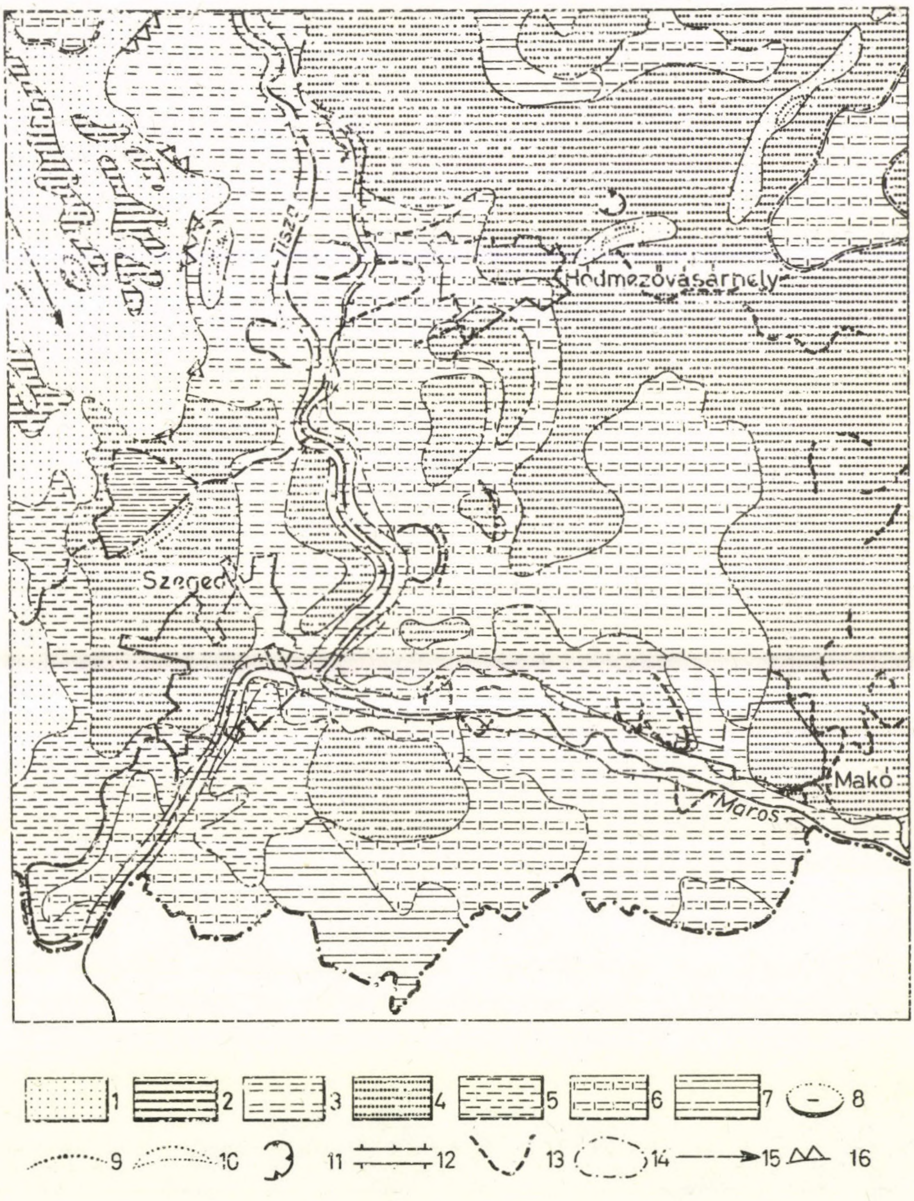
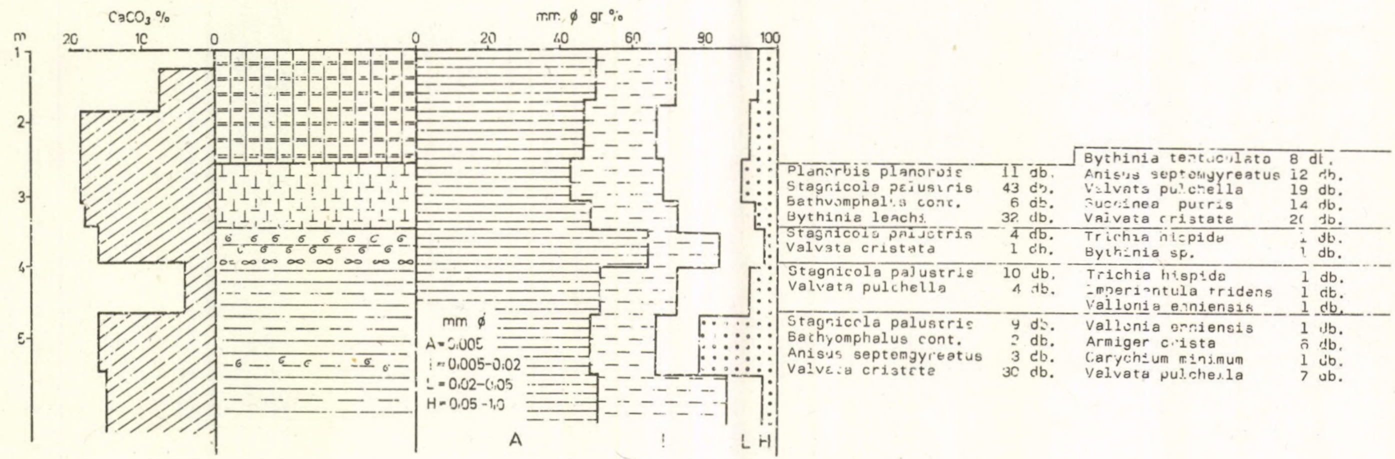


Fig. 1.: Morpholithological position of Hódmezővásárhely and its environs

1 = sand; 2 = calcareous mud; 3 = Holocene alluvial silt; 4 = Pleistocene loess silt; 5 = Holocene alluvial loess silt; 6 = marshy clay, meadow clay; 7 = Holocene alluvial clay; 8 = winddrift, sand hummocks, deflational depression; 9 = blown sand dune; 10 = dune; 11 = loess exposure; 12 = infilling over large areas; 13 = cut-off meander; 14 = isolated small basin, alkaline soil in basin; 15 = Mid-Pleistocene alluvial fan; 16 = inactive steep bluff.



<u>Fig. 2.</u>: Biostratigraphical profile of the Hódmezővásárhely brickyard exposure /1969/

Speculations about the genetic origin of the deposits have a great chronological importance. If the loess-like formations on the left bank of the Tisza in areas east of the river are of eolian origin, then they must be considered theoretically as Upper Pleistocene.

But our lithological, pedological and molluscan analyses /see detailed discussion below/ demonstrated that the "infusion loess" and underlying sediments in the Hódmezővásárhely brickyard accumulated as a result of fluvial, flood-plain, marshy and lake sedimentation in the Upper Würm. Many other exposures in the area exhibit similar stratigraphic sequences.

2. "Infusion loess" in the Hódmezővásárhely exposures

The town is situated on a flood-free surface 1o kms east of the present-day main channel of the Tisza river. The brickyard exposures are found in a flat area between two dry channel branches north of the road linking Hódmezővásárhely and Orosháza /Fig. 1./.

Sandy strata store the ground-water generally at a depth of 6 - 7 m, in the area. The open-cast mines are deeper, and hence the water must be pumped. In abandoned pits water-level rises to 1.5 - 3 m near the surface, at springtime. The lithological profiles of the exposures are depicted on figs. 2., 3., 4. According to these, infusion loess is 1.5 m or 2.5 m thick together with the meadow soil profile. The underlying mainly clayey, silty and sandy strata consist of thinly laminated few cm thick microlayers.

a/ Lithological profile /1969/ of the Hódmezővásárhely brickyard exposures /Fig. 2./

o.oo - o.8o m black, compact meadow soil
o.8o - 1.2o m meadow soil with light coloured krotovinas /burrows/

1.2o - 1.6o m meadow soil, carbonate horizon with light and dark coloured krotovinas
1.6o - 2.5o m pale yellow "infusion loess" with tiny carbonate concretions, krotovinas and shell fragments. It can be clearly distinguished that the unstratified loess-like structure is typical only to a depth to which burrows had penetrated
2.5o - 3.05 m gleyey stratified yellow clay with carbonate content
3.05 - 3.75 m below the caliche horizons rhytmically deposited finely stratified silt and clay layers
3.15 - 4.55 m rhytmically deposited finely laminated few cm thick mostly clay, silt and loess, frequently quartz sand horizons in which aquatic and marsh molluscs are common
4.55 - 5.35 m finely stratified grey silt with mica
5.35 m - the last 1.5 m of the exposure above the base which is sand, was under water at the time it was examined

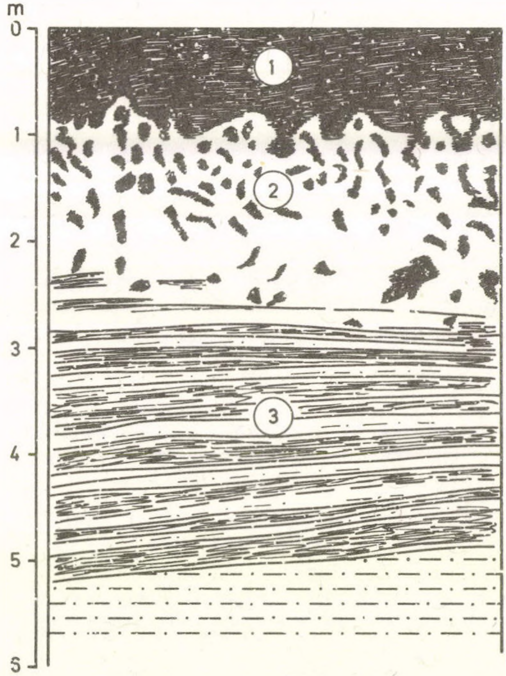


Fig. 3.: Sketch based on photo interpretation /1969/ of the Hódmezővásárhely brickyard exposure meadow soil /1/ infusion loess /2/ the underlying silt-clay strata /3/ and their structure

The even deposition of rhytmically alternating, few cm thick strata in between 2.5o m and 5.35 m in the profile, its grain-size and the presence of aquatic-mash molluscan species seems to suggest that the stratigraphic sequence was deposited in stagnant pools, inland water, or by seasonal floods.

b/ The 1oo m wide cross-section of the 1977 exposure at Hódmezővásárhely revealed a similar profile. However, the alluvial sand strata at the base are situated a few meters lower than in the former profile, hence the section available for brick-making is thicker. We have observed in the various mining pits that the surface of the sand strata containing the water, is uneven.

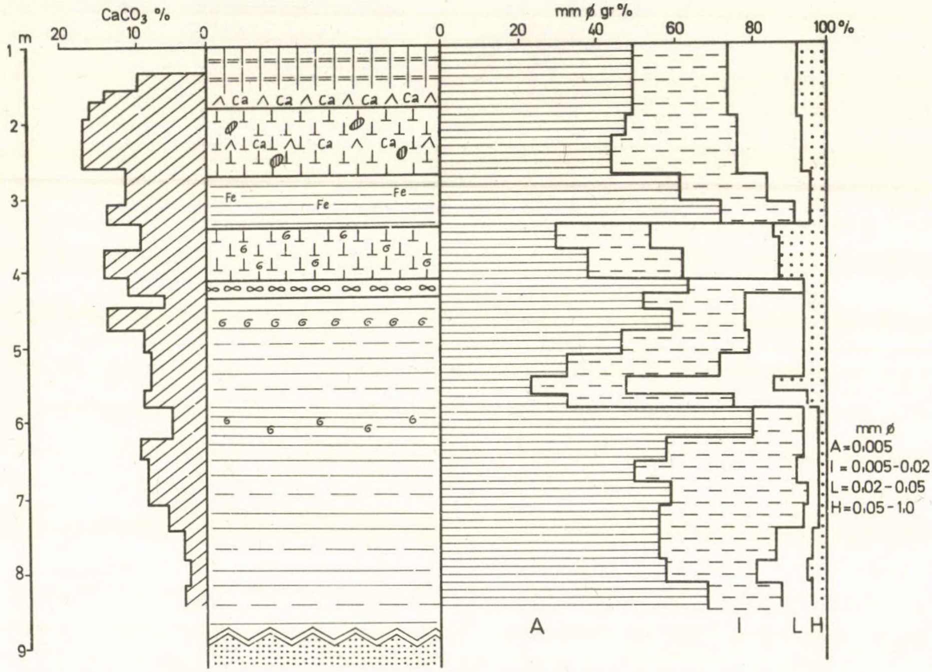


Fig. 4.: Lithological profile of the Hódmezővásárhely brickyard exposure /1977/ /M. Pécsi - E. Szebényi/

Lithological profile /1977/ of the Hódmezővásárhely brickyard exposure /Fig. 4./

o.oo - o.77 m	dark coloured, compact meadow soil very rich in humus aggregates, plant remains, Fe aggregates, shell fragments with small carbonate concentrations at the bottom
o.77 - 1.66 m	yellow, brownish yellow, silty clay with an "infusion loess" structure, small carbonate concentrations, many shell fragments at the bottom
1.66 - 2.32 m	light and dark coloured ochre-grey, gleyey clay, shell fragments carbonate concentrations, Fe and Mg nodules
2.32 - 3.oo m	vareigated sily clay, intensive Fe precipitation at the bottom, very many molluscs, structure slightly similar to "infusion loess"
3.oo - 3.2o m	caliche horizon in gleyey silt
3.2o - 3.72 m	grey, stratified silty clay; at 3.oo m there is a horizon with Mg precipitates-above which there are many marsh molluscs /dominantly stagnicola palustris/Molluscs for radiocarbon analysis were collected from this layer/
3.72 - 4.78 m	rhytmically alternating thin layers /few cms/of silt clay and fine sand; the finely stratified layers are near horizontal, without interruptions
4.78 - 5.12 m	grey, compact gleyey clay with molluscs
5.12 - 6.3o m	variegated gleyey clay, Fe and carbonate concentrations, Fe and Mg nodules, shell fragments
6.3o - 6.72 m	stratified variegated clay with silt layers that contain mica, Fe concentrations and Mg nodules
6.72 - 7.o2 m	dark grey silty clay with Fe spots
7.o2 - 7.32 m	dark yellow clay rich in mica and molluscs
7.32 m	greyish-yellow medium-grained alluvial sand with mica

Cyclic changes in stratification characterize the whole profile.

The exposure is about loo m wide, there is an even horizontal layering of deposits in the profile; it is made up of strata with different colours and granulometric composition. In the 6 - 8 m thick sediment sequence 12 beds could be distinguished overlying the alluvial sand at the base. Although it seems that sedimentation had been uninterrupted, however, the deposition of the various beds may be regarded as a separate partial cycle. These short sedimentation cycles may have lasted a few thousand years and they could be correlated with climatic fluctuations, with consequent changes in humidity and discharge. An increase in discharge not only influences the frequency and duration of floods. The shifting of the channel bed even under similar climatic conditions would result in changes of alluviation e. g. in the type of sediment deposited or its grain-size.

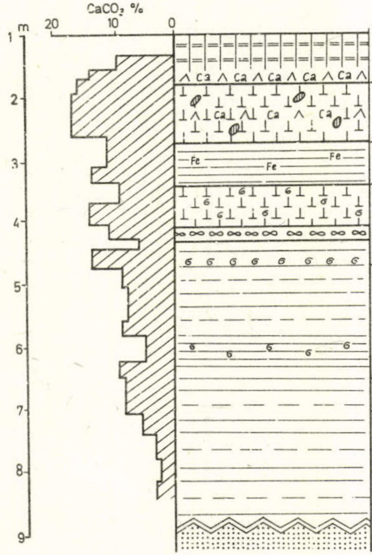
The rate of accumulation of alluvial deposit on the Great Hungarian Plain may be considered according to our observations as 1600 - 2000 years/m, farther away from the channel, flood plain deposition occurs at a slower rate.

3. Molluscan analysis of the Hódmezővásárhely exposure

Continuous sampling was carried out at 1 dm interval. Molluscs were taken from 1 dm^3 samples, in all 3761 specimens were collected from the whole profile. Among the shells many consisted of only broken fragments, most of which were aquatic species. Many of the aquatic specimens were smaller than the normal size indicating an overcrowded living-space for these animals, and a limited extent of the inundation. This fact suggest that the area was only temporarily covered by water and when the water was receeding the size of the molluscs grew smaller just like in the case of recent animals.

Subsequent changes in the ratio of aquatic and terrestrial molluscs is a further proof of periodic inundations. Intermittent flooding of the area accounts for the presence of water molluscs tolerant of variable conditions. These snails thrive in muddy pools, in shallow, stagnent water.

In the lowest layer of the exposure between 7.12 - 6.72 m only aquatic molluscs were found. A 139 specimens of 10 species could be determined /Fig. 5./.



Trichia hispida	3 db.	Succinea putris	1 db.				
Abida frumentum	1 db.	Stagnicola palustris	2 db.				
Chondrula tridens	10 db.	Anisus septemgyreatus	1 db.				
Arianta arbustorum	3 db.	Bythinia leachi	6 db.				
Arianta arbustorum	1 db.	Succinea csucs	1 db.	Segmentina nitida	1 db.	Cincinnea pulchella	1 db.
Succinea putris	1 db.	Anisus septemgyreatus	3 db.	Vallonia sp.	4 db.	Planorbis planorbis	9 db.
Cincinnea piscina-		Succinea oblonga	6 db.	Vertigo sp.	1 db.	Bythinia leachi	42 db.
lis	2 db.	Stagnicola palustris	7 db.	Succinea pfeifferi	10 db.		
Trichia hispida	4 db.	Anisus septemgyreatus	10 db.	Cochlicopa lubrica	3 db.	Pupilia sp.	12 db.
Cincinnea pulchella	3 db.	Succinea oblonga	59 db.	Succinea pfeifferi	4 db.	Stagnicola palustris	8 db.
Vertigo sp.	3 db.	Cincinnea piscinalis	2 db.	Vallonia sp.	19 db.	Planorbis planorbis	4 db.
Succinea pfeifferi	454 db.	Armiger crista	167 db.	Pisidium obtusale	380 db.	Succinea csucs	1 db.
Stagnicola palust-		Physa fontinalis	9 db.	Bythinia leachi	17 db.	Vallonia sp.	43 db.
ris	391 db.	Bathyomphalus cont.	3 db.	Cincinnea piscinal.	41 db.	Vertigo sp.	1 db.
Planorbis planor-		Cincinnea pulchella	322 db.	Anisus septem.	128 db.	Segmentina nitida	203 db.
bis	151 db.	Planorbis corneus	33 db.	Succinea csucs	34 db.	Radix peregra	12 dh.
Bathyomphalus cont.	253 db.	Bythinia leachi	706 db.	Aplexa hypnorum	14 db.		
Trichia hispida	1 db.	Arianta arbustorum	1 db.				
Succinea pfeifferi	1 db.	Succinea putris	3 db.				
Stagnicola palustris	3 db.	Anisus septem.	1 db.				
Vertigo sp.	1 db.	Bathyomphalus cont.	1 db.				
Succinea csucs	1 db.	Bythinia leachi	8 db.				
Succinea pfeifferi	3 db.	Stagnicola palustris	3 db.	Succinea csucs	18 db.		
Cincinnea pulchella	10 db.	Cincinnea piscinalis	6 db.	Cochlicopa lubrica	1 db.		
Succinea pfeifferi	3 db.	Stagnicola plaustris	8 db.	Segmentina nitida	20 db.		
Cincinnea pulchella	21 db.	Planorbis planorbis	43 db.	Bythinia leachi	30 db.		
Planorbis corneus	2 db.	Anisus septem.	4 db.	Armiger crista	7 db.		
Aplexa hypnorum	1 db.						

<u>Fig. 5.</u>: Biostratigraphical profile of the Hódmezővásárhely brickyard exposure /1977/. /M. Wágner/

In the overlying strata, from 6.72 - 5.4o m, the predominance of aquatic molluscs is also characteristic, however, both the number of species and genera decreases.

Still fewer molluscs were found in the next layer between 5,4o - 3.72 m, where only 21 specimen of 1o species were discovered.

The layer between 3.72 - 2.32 m is exceptionally rich in molluscan fauna and 91 per cent of all molluscs from the whole exposure were taken from this layer. Seventeen species were found here. Undoubtedly it was during this time that the inundation of the area lasted for the longest period.

A period of marked regression followed and the area was no longer covered by open waters. The infusion loesses were formed during this time. Eighty per cent of the molluscs in the strata between 2,32 - 1,87 m were terrestrial species, Succinea oblonga being the most common. These animals prefer moist grasslands, fresh green meadows.

In the layer from 1,87 - o,97 m the predominance of water molluscs is once more noticeable, here 8o per cent of the molluscs were aquatic species. The remaining 2o per cent are terrestrial molluscs, but these were probably washed into the deposits from elsewhere.

Among the terrestrial snails thermophilous species /Chondrula tridens/ dominate in the meadow soil from o,97 - o,o m.

Characteristic changes in the ratio of aquatic and terrestrial molluscs in the profile are depicted on fig. 6.

4. Paleomagnetic analysis of the Hódmezővásárhely brickyard exposure /1977/

The purpose of the paleomagnetic study of the exposure was to find the Laschamp event. Forty samples were collected, one from each at 15 - 2o cm interval. One specimen from each

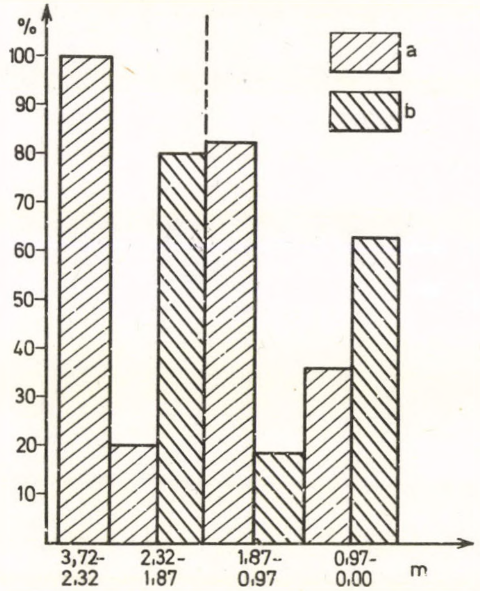


Fig. 6.: Changes in the ratio of aquatic /a/ and terrestrial /b/ fauna in the Hódmezővásárhely brickyard exposure /1977/ /M. Wágner/

sample was progressively demagnetized in alternating fields /AF/. The stable component of magnetization could be isolated at AF amplitudes between 100 - 150 and 500 Oe. The second specimen of the sample was cleaned in one step only at 250 or 300 Oe. Apart from the topmost sample the stable magnetic component of each pair of specimens proved to be consistent.

The results of measurements are summarised on Fig. 7. The first column shows the depth, the second column lists sample codes. The declination /D/ and inclination /I/of stable magnetization are shown each with their confidence interval

$\sqrt{I}\ dD = \dfrac{\alpha_{95}}{\cos I}$ where α_{95} is Fisher's radius of confidence the parameter of reliability. $4\,I_{300}$ /nT/ is four times the value of intensity after demagnetization at 3oooo e.N indicates the number of measurements used to determine the stable magnetic direction.

The first number of this column indicates the number of determinations from the first, and second specimen, respectively. /0+/ marks that the NRM of the second specimen is consistent with the isolated stable magnetization of the first.

The next columns show /four times/ the value of average NRM intensity in nT units, magnetic susceptibility in SI units, the Königsberger ratio /Q/ and the ratio of the stable component to NRM, respectively $/I_{300}/I_{NRM}/$.

The paleomagnetic data on Table 1 are illustrated for easier reference on the paleomagnetic profile of the exposure /Fig. 7./. The length of horizontal bars indicate on the respective scale, the confidence of declination and inclination.

Fig. 8. illustrates the directions of stable magnetization on a stereographic projection. O marks the only reversed magnetic direction encountered. The mean direction of magnetization /x/ is $D = 347.75^{\circ}$ $I = 54.83^{\circ}$ with statistical parameters /Fisher, 1953/ $k = 12.9$ and $\alpha_{95} = 6.9^{\circ}$ where k is the precision and α_{95} is the radius of confidence circle.

The rate of deposition of the sediments has been given as o.5 - o.7 m/looo years. If it is correct to assume that the stable magnetization is primary i. e. it is of depositional origin in a broader sence, then a thousand two thousand year long polarity event should be represented in at least 3 - 8 samples. A small positive inclination was detected at a depth of 3 m and there was a small negative inclination at 5 m surrounded by moderately reduced positive inclinations, but all declinations were normal /Fig. 7./.

Hence neither of these two anomalous inclinations /at 3 m and 5 m respectively/ can be regarded as inclinations of polarity events.

The minimum C^{14} age of the Laschamp event is 873o years B. P., while its maximum K-Ar age was determined as 2o ooo years B. P. /Bonhommer, Zahringer, 1969/. Denham and Cox

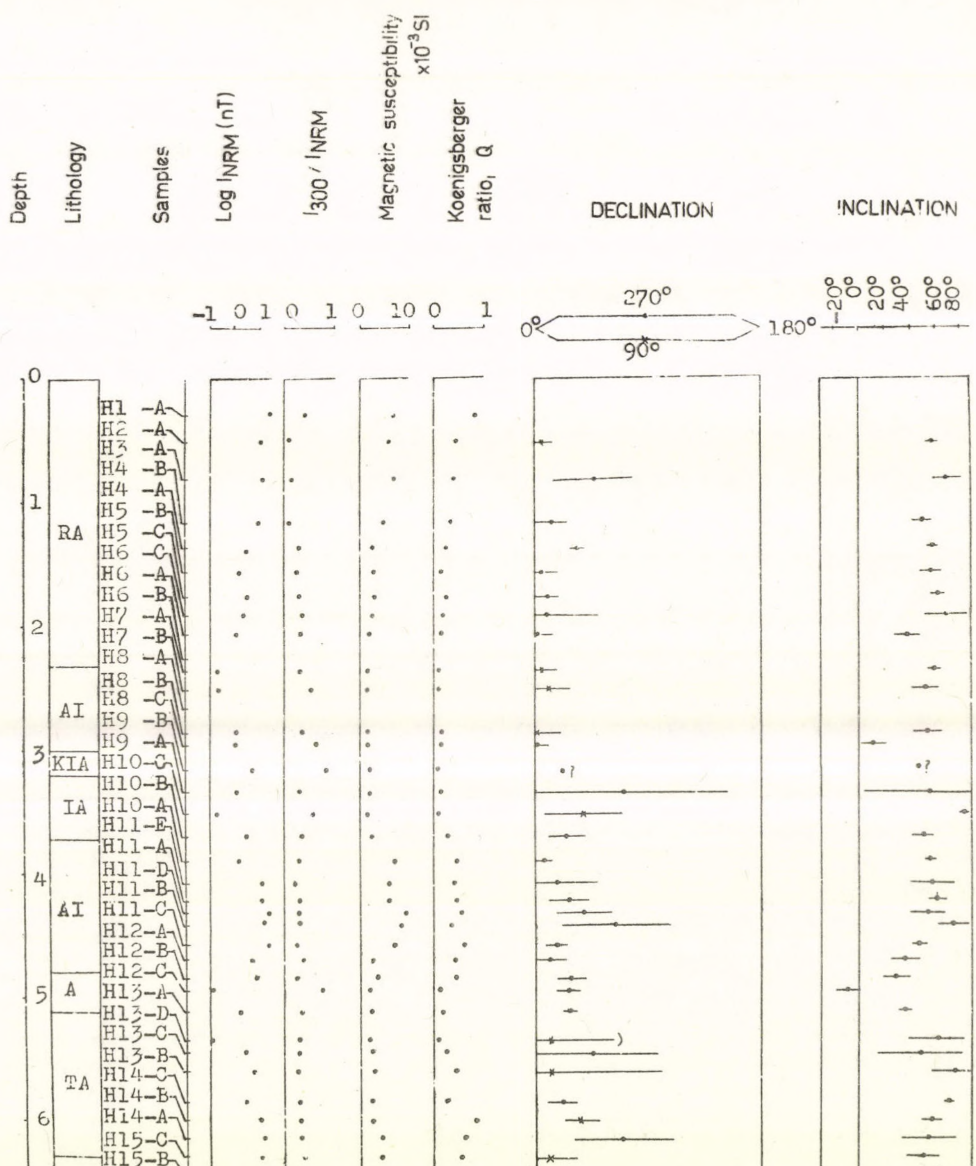


Fig. 7.: Paleomagnetic profile of the Hódmezővásárhely brick-yard exposure

RA = meadow clay; AI = clayey silt; KIA = silty clay with concretions; IA = silty clay; A = clay; TA = variegated clay; I = silt.

Table 1. Results of paleomagnetic measurements at Hódmezővásárhely /1979/

Depth m	Sample code	Characteristics of stable magnetization							$4I_{NRM}$ /nT/	$\varkappa\,10^{-6}$ /SI/	Q	$\frac{I_{300}}{I_{NRM}}$
		$\bar{D}^o$	$\bar{I}^o$	k	dD	dI	$4I_{300}$ /nT/	N				
0.30	H1 – A	Unstable					3.9		110.0	684	0.80	0.04
0.52	H2 – A	4.28	56.61	756.7	8.2	4.5	4.2	3 + 0	49.0	570	0.42	0.09
0.82	H3 – A	312.96	68.93	38.3	34.8	12.5	6.4	4 + 1	53.5	691	0.38	0.12
1.17	H4 – B	347.20	48.75	186.3	10.3	6.8	2.5	4 + 0/+/	32.0	489	0.32	0.08
1.37	H4 – A	327.74	57.04	789.5	6.1	3.3	3.0	3 + 1	11.2	249	0.22	0.27
1.57	H5 – B	355.81	56.20	223.2	11.1	6.2	1.3	3 + 1	5.7	251	0.11	0.23
1.77	H5 – C	350.67	61.35	399.5	7.9	3.8	3.4	4 + 1	12.7	276	0.23	0.27
1.92	H6 – C	351.97	68.73	38.3	41.3	15.0	2.7	3 + 1	8.4	249	0.16	0.32
2.07	H6 – A	358.79	37.65	82.1	12.9	10.2	1.4	3 + 1	4.6	187	0.12	0.30
2.27	H6 – B											
2.37	H7 – A	5.36	59.85	284.9	11.0	5.5	0.7	4 + 0	2.4	134	0.08	0.29
2.52	H7 – B	11.25	51.67	55.5	16.8	10.4	1.0	4 + 1	2.0	119	0.08	0.50
2.67	H8 – A											
2.87	H8 – B	1.68	53.92	79.8	17.7	10.4	1.4	3 + 1	4.1	144	0.14	0.34
2.97	H8 – C	359.09	10.36	123.5	8.4	8.3	2.4	3 + 1	4.0	149	0.13	0.60
3.17	H9 – B	338.40	45.40				2.0	0 + 1	2.0	182	0.05	0.80
3.35	H9 – A	288.42	54.63	7.6	83.1	48.1	1.2	2 + 1	4.4	197	0.11	0.27
3.52	H10– C	39.58	83.52	1070.3	33.7	3.8	1.3	3 + 0/+/	2.4	137	0.08	0.54
3.71	H10– B	334.47	48.98	43.0	14.2	9.3	3.4	6 + 1	10.6	211	0.25	0.32
3.90	H10– A	352.95	55.25	401.1	5.3	3.0	15.1	6 + 1	56.5	668	0.42	0.27
4.08	H11– E	343.47	57.88	53.4	32.0	17.0	9.0	2 + 1	45.9	599	0.38	0.20
4.22	H11– A	332.69	60.89	146.5	15.6	7.6	15.0	3 + 1	49.2	570	0.43	0.30
4.32	H11– D	321.61	53.20	84.6	22.5	13.5	24.5	2 + 1	92.6	901	0.51	0.26
4.42	H11– B	295.27	74.08	59.2	43.7	12.0	15.0	3 + 1	52.3	803	0.32	0.29
4.58	H11– C	342.51	47.78	132.3	8.8	5.9	18.6	5 + 1	80.9	685	0.59	0.23
4.70	H12– A	348.88	36.32	73.1	13.4	10.8	6.6	3 + 1	18.3	227	0.40	0.36
4.85	H12– B	330.75	29.44	80.4	11.8	10.3	6.7	3 + 1	28.2	325	0.43	0.24
4.95	H12– C	333.97 –	8.42	206.9	8.7	8.6	3.4	2 + 1	3.5	167	0.10	0.74
5.12	H13– A	332.60	37.20		4.0	3.2	2.0	2 + 0/+/	6.3	205	0.15	0.32
5.35	H13– D	13.34	62.25	32.2	47.2	22.0	0.9	2 + 1	3.2	194	0.08	0.28
5.45	H13– C	313.78	48.21	8.4	50.7	33.8	2.8	3 + 1	9.9	231	0.21	0.28
5.60	H13– B	13.65	77.29	21.5	92.3	20.3	5.9	3 + 1	23.5	279	0.42	0.25
5.85	H14– C	338.96	71.69	766.1	10.5	3.3	3.0	3 + 1	10.5	219	0.23	0.29
6.00	H14– B	36.09	56.81	156.2	13.5	7.4	12.1	3 + 1	39.7	243	0.81	0.30
6.15	H14– A	289.21	55.71	32.8	38.9	21.9	17.3	2 + 1	53.5	442	0.60	0.32
6.30	H15– C	12.50	50.81	50.9	20.6	13.0	16.5	3 + 1	43.4	407	0.53	0.38
6.45	H15– B	9.83	61.92	444.4	9.3	4.4	10.2	3 + 1	40.1	357	0.56	0.25
6.60	H15– A	10.71	41.15		66.7	50.2	1.1	1 + 1	3.0	167	0.08	0.37
6.75	H16– B	18.71	50.20		22.8	14.6	1.2	1 + 1	2.0	181	0.05	0.60
6.90	H16– A	39.39	43.10	5208.0	2.3	1.7	1.1	3 + 0/+/	3.3	192	0.08	0.33

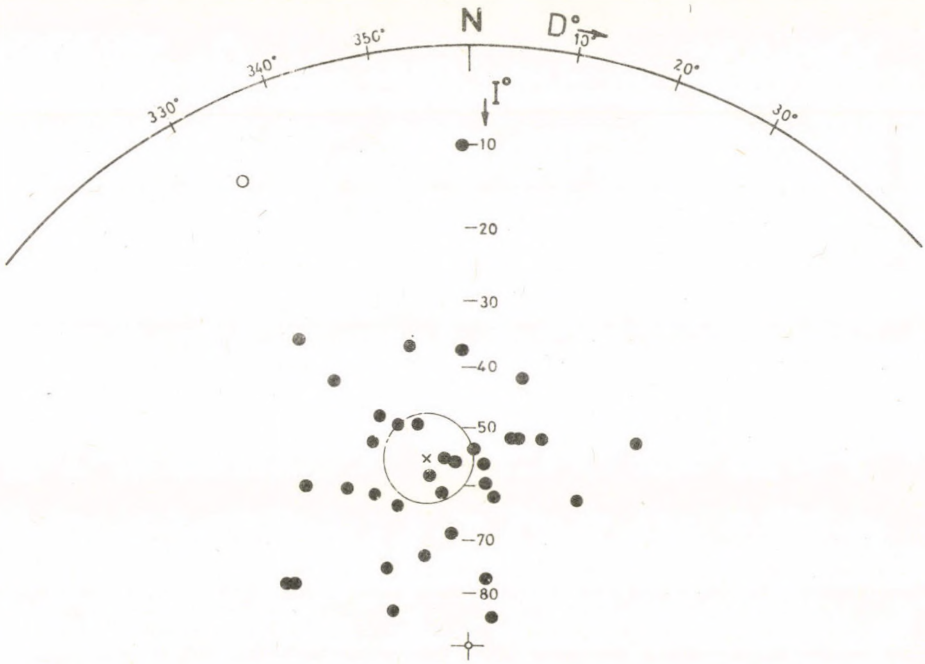
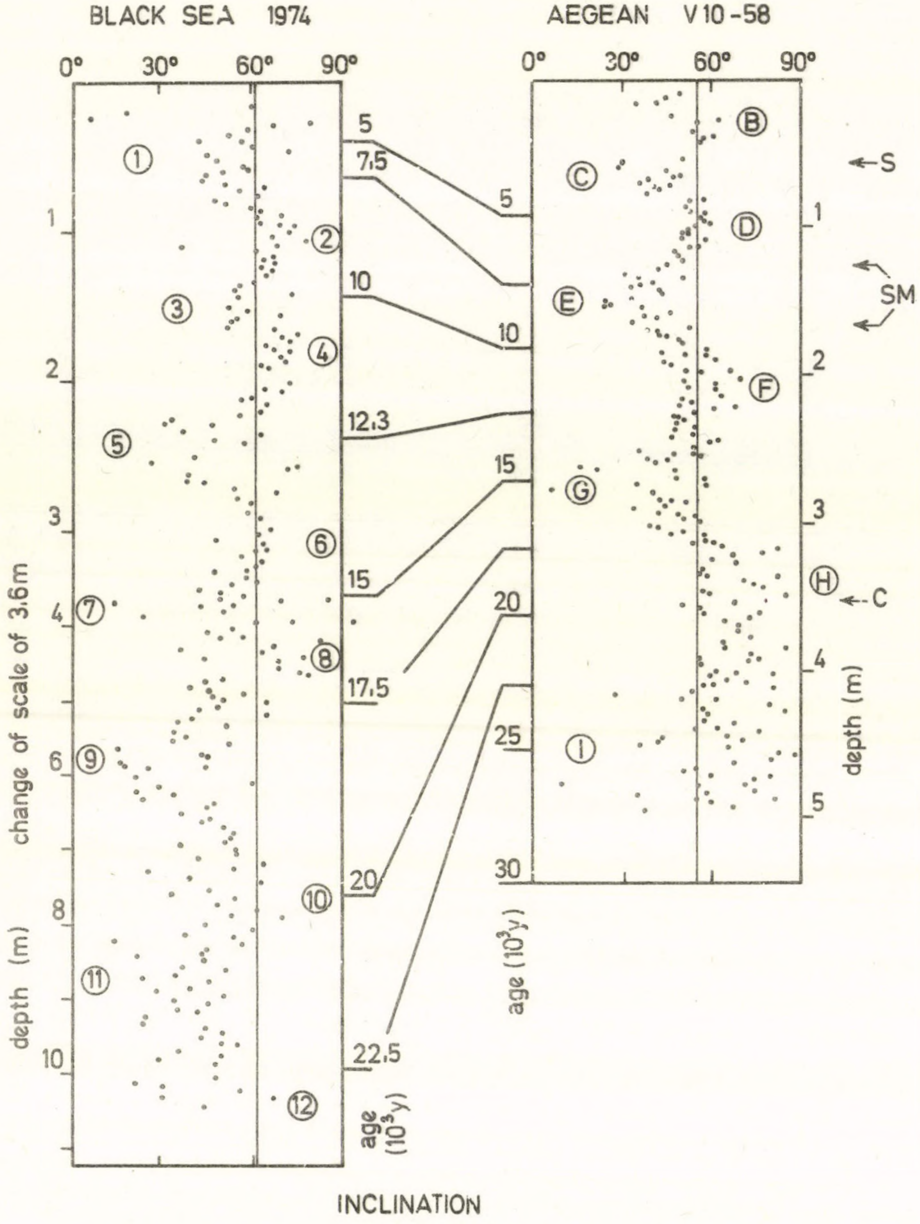


Fig. 8.: Stereographic projection showing the directions of stable magnetization in the Hódmezővásárhely brickyard /1979/ /P. Márton/

/1971/ have demonstrated by the paleomagnetic analysis of lake sediments /Lake Mono, California/ dated by C^{14} method that if the Laschamp event had occurred before 13 3oo B. P. then it must have lasted for less than 17oo years. Yaskawa et al/1973/ have found anomalous magnetic direction in the Lake Biwa sediments which they estimated as 18 ooo years old. In deep sea cores from the Gulf of Mexico an anomalous magnetic direction was detected between 12 5oo - 17 ooo years /Clark and Kenneth, 1973/. Negative inclinations were measured in 12 5oo year old sediments from two small Canadian lakes /Mott and Foster,1973/. The anomalous magnetic direction in the Lake Erie sediments is younger than 14 ooo years /Creer, 1976/.



<u>Fig. 9.</u>: Inclination plots of a Black Sea core /Creer, 1974/ and an Aegean Sea core /Opdyke et al., 1972/

Fig. 9. shows inclination plots of a Black Sea core /Creer, 1974/ and an Aegean Sea core /Opdyke et al., 1972; Creer, 1974/. In the above two cores negative inclinations were not recorded anywhere, and inclination changes were interpreted as secular variation in the earth's magnetic field /Creer, 1974/.

Changes of inclinations below 3.5 m in the Hódmezővásárhely profile may also be caused by secular variation of the earth's magnetic field, but this is still to be proved.

5. The age and origin of "infusion loess" or alluvial loess silt on the Great Hungarian Plain

The undisturbed deposition of stratigraphic sequences in the Hódmezővásárhely exposures seemed to be suitable for paleomagnetic analysis, and hence for the determination of the absolute age of the sediments.

The location, position and structure of "infusion loess" in relation to the underlying deposits has been studied in several brickyard exposures on the Great Hungarian Plain east of the Tisza river. Lithological and loess stratigraphical analysis of several exposures were completed /Martfü, Törökszentmiklós, Kunszentmárton, Mártély/ and enough molluscs were collected for radiocarbon analysis. We had been looking for evidence to confirm the supposition that the "infusion loesses" /alluvial loess silts/ were of Upper Pleistocene age.

A Koch's /19oo/ classification of fossil vertebrate remains was reexamined by H. Horositzky /19o6/. Horositzky classified the large mammals as diluvian /Pleistocene/ which were found during the excavation and regulation of the Tisza river.

Recently M. Kretzói /1978/ outlined former ecological conditions on the basis of upper Pleistocene large mammals and their faunal assemblages in the Carpathian Basin.

The paleomagnetic polarity of "infusion loesses" of the "Middle Tisza" valley had been studied by M. A. Pevzner in two brickyard exposures /Martfü and Törökszentmiklós/. All samples showed normal polarity /M. Pécsi - M. A. Pevzner - E. Szebényi, 1979/ and no traces of the Laschamp event /8 - 2o ooo years B. P./ had been found in these deposits.

During a detailed examination of the brickyard exposures on the Great Hungarian Plain east of the Tisza river signs of genuine cryoturbation features were only found in Hódmezővásárhely and Martfü /M. Pécsi, 1966/. In the majority of the exposures indications of permafrost deformations from the last glacial stage were absent.

Cryoturbation features were also not found in the deposits on the Danube flood plain in the Little Hungarian Plain and on the Great Hungarian Plain. The "infusion loesses" on the Danube flood plain are mostly of Holocene age. Further evidence was provided by the discovery of archeological finds and Holocene tree trunks in the alluvial sand and gravel underlying the alluvial loess silts in the Danube valley /M.Pécsi, 1957, 1959/.

In the past few years many Holocene tree-trunks were recovered from alluvial gravel of the Danube in Austria and Germany and they were determined as 4oo - 1o ooo years old /A. Becker, J. A. Fink/. In view of these facts in the Vienna Basin most of the Prater terrace of the Danube and its alluvial loess silt cover which was formally dated as Würm glacial formations should now be considered as dating from the Holocene /J. Fink, 1978/.

Aerial photographs of the Great Hungarian Plain east of the Tisza river revealed that the Holocene channels of the rivers migrated over the whole area and reworked the former deposits and covered them with younger alluvium.

There are some smaller and larger areas on these extensive plains which had not been overlain by Holocene alluvial loess silt and the "plain loess" or "infusion loess" of Upper Pleistocene /Würmian/ age is still on the surface.

From the Hódmezővásárhely brickyard exposure /1977, Fig. 4./ 2oo gr of molluscs were collected from the grey silty clay layer situated at 3.2o - 3.72 m. According to the analysis of the Radiocarbon Dating Laboratory, University of Helsinki these molluscs were 24 13o±46o years old[1]. The radiocarbon age of molluscs collected from a silt layer situated at 2.2o - 2.6o m in the Törökszentmiklós brickyard exposure, was 2o 1oo±3oo B. P.[2]. This latter exposure is in a similar geological and geomorphological position like the Hódmezővásárhely profile.

On the basis of these radiocarbon dates and supposing that the rate of sedimentation had been around 2ooo years/m we may conclude that the deposition of the material of the infusion loesses probably occurred 18 - 2o ooo years B. P. Should our chronological conclusions prove correct, it would then provide an explanation for the absence of the Laschamp event. However, it is still possible that the Laschamp event occurred later, and the sediment sequence in the profile is older?

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[1] Hel - 12o3 Hódmezővásárhely 24 13o±46o Y B. P. 0. ^{13}C-8.o per cent 0

[2] Hel - 12o4 Törökszentmiklós 2o 1oo±33o Y B.P. ^{13}C-9.5 per cent 0

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LITHOLOGICAL, PEDOLOGICAL, STRATIGRAPHICAL AND PALEOMAGNETIC ANALYSIS OF THE LOESS PROFILES AT PAKS

M. Pécsi - E. Szebényi - M. A. Pevzner - Gy. Hahn - D. Hock - Gy. Scheuer - F. Schweitzer

Probably the most complete profiles of Pleistocene loess in Hungary are displayed in the profile at Paks birckyard and this may be true for the Middle Danubian Basin as a whole[x] . Since the 193o-s many Hungarian and foreign researchers of the Quaternary had studied these profiles and drew their conclusions /see references/. The various profiles described by the authors show more similarities than differences. Dissimilarities of description partly stem from the fact that profiles were taken at different locations and each author presented his own ideas about the genetic interpretation of lithological formations of the stratigraphic sequences. In brief, the loess profiles at Paks contain glacial loess bands or sequences that were most likely deposited by eolian and derasional slope processes. These are interrupted by various types of fossil soil formations and fluvial sands which were formed during the interglacials or interstadials. The loess series are 5o - 55 m thick at the most, while below, there is a 3o - 4o m thick sedimentary sequence of silty, sandy clay, clay and sand layers interlayered with red soils and red clays.

The latest profile we have analysed which included the exposure at Paks brickyard and a borehole drilled at the foot of the exposure enabled us to register 12 loess and 2 sand layers, and 12 - 13 buried fossil soils /Fig. 1./. This does not include the few poorly developed humus horizons and embrionic soil formations of the profile

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[x] The Danube River had eroded the Mezőföld loess plateau into a steep bluff between Dunakömlőd and Paks /1o5-1o8 kms south of Budapest/.

In the northern extension of the Paks loess wall on the level of the high flood-plain of the Danube near the village of Dunakömlőd and along the main road, a borehole was drilled at the foot of the loess bluff. The 4o m deep bore revealed the presence of further 6 red fossil soils interbedded with Pleistocene silt layers. Thus the 8o - 9o m thick Pleistocene stratigraphic sequence consists of a 5o - 55 m thick loess series while below, the silty, clayey deposits are 35 - 4o m thick. The whole profile contains 18 fossil soils altogether.

On the basis of detailed lithological, pedological, paleonthological and paleomagnetic analyses we have subdivided the stratigraphic sequence of the Paks loess bluff into four units.

1. The 8 - 1o m thick youngest loess of Paks
/The Dunaujváros - Tápiósüly Loess Complex/

This loess complex consists of stratified and unstratified loosely consolidated loess and sandy loess layers interbedded with only two pale embrionic humus soil horizons /loess serozem/. The stratified loess and sandy loess layers in most cases infill dell-like /derasional/ valleys and in the layers between 7 - 8 meters a large number of decayed bone fragments have been discovered. Fragments of reindeer shovels have often been found together with charcoal remains at this level in the Paks profile and in other Hungarian loess sections.

The age of charcoal remains was determined by the radiocarbon method in Tápiósüly 16,75o±4oo years B.P. in Dunaujváros it was 2o,52o±29o years B.P. The Dunaujváros-Tápiósüly Loess Complex is 1o meter thick at Paks. It may be stated that the deposition of the whole sequence occured between 25 and 1o thousand years B. P. Based on additional correlative analyses we may conclude that the loess complex is younger than 25 thousand years. /M. Pécsi ,1975; M. Pécsi - Mrs. M. Pécsi, É. Donáth - E. Szebényi - Gy. Hahn - F. Schweitzer - M. A. Pevzner, 1977./

other calculations seem to indicate that the forest steppe soils of the "Basaharc-Double" Soil Complex developed 4o - 45 thousand years ago /M. Pécsi 1975/.

The "Basaharc-Base" Soil /BA/ is a dark coloured remarkably well developed fossil soil in the young loess at Paks. It is nearly 2 m thick /between 22-24 m; Fig. 1./; it has a compact structure with normal carbonate content. The dark-brown chernozem type soil shows signs of former intensive biological activity. This latter soil together with the other two fossil soils MF and BD developed during the warmer interval of the last glacial /W/. The BA fossil soil had been formed about 65 - 7o thousand years B. P.

- Reddish brown forest soil at the base of the young loess sequence in the Paks loess profile

The "Mende-Base" Soil Complex is a very well developed fossil soil in the Paks profile between 27 - 29 m /Fig. 1./. Vertebrate[x] and molluscan fauna of the last glacial period was collected from the 25 m thick young loess series. The lithostratigraphical and morphological position of the "Mende-Base" Soil Complex was correlated with river terraces and on the basis of available evidence we have classified these soils as formations of the last interglacial period /Gy. Hahn, 1976; M. Pécsi, 1965. 1975/. They probably developed under warmer and more humid submediterranean climatic conditions 11o - 12o thousandyears ago.

3. The old loess of the Paks profile /Paks Loess Complex/

The old loess sequence has a more compact structure than

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[x] Coelodonta antiquitatis Eguus sp. /Würm type/, Elephas sp., Cervus sp., Bos or Bison sp., Rangifer tarandus, Leo spelus /determined by Dr. M. Kretzoi/.

the young loess. It is characterized by several horizons with large calcium carbonate concentrations /loess dolls/. The intercalated sandy strata usually indicate erosional unconformities. The old loess at Paks may be subdivided into two distinct units;

- The upper part of the Paks Loess Complex /Fig. 1.//between 29 - 38 m 11o - 118 m a.s.l./ consists of two old loess layers, two alluvial sandy strata, a poorly developed fossil forest soil horizon and a hydromorph marshy forest soil. These formations may be observed along the whole length of the exposure in a nearly horizontal bedding. In the southern part of the exposure the sandy strata attain greater thickness.

In the sandy layers and marshy soils of the upper part of the Paks Loess Complex fresh-water molluscan fauna, fragments of Elephas trogonterii's teeth and tusks and molars of Allohippus fauna, characteristic of the Biharium stage, had been found. We consider the sandy layer at the base of the upper part of the Paks Loess Complex as a Mindel-Riss interglacial formation /L. Ádám - S. Marosi - J. Szilárd, 1954/.

- The lower part of the Paks Loess Complex /Fig. 1.; 38 - 52 m, 96 - 1o9 m a.s.l./ is made up of three old loess layers and three reddish coloured fossil brown forest soils. At the foot of the exposure in the Paks profile two remarkably well developed reddish-brown fossil soils, the so called "Paks-Lower" Double Soil Complex /PD/ may be observed. The Brunhes-Matuyama paleomagnetic boundary /o.69 million years/ was discovered in the underlying loess strata /M. Pécsi - M.A. Pevzner, 1974/. Repeated analyses revealed that this paleomagnetic boundary can be located at the same level both in the Paks profile and in the profile near Dunakömlőd. It means that the 44 m thick loess sequence of the Paks exposure developed during the Brunhes normal paleomagnetic epoch in the last o.69 million years /M. Pécsi - M.A. Pevzner, 1974 and P. Márton, 1979/.

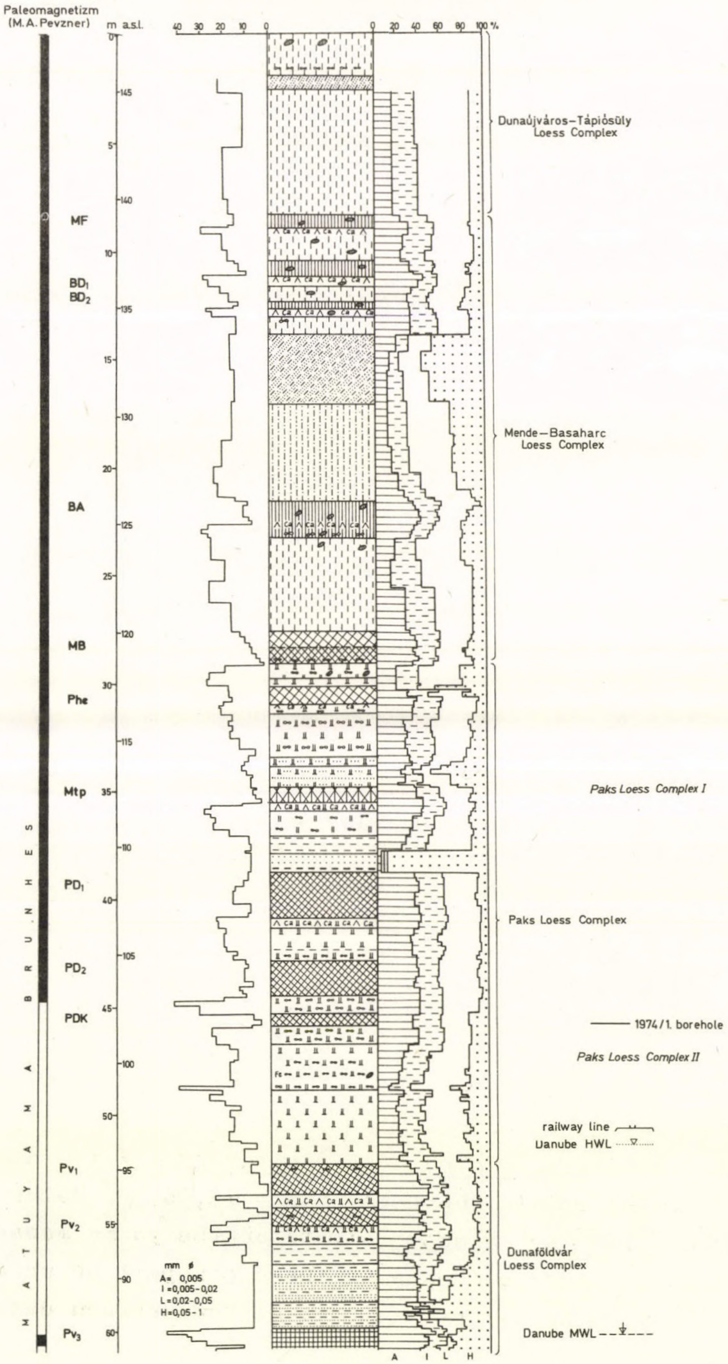


Fig. 1. Loess profile of Paks /1977/ together with the 1974/1 borehole profile /M. Pécsi - E. Szebényi/

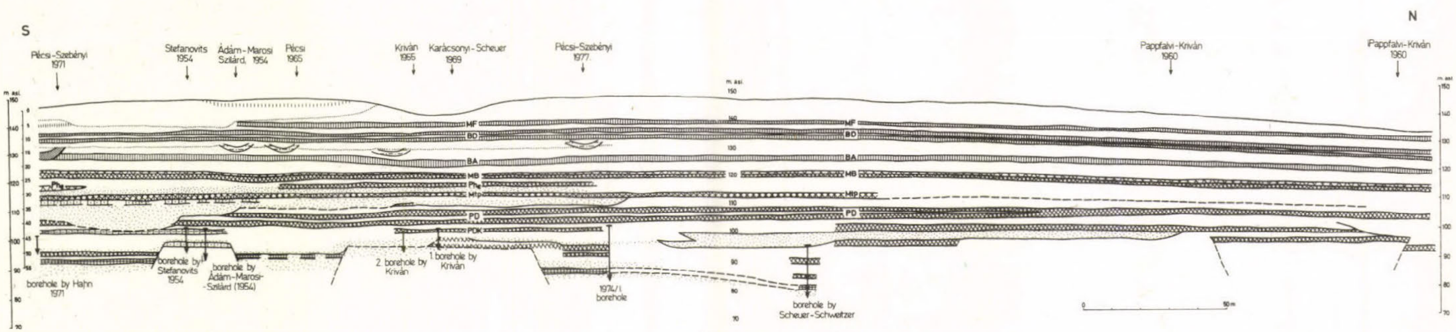
2. The loess series between 1o - 3o meters in the Paks profile
/The Mende-Basaharc Loess Complex/

This section of the profile together with the overlying 1o m thick youngest loess complex has been classified as the young loess in the Carpathian Basin by B. Bulla /1937-38/and others. The stratigraphical sequence of the young loess may be considered more or less complete, although we have discovered some changes even within the 2o m long section at Paks brickyard, mostly erosional-derasional hiatuses and buried derasional valleys /Fig. 2., 3./.

We have named this 2o m thick young loess section as the Mende-Basaharc Loess Complex which is interrupted by three typical forest steppe soil complexes. These fossil soils are similarly well developed in several other profiles of young loess in Hungary and they have been named after the fossil soil horizons first described at the Mende and Basaharc type profiles. In the bottom of this loess complex there is a well developed brown forest soil horizon which we call the "Mende Base" Soil Complex after the type profile at Mende /M. Pécsi 1965/.

- In the loess profile at Paks brickyard only the upper part of the "Mende-Upper" Soil Complex /MF_1/is present /between 8.4 - 9.3 m, Fig. 1./. In the profile at Mende this layer contains charcoals and a radiocarbon analysis of these revealed that the fossil soil developed probably 27 - 29 thousand years ago /M. Pécsi, 1966, 1975/.

- The "Basaharc-Double" Soil Complex /B D. / is well developed in this profile /between 1o,5 - 13,9o m/. Below this soil complex lies the thickest strata of the young loess. It is an 8 m thick loess sequence in the upper part of which derasional sandy loess layers are common. Radiocarbon data and



<u>Fig. 2.</u> Geological section of the Paks loess exposure /constructed by M. Pécsi/. Exposures and boreholes studied by different authors are also indicated.

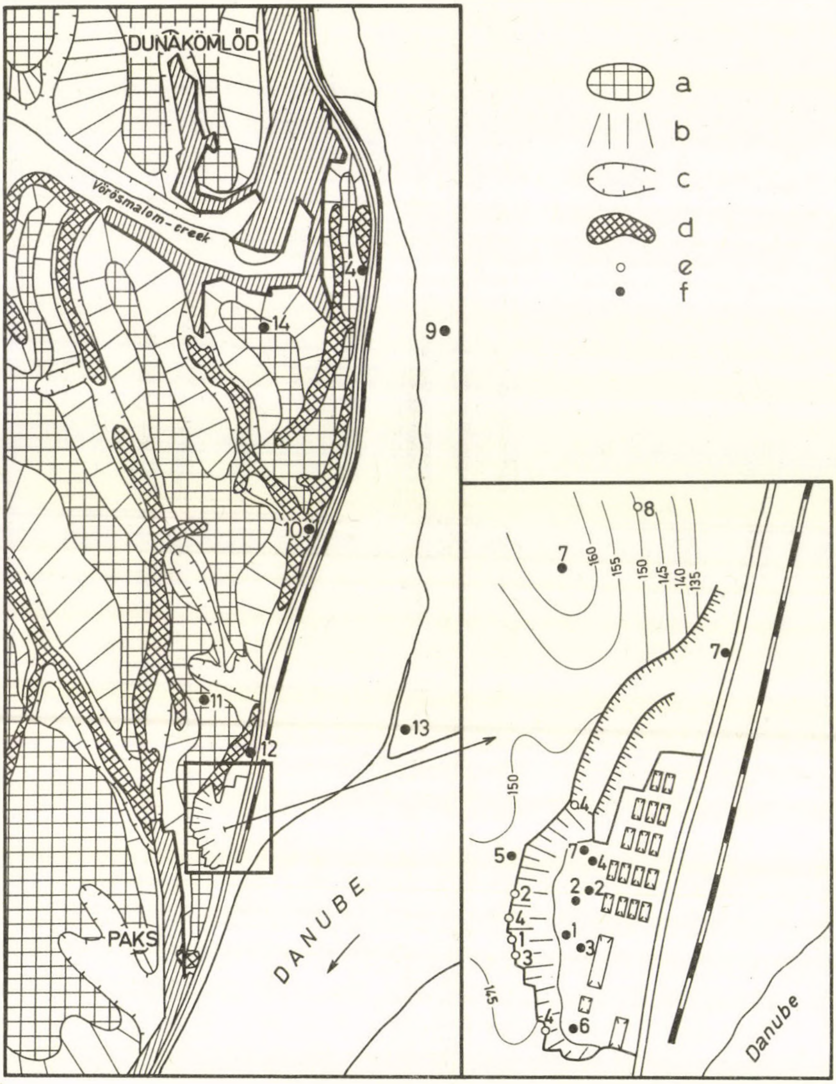


Fig. 3. Location of profiles and bores around Paks is illustrated on a sketch map - a=loess hill; b=slopes; c=valleys; d=natural exposures; e=profile; f=soil mechanical borehole; 1-L. Ádám, S. Marosi, J. Szilárd 1954; 2-P. Kriván 1955; 3-P. Stefanovits 1954; 4-M. Pécsi, E. Szebényi 1971-77; 5-S. Karácsonyi, Gy. Scheuer; 6-Gy. Hahn 1971; 7-M. Pécsi, Gy. Scheuer, F. Schweitzer 1978; 8-S. Pappfalvi, P. Kriván 1960; 9 - 14-M. Pécsi, Gy. Scheuer, F. Schweitzer 1978-79.

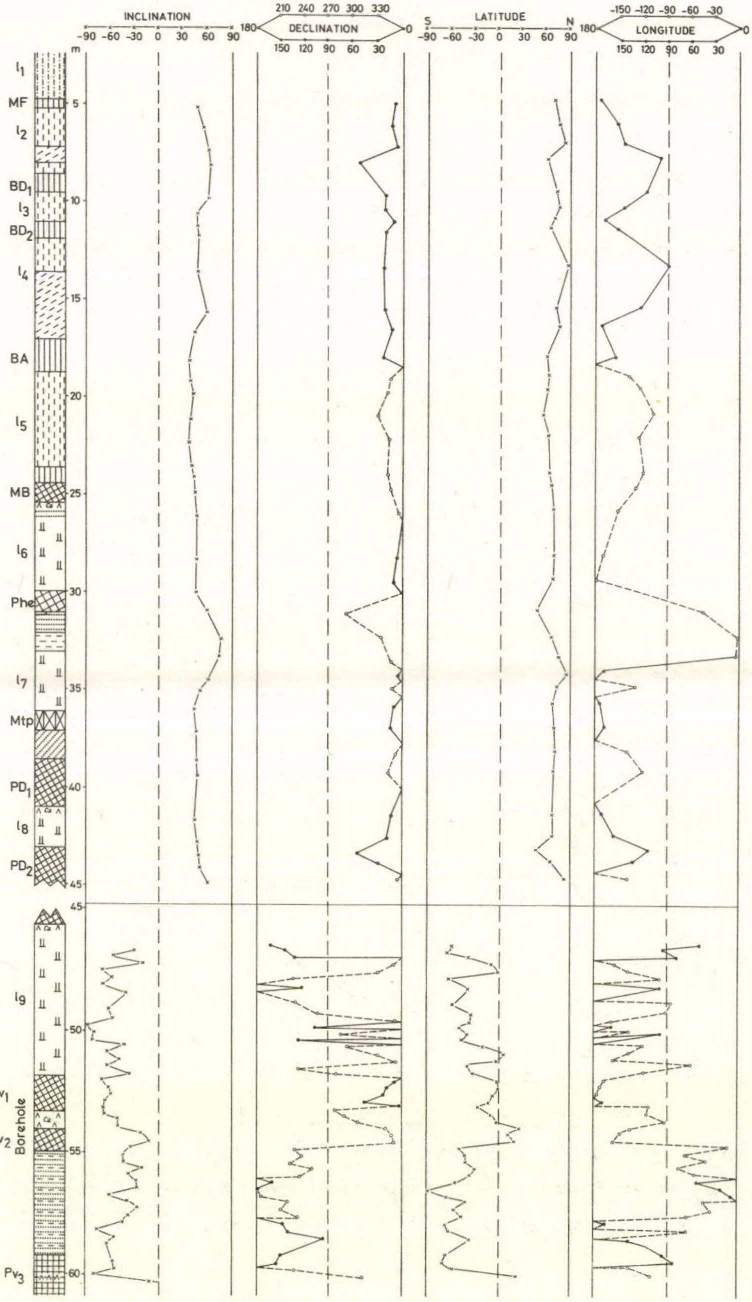


Fig. 4. Paleomagnetic profile of the Paks loess exposure and borehole profile according to M. A. Pevzner

In the Paks-Dunakömlőd loess bluff we have discovered in an exposure yet another fossil soil below the PD soil and named it the Paks-Dunakömlőd fossil soil /PDK/. This latter soil and the underlying 5 - 6 m thick old loess /Fig. 4./exhibit reversed magnetization without interruption and therefore they must have developed during the Matuyama epoch. In the Paks profile this is the oldest loess layer /between 46 - 52 m; Figs. 1., 4./ which may still be considered loess in the broadest sense of the word. This is the base of the old loess sequence of the Paks Loess Complex. On the basis of its stratigraphical position and paleomagnetic data, the lowest layers of the Paks Loess Complex formed approximately o.9 - 1 million years B.P.

The above outlined stratigraphic sequence is exposed and may be observed in the loess bluff at Paks brickyard and Dunakömlőd. The redbrown forest soils /PD, PDK/ at the lower part of the Paks Loess Complex might be considered on the basis of their pedological structure as dry mediterranean forest soils. The Paks-Lower Double soil was probably formed during the Cromer interglacials /Cr_2+Cr_3/.

4. Lower Pleistocene lithostratigraphical sequence of silt, clay and red soils
/The Dunaföldvár Loess Complex/

In the past few years we had commissioned the drilling of bores at the foot of the high loess bluff in Dunaföldvár. A 3o m thick Pleistocene stratigraphical sequence below the level of the Danube became thus available for analysis. This is the so called Dunaföldvár Loess Complex which consists of 6 red soils /2 or 3 of these are red clays/, two dark coloured meadow, mashy soils and repeated sequences of gleyey silt and clay strata /M. Pécsi - M. A. Pevzner, 1974; M. Pécsi, 1975./.

The 4o m deep coring /1974/ at the foot of the Dunakömlőd loess bluff revealed surprisingly similar stratigraphical series. From among the 6 red soils found in this series the 2nd, 4th and 5th /so numbered/ have definitely red clayey structure, while the 3rd and 6th red soil developed on a sandy deposit, their colour is bright red.

The molluscan fauna seem to indicate that the red soils had formed during warm, moderately dry climatic phases, while the grey coloured gleyey strata interlayered with them contain molluscan fauna of cooler and colder climatic phases of the Pleistocene /M. Wágner, 1978./.

From the 15 m deep borehole drilled at the foot of the Paks exposure fully oriented samples /Figs. 1., 4./ were collected for paleomagnetic analysis. Below the 7 m thick oldest loess layer a red coloured double forest soil was found. Underlying this soil sandy silt, alluvial sand strata, 4,5 m thick, had been deposited. Another red clay soil, 1 m thick was the last layer cut by the borehole.

The samples collected from the Paks profile and borehole were thermally demagnetized for two-three hours in a single step at 22o°C. All samples turned out to have secondary magnetization /viscous, and in the cores additionally, drilling imposed remanense/. The proportion of viscous magnetization of certain samples, was as high as 95 - 99 per cent. The isolation of primary magnetization was greatly hindered by this fact. The intensity of cleaned magnetization varied between o.2 - 17/xlo^{-6} $_{emu}$. The greatest intensity of magnetization was recorded in the borehole between 14.66 - 15.51 m, it was 81ox lo^{-6} $_{emu}$.

Laboratory measurements show that the samples from the young loess and from the old loess above the "Paks Lower" Double Soil Complex were all normally magnetized.

The underlying 15 m thick sediments exhibited complex magnetic characteristics. These rocks possess reversed inclinations, however, both normal and reversed declinations occur. Normal declinations are more frequent. This behaviour may either be due to the presence of secondary magnetization or to a pecularity of the ambient field. Fig. 4. shows the magnetic inclination, declination and the latitude and longitude of the virtual geomagnetic pole /VGP/. Each datum was obtained by taking the running vector average over three values in the open exposure and 11 values in the borehole. As it can be seen from Fig. 4. paleomagnetic poles computed from magnetizations of reversed inclination and normal declination fall on the equator or close to it.

In order to test the reliability of paleomagnetic data obtained from the cores, samples were collected from a test pit dug at the foot of the loess bluff near the site of the borehole. All samples from the pit with the exception of one, showed reversed magnetic inclinations and declinations, while the borehole samples from this interval displayed different magnetic declinations.

Thus it may be concluded that the loesses of the Paks open exposure were formed during the normal polarity Brunhes epoch, the underlying loesses taken from the borehole formed during the end of the Matuyama reversed epoch.

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THERMAL INVESTIGATION OF THE LOESSES AND FOSSIL SOILS OF PAKS

Mrs. Pécsi, É. Donáth

1. Qualitative evaluation

The qualitative and quantitative analyses of clay minerals of the fossil soils and of some loess samples from the Paks exposure were carried out by a derivatograph. For control purposes some of the samples were also examined by X-ray. By this method those minerals could also be detected which did not provide a characteristic thermal decomposition curve, e.g. feldspars, sericite, etc., and the mineral determined as hydrous oxide of iron by derivatograph, could be identified as hydrohematite.

According to thermal analyses illite proved to be the predominating clay mineral in almost all samples. Accessory clay minerals were as follows: montmorillonite, kaolinite and chlorite. In most cases two or more clay minerals could be determined in the same sample. In those samples where clay minerals occured in a smaller quantity illite was proportionally less.

Kaolinite was found in both fossil steppe and forest soils but could not be identified in the parent material i.e. in the young or old loess samples.

Montmorillonite occured in various quantities; it was always present in steppe soils, while in forest soils its amount was less or none.

Chlorite could be identified in all fossil soils, though in different quantities.

Many soil samples contained pyrite, it was found mostly in the A horizon of meadow soils. Nearly all samples contained a considerable amount of quartz.

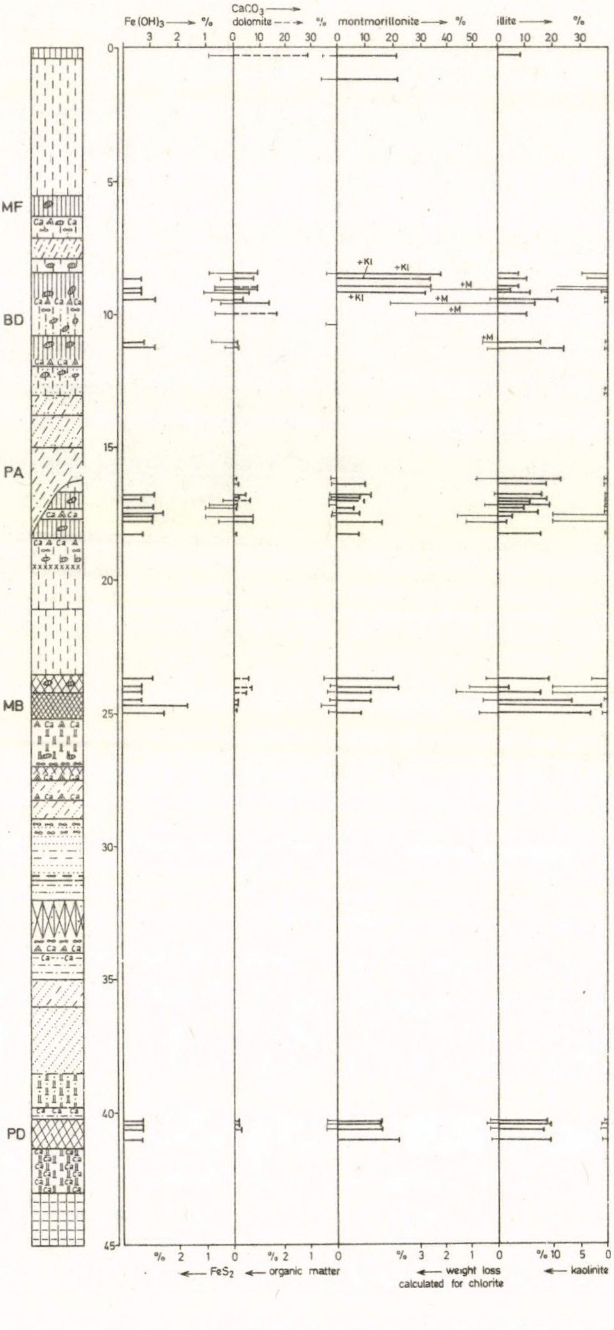
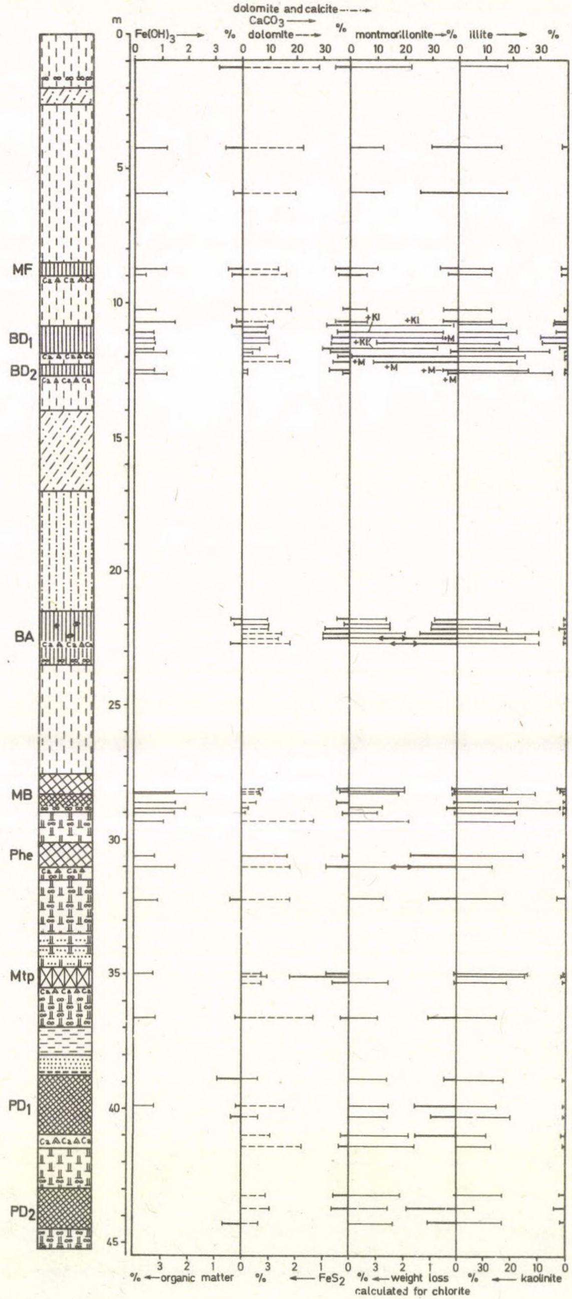


Fig. 1. DTG analysis of the loess profile /1971/ at Paks brickyard



<u>Fig. 2.</u> DTG analysis of the loess profile /1977/at Paks brick-yard - +KI=weight loess for montmorillonite and chlorite calculated for montmorillonite; +M=% value of chlorite and montmorillonite between 6oo - 7oo°C

From among the carbonate minerals samples contained mostly both dolomite and calcite, together, or only one of the two.

Hydrous oxides of iron occured together with pyrite and they probably had developed from pyrite by oxidation. Sometimes they were found without pyrite. In this latter case their genesis was probably connected with hydrolysis of the parent material.

Organic matter was generally detected in the upper horizon of the fossil soils, but in some cases it was also found in the young and old loess layers /Figs. 1., 2./

2. Quantitative evaluation

Soil samples were collected from the exposure at Paks brickyard investigated in 1971 and 1977 /Figs. 1., 2./. The analysis of fossil soils was carried out in samples including the "Basaharc-Double" Soil Complex /BD/ and the "Paks-Lower" Double Soil Complex /PD/ and all other fossil soils in between.

Without pre-treatment and fractionation samples /1ooo mg/ were placed in a MOM derivatograph and were analysed under the following conditions of sensibility: DTA: 1/1o; TG: 2oo mg; DTG: 1/1o. rate of heating 1oo^{o}/min.

Chernozemlike soil marked BD_1 /upper soil horizon of the "Basaharc-Double" Soil Complex/ profile of 1971, Fig. 1.

In the A horizon of the soil /between 8.5 and 9.1 m/ total clay mineral content amounts to 5o per cent. The quantity of montmorillonite together with the chlorite /3o to 35 per cent/ exceeds that of illite /2o per cent/. Kaolinite was around 1o per cent in two samples. Chlorite could be separately identified in the lower horizon of the soil, in other cases its thermal decomposition coincided with that of montmorillonite.

Among the carbonate minerals calcite predominanted /7 per cent/, the quantity of hydrous oxides iron and pyrite was the same /o,7 per cent/. The upper sample of the A_1 horizon contained no iron minerals, but this was the only horizon with an organic matter oontent.

In the A_2 horizon /9.1 - 9.3 m/ the total clay mineral content was about the same /3o per cent/, the predominance of montmorillonite decreased downwards. The quantity of kaolinite also decreased from 1o to 3 per cent. Between 9.3 and 9.5 m montmorillonite ceased to be present. In samples from this horizon the quantity of chlorite increased, organic matter, however, could not be found. As compared to the A_1 horizon, the amount of pyrite increased /up to 1.o8 per cent/. Lower down, the amount of hydrous oxides of iron was 1.17 per cent.

In the A/C-C horizon /9.5 - 9.7 m/ much chlorite and illite /24 per cent/ were found replacing montmorillonite; the quantity of kaolinite was small / 1 per cent/. This horizon was rich in carbonate minerals /14 per cent/, pyrite was of medium quantity /o.5 per cent/ while organic matter and hydrous oxides of iron could not be identified.

Chernozemlike soil marked BD_2 /11.1 - 11.5 m/ is represented only by an A_2 horizon /Fig. 1./. The total clay mineral content was around 35 per cent. Illite predominanted, the quantity of chlorite and kaolinite was less than 1 per cent. The quantity of carbonate minerals/of about 1.5 per cent/was also low. In this horizon no organic matter content could be determined; the quantity of hydrous oxides of iron was relatively high, and a medium quantity of pyrite was found.

Chernozem type soil marked BA /16.8 - 17.4 m/. "Basaharc Base" Soil in the A_1 horizon the total clay mineral content amounted to about 38 per cent in the three analyzed samples. Illite predominanted /about 25 per cent/ while montmorillonite was only about 11 per cent. Chlorite and kaolinite were found only in smaller quantities, the latter was less than 1 per cent. In spite of its dark-brown colour it contained a small amount of organic matter /o.3 per cent/. Pyrite represented only 1 per cent, while the quantity of hydrous oxides of iron amounted to 1.17 per cent in the two lower samples. Between 17.25 - 17.4o m it contains a small quantity of calcite up to 1 per cent.

In the A_2 horizon of the BA soil total clay mineral content was about 3o per cent, illite predominanted, montmorillonite was found in the lower, chlorite only in the upper part, in smaller quantities. Pyrite /about 1 per cent/ and hydrous oxides of iron /1.1 per cent/ were found in the lower horizon; organic matter was found /o.3 per cent/ in the upper part of the horizon.

In the A/C horizon between 17.9 and 18.1 m the quantity of montmorillonite /o to 24 per cent/ and kaolinite /about 8 per cent/ increased. Chlorite was present in the whole layer in medium quantity, though its amount decreased in the lower horizons. In these samples the quantity of hydrous oxides of iron was the same /1.17 per cent/, in the whole layer organic matter content decreased /o.2 per cent/ and pyrite showed the highest value /1.o8 per cent/.

The BA soil was also investigated in the northern profile of Paks brickyard where it was situated between 21.5 and 23.2 m, in a similar development. Its clay mineral content was, however, higher /4o to 5o per cent/ and in the lower third of the horizon the quantity of montmorillonite increased considerably, the carbonate content was 24-36 per cent. Similarly chlorite was most abundant in the C horizon. No amount of hydrous oxides of iron could be detected. Based on thermal analysis organic matter content amounted to o.3 per cent.

Dell infilled with loessic semi-pedolite /Fig. 1. between 16-18 m/. The BA soil was interrupted by a buried dell infilled with stratified loessic sandy semi-pedolite, in the southern part of the exposure /between 16 and 18 m in the 1971 profile/. In the four samples of this alluvial soil total clay mineral content was less than in either the BD, or the BA soil /35 per cent/. The dominating clay mineral was illite /about 3o per cent/, montmorillonite was much less /about 5 per cent/. In the upper and lower strata a small quantity of chlorite could be detected. Calcite was rare /1 to 2 per cent/ and the organic matter content was also low /o.2 per cent/. From the lowest strata hydrous oxides of iron were determined to be 1.5 to o.7 per cent .

The "Mende-Base" Soil Complex /MB/. In the 1971 profile /between 23.6 and 25.1 m/ six samples were analyzed from this redbrown forest fossil soil complex. In the A horizon the total clay mineral content is high, in some cases it reaches 5o per cent. In addition to montmorillonite /18 to 2o per cent/ illite also predominated /about 15 per cent/. Kaolinite proved to be of significant quantity in all samples /3 to 1o per cent/, chlorite was found in medium quantity. Dolomite and calcite content averaged about 5 per cent, the amount of hydrous oxides of iron varied between o.7 and 1 per cent, the organic matter content was o.2 per cent, and pyrite was absent.

In the B horizon /24.3 to 25.1 m/ there was a slight increase in the total clay mineral content, illite still predominanted, and the occurrence of montmorillonite was considerably restricted /Fig. 2./. Average kaolinite content was 2 percent, calcite was rare /o.5 - 1 per cent/, the quantity of organic matter was o.2 per cent. None of the samples contained pyrite, the amount of hydrous oxides of iron, however, showed a rather high concentration /2.3 per cent/ just as it should commonly be expected in the B horizon of red coloured forest soils.

The Mende-Base Soil Complex /MB/ in the 1977 profile /27.5 to 19.15 m/ is a redbrown forest soil /Fig. 2./. In the soil was characterized by a lower total clay mineral content /together with chlorite 25 per cent/ than the MB soil complex. The Phe soil contained no montmorillonite. Relatively large amount of chlorite was found, but kaolinite content was less than 1 per cent. Dolomite a dominant mineralogical component of the overlying horizon, was abundant /14 per cent/, but hydrous oxides of iron /o.7 per cent/ and pyrite /o.3 per cent/ were present in small quantities. Organic matter could not be found.

In two samples from this soil total clay mineral content averaged 26 per cent, illite predominated, chlorite was relatively abundant, but kaolinite content was less than 1 per cent. The quantity of dolomite and calcite amounted to 14.7 per cent, hydrous oxides of iron 1.5 per cent and pyrite o.4 per cent . Organic matter could not be determined.

Hydromorph forest soil marked Mtp /between 34.9 and 36.15 m in the 1977 profile. Fig. 2./. Total clay mineral content was 38 per cent on the average, in all the three samples. The upper part contained mainly illite and 1 to 2 per cent kaolinite and contained almost no montmorillonite. In samples from the lower part, the ratio of illite decreased and montmorillonite content increased to 16 per cent, hence the total clay mineral content rose to 4o per cent. The average quantity of calcite and dolomite was 7.5 per cent. None of the samples contained organic matter. The chlorite and pyrite content was low, or was absent in the upper horizons; in the lower part pyrite content increased /o.7 per cent/. The middle part of this soil horizon had probably undergone intensive oxidation since a greater amount of hydrous oxides of iron /2.3 per cent/ were found as substituting the pyrites.

The upper soil /PD_1/ of the "Paks-Lower" Double Soil Complex /PD/ /38.4 - 4o.5 m/ in the 1977 profile. The average clay mineral content of the five samples taken from this soil was 48 per cent which increased up to 55 per cent in the middle part of the profile. In the three samples from the upper horizon illite predominanted /25 per cent/, in the two lower horizons montmorillonite amounted to 3o per cent. In this soil profile kaolinite occured only in a small quantity /up to 1.5 per cent/. In the samples from the middle horizon chlorite was of medium quantity. Changes in the carbonate mineral content within the profile proved to be interesting. The sample from the A horizon contained calcite; in the second sample the high dolomite content /15 per cent/ could probably be accounted for by the presence of an almost 2 m thick transitional horizon of accumulation. Samples contained dolomite and calcite in medium quantity /6 per cent/, pyrite was found only in the sample from the lowest horizon /o.3 per cent/. The quantity of hydrous oxides of iron was also low /o.7 per cent/. Organic matter content was exceptionally abundant /o.4 to o.9 per cent/ in all horizons apart from the lowest one, where it showed a decreasing trend downwards.

In the Cca horizon of the PD_1 soil total clay mineral content decreased /only around 45 per cent/. Montmorillonite predominanted /26 per cent/ as against illite /17 per cent/. It had no chlorite and contained only 1 per cent kaolinite. It was rich in dolomite /2o per cent/, a small quantity of pyrite was also discovered.

B-B/C horizon of the soil marked PD_2 /42.5 - 44 m/. Total clay mineral content averaged 4o per cent with nearly the same amount of illite and montmorillonite. Although montmorillonite showed a slight predominance. Kaolinite was 3 per cent and chlorite 1.5 per cent. Dolomite and calcite content varied between 5 and 8 per cent. Organic matter was found in considerable quantity /o.7 per cent/ in the third sample. Pyrite was of medium quantity. Hydrous oxides of iron could not be detected though the soil had a reddish colour /7.5 YR 7/4/. Iron might be present in form of hematite this, however, could not be detected by thermal analysis.

upper part of the B horizon of this soil complex /28 - 29,5 m/ the clay mineral content is around 5o per cent. The quantity of montmorillonite decreases downwards /from 3o to 2o per cent/, while that of illite increased /from 2o to 3o per cent/. Hence illite became predominant. The quantity of kaolinite is low /less than 1 - 3 per cent/ like in the B horizon of the 1971 profile. The quantity of chlorite is uniformly low. The amount of hydrous oxides of iron increased downwards, pyrite decreased. Organic matter /o,3 per cent/ could only be detected in the sample from the upper part, at the boundary of the A and B horizons, of this fossil soil with friable structure, rich in krotovinas. The "A" horizon was not investigated.

The B and B/C horizons of this soil were characterized by an ochre-red colour, with carbonate precipitates. Total clay mineral content varied between 31 and 5o per cent. In the lower part of the B horizon montmorillonite content decreased but towards the B/C and Cca horizons its ratio increased once more. Illite predominated. The quantity of carbonate minerals rapidly decreased downwards. Only a small amount of calcite /about o.5 per cent/ was present here, from the total of about 4.4 per cent dolomite and calcite. In the B/C horizon the accumulation of calcium carbonate occurred in form of carbonate concretions. Hydrous oxides of iron were found in all samples /1.5 per cent/, organic matter in none, while pyrite /about o.4 per cent/ was absent in the middle sample.

Total clay mineral content of the sample taken from the Cca horizon proved to be 43 per cent on the average. The amount of montmorillonite slightly exceeded that of illite /22 and 21 per cent resp./ Chlorite and kaolinite were absent, but an exceptionally high quantity of dolomite occurred with a medium amount of hydrous oxides of iron. No organic matter and pyrite could be detected /Fig. 2./.

Poorly developed forest soil marked "Phe" /3o.2 - 31.1 m/. In the 1977 profile the B/C horizon of the sandy forest

3. Conclusions

The PD-soils had probably developed under dry, warm forest steppe climatic conditions. In addition to the nature of the soil structure this may be supported by further evidence based on thermal investigations[x] which revealed that the organic matter content of the PD double soils of Paks was much higher /o.7 to o.9 per cent/ than that of the fossil soils of the young loess /o.2 to o.4 per cent/. Thermal investigations provide yet another proof for our supposition that the PD soils might genetically be of mediterranean character, a well-developed dry forest-steppe soils.

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[x] Pedological investigations determined the humus content of the PD soils as only o.2 to o.4 per cent.

MINERALOGICAL ANALYSIS OF THE PAKS LOESS PROFILE

E. Szebényi

1. The aim of heavy mineral investigations

The analysis of heavy minerals seeks to establish the source area of the Paks loess deposits and by studying the mineralogical composition of these sediments attempts to unravel the nature of the deposits. By investigating the quantitative, qualitative parameters and the consistency of minerals we may be able to determine the possible place of origin of the thick loess series, to reconstruct changes in the development of fossil soil horizons interbedded in the loess, and finally to date important former sedimentation cycles.

Result of our mineralogical analyses are depicted in Fig. 1. The figure shows the complete profile of the loess series as known today and the terms "weathered" and "coated" mineral are used. Mineral grains were classified as completely weathered the qualitative analysis of which was not possible due to the advanced state of weathering /E. Szebényi, 1954/. In such cases an optical examination yielded no results, the minerals were indetectable.

By "coated mineral" we mean all those that have either a manganese or iron coating hence their determination is difficult or impossible. A few heavy minerals /specific weight greater than 2.9/ were also included. "Carbonate minerals" include calcite, aragonite and dolomite, all three occur in large quantities in loessial deposits. Their percentage ratio was calculated separately from the rest of the heavy minerals since carbonates can form or dissolve during the diagenetic process of loess or soil formation. The percentage ratio of

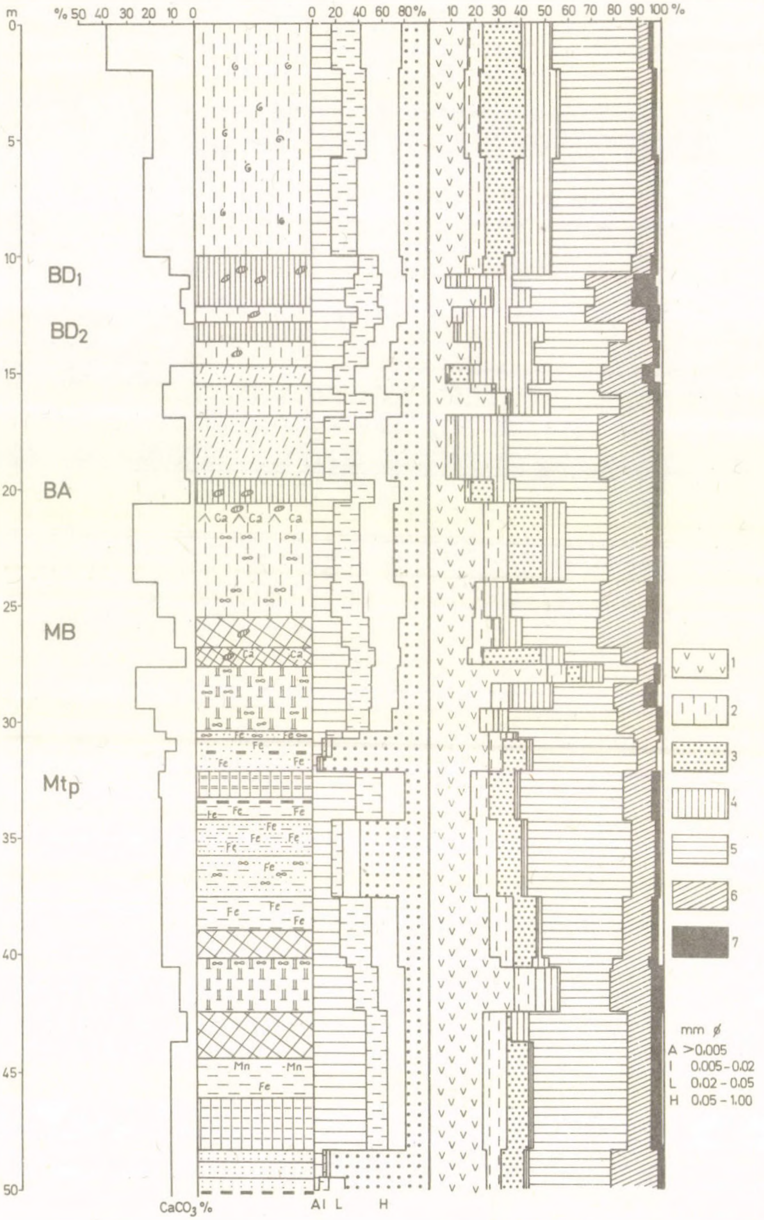

Fig. 1. Mineralogical analysis of the southern loess profile at Paks brickyard - 1=weathered mineral; 2="coated" mineral; 3=carbonate; 4=heavy mineral; 5=quartz; 6=mica; 7=feldspar

carbonate minerals in the present day profile undoubtedly differ from the amount that had been present in the original transported material.

On Fig. 1. the percentage ratio of $CaCO_3$ was shown for each layer in the loess profile and the granulometric composition of each layer was also indicated /ratio of clay, silt, loess and sand fractions/.

Grains with an o,o3 - 1.o mm were studied by mineralogical analysis. In order to separate these sand grains from organic matter they were treated by hydrogene-peroxide. Control samples were treated with a solution containing HCl and HNO_3 / aqua regia/. The percentage value of a specific mineral on our graph indicates its ratio from a total of 1ooo grains.

"Completely weathered" minerals attain their highest percentage ratio in old loess layers and deposits. They occur in a "medium" quantity in the young loess they are least abundant in soil horizons and in stratified loess. In the chernozem type fossil soils interbedded in the young loess weathering is less advanced than in the youngest loess layers. During the process of soil formation climatic conditions had probably been favourable for the development of a steppe vegetation. A continued weathering of already weathered grains during the period of soil formation may have lead to the complete destruction and disappearance of these grains, depending on their degree of resistance. As a result of biological activity in the soil and vegetation, the weathered grains disappear, while in the loess layers with a poorer vegetation they accumulate. A further proof is provided by the phenomenon that the lowest values for the degree of weathering are indicated in chernozem brown soils, while in the B horizons of redbrown forest soils they are somewhat greater /here the minerals continue to decompose/.

The quantity of minerals with an iron-manganese coating is slightly greater in the older formations.

Among the carbonate minerals the ratio of dolomite increases significantly in the older formations. This might indicate in situ development or epigenesis.

The percentage ratio of the heavy minerals is markedly higher in the young loess compared to the old loess layers.

Quartz is the main constituent of loess. In our classification where we separated "weathered" and "coated" minerals the percentage ratio of quartz may be misleading. In the control samples it was between 7o - 9o per cent.

Mica, especially muscovite is the second most typical mineral of loessy, silty deposits. Its quantity varies in the sediment sequences. It is most abundant in the Mende-Basaharc Loess Complex.

The quantity of feldspar is not significant in the Hungarian loess deposits, it reaches 6 - 11 per cent in the "Basaharc-Double" Soil Complex /BD/ and in the "Mende Base" Soil Complex /MB/ respectively.

2. Subdivision of the southern profile of the loess exposure at Paks on the basis of heavy mineralogical analysis

The boundary of the first section can be drawn at lo m directly below the so called Dunaujváros-Tápiósüly Loess Complex. In the upper section of the young loess the distribution of minerals is fairly uniform /Fig. 1./. Among the heavy minerals white garnet, green hornblende and some brown hornblende, zircon, rutile, tourmaline, apatite and magnetite are typically present in the loess deposits. Molluscan shell fragments are also abundant. Sand grains are coarse. They were probably supplied from a nearby area, sedimentation occurred simultaneously with the transportation of the material from the source area. Minerals exhibit the same characteristics throughout the whole length of the section. Mineral, other than those commonly found in the loessy, silty, sandy areas of the surrounding environment were not discovered.

The second section in the Mende-Basaharc Loess Complex is bounded by the base of the "Basaharc-Double" Soil Complex /BD/. The series which also contain soil horizons are composed of finer sand grains. Apart from white garnet a large amount of pink garnet /1o - 12 per cent as a ratio of heavy minerals/ is also present, the quantity of green hornblende increases, pargazite, chlorite, staurolite and disthene could also be detected. The decrease in the ratio of carbonate minerals /calcite-aragonite/ is due to the process of soil formation. The percentage ratio of micas /especially muscovite/ is the highest here. These deposits were probably carried from a greater distance, the coarser grains had been already deposited at another site, while the fine sand rich in mica, was transported farther, to the present site.

The third section ends at the base of the "Mende-Base" Soil Complex /MB/. The sand particles in this sequence are similarly fine grained. Molluscan shell fragments are found in all horizons though in a much smaller quantity than in the Dunaujváros-Tápiósüly Loess Complex. The ratio of pink garnet decreases significantly /2 - 4 per cent/. Basaltic hornblende predominante over the green hornblende. In the former two sections the quantity of biotite was insignificant, while in this section the brown and black-brown biotites are abundant. The 6o cm thick old loess layer that directly underlies the MB soil should also be included in this section since its mineralogical composition is essentially the same.

The mineral assemblage of the above outlined three sections all consisted of similar components, the only difference being that the percentage ratio of specific heavy minerals varied in the stratigraphic horizons. Throughout this 27 m sedimentary sequence the mineralogical composition shows a great resemblance which may support the argument that they originate from a common source area and were transported to different distances.

Interlayered between the MB soil and a sandy strata there is a two and a half meter thick loess band. This may be considered in our classification as the <u>fourth section</u>. The layer contains olivine. The hornblendes are intensively weathered, green micas and molluscan shell fragments are abundant. The ratio of minerals coated with manganese and iron has greatly increased.

<u>The fifth section</u> consists of two sand strata and a hydromorph spoil interbedded in between them. These layers contain fewer molluscan shell fragments. The amount of heavy minerals present is about the same as in the fourth section, the only difference is that the quantity of hornblende decreases and redbrown and pale-yellow biotites are more abundant. Olivine is also common.

<u>The sixth section</u> contains a silt horizon below the sand layer, a redbrown forest soil and the underlying loess band. Compared to the fifth section these layers are rich in pyroxene, pargazite and olivine. Another mineralogical boundary may be drawn within this section at 4o meters. At this point the optical characteristics of the minerals change, and the ratio of coarse particles in the sand fraction increases. Among the heavy minerals pink garnets are the most abundant and the quantity of rutile, tourmaline, epidote and zircon is significantly less. Apatite gradually becomes less and less and finalyy disappears /4.5 - o.5 per cent/.

Two main sedimentary cycles can be distinguished in the stratigraphic sequence of the Paks profile. The first incorporates the so called young loess series at the base of which the "Mende-Base" Soil Complex is situated. The upper part of the Paks Loess Complex developed during the second cycle in-cludint the "Paks-Lower" Double Soil Complex /PD/ as the last formation. The heavy mineral assemblages of the two sediment-ary cycles are different, however, each cycle consist of es-sentially similar assemblages regardless of the fact wether they are made up of fossil soil horizons, stratified loess, sandy or silty strata. Qualitative differences can only be ob-served in the distribution of specific mineral types, quanti-tative differences are not significant enough to merit serious attention. Apatite, and easily weathered mineral disappears in the sixth section. Olivine is a mineral found only in the Paks Loess Complex. The percentage ratio of heavy minerals was much higher in the Dunaujváros-Tápiósüly Loess Complex and in the Mende-Basaharc Loess Comples compared to the Paks Loess Complex. Differences in the mode of transportation and in the original supply of material probably account for these dis-similarities.

V. Codarcea /1977, Romania/ has completed a heavy miner-alogical analysis of the 1971 southern profile of the Paks ex-posure /her results are incorporated in our report/. She ana-lysed particles with a grain size of o.3 - o.o6 mm Ø. Accord-ing to her investigations magnetite is the dominant heavy mi-neral together with garnets and hornblendes. She found miner-als similar to those discovered by the author during the ana-lysis of a 1954 profile at Paks. Codarcea does not mention the presence of olivine and apatite. Differences between the per-centage distribution of minerals in the two classifications also occur. Codarcea found more biotite in the "Tápiósüly" Loess Complex. In the profile examined by the author /Fig.1./ biotite was detected in larger quantity at the upper boundary of the lower Pleistocene. Distinc mineralogical boundaries could not be drawn on the basis of Codarcea's work because sampling had not been continuous. The percentage value of heavy minerals from all minerals was also not calculated. According to Codarcea the grains were only slightly rounded and she arrived at the conclusion that the material had been transported only for a short distance. She considered the lower horizons of the Paks Loess Complex as alluvial deposits.

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MOLLUSCAN FAUNA IN THE PAKS LOESS PROFILE

M. Wagner

1. Method of sampling and an evaluation of the stratigraphic position of the molluscan fauna

Samples were collected from two profiles in the loess exposure at Paks brickyard. Each profile is 44 m, one situated in the southern, the other in the northern part of the exposure /Figs. 1., 2./. Samples were taken at 1o cm occasionally 2o cm interval, a sample size of 1 dm³ for each monolith was adopted. We separated the gastropods from the loess material by washing.

From the southern profile 9932 specimen were collected /Fig. 1./, while in the northern profile 2259 molluscs were found /Fig. 2./. We classified the Pleistocene molluscan fauna in the exposure into five main ecological groups.

1. Hygrophile species of moist woodlands /riparian forests on flood plains/;
2. thermophile species, dry toleratn;
3. hygrophile species of open country /in general/;
4. ubiquitous species;
5. water species /in general/.

In the southern profile 979 individuals of moist woodland species, 453 specimen of hygrophile species of open country, 116 thermopile specimen, 32 marine molluscs were found.

From the northern profile 165 individuals of moist woodland species, 13 specimen of hygrophile species of open country, 91 thermophile specimen and 199o individuals of ubiquitous gastropods were recovered. Five specimen of Pleistocene water species now extinct were also discovered.

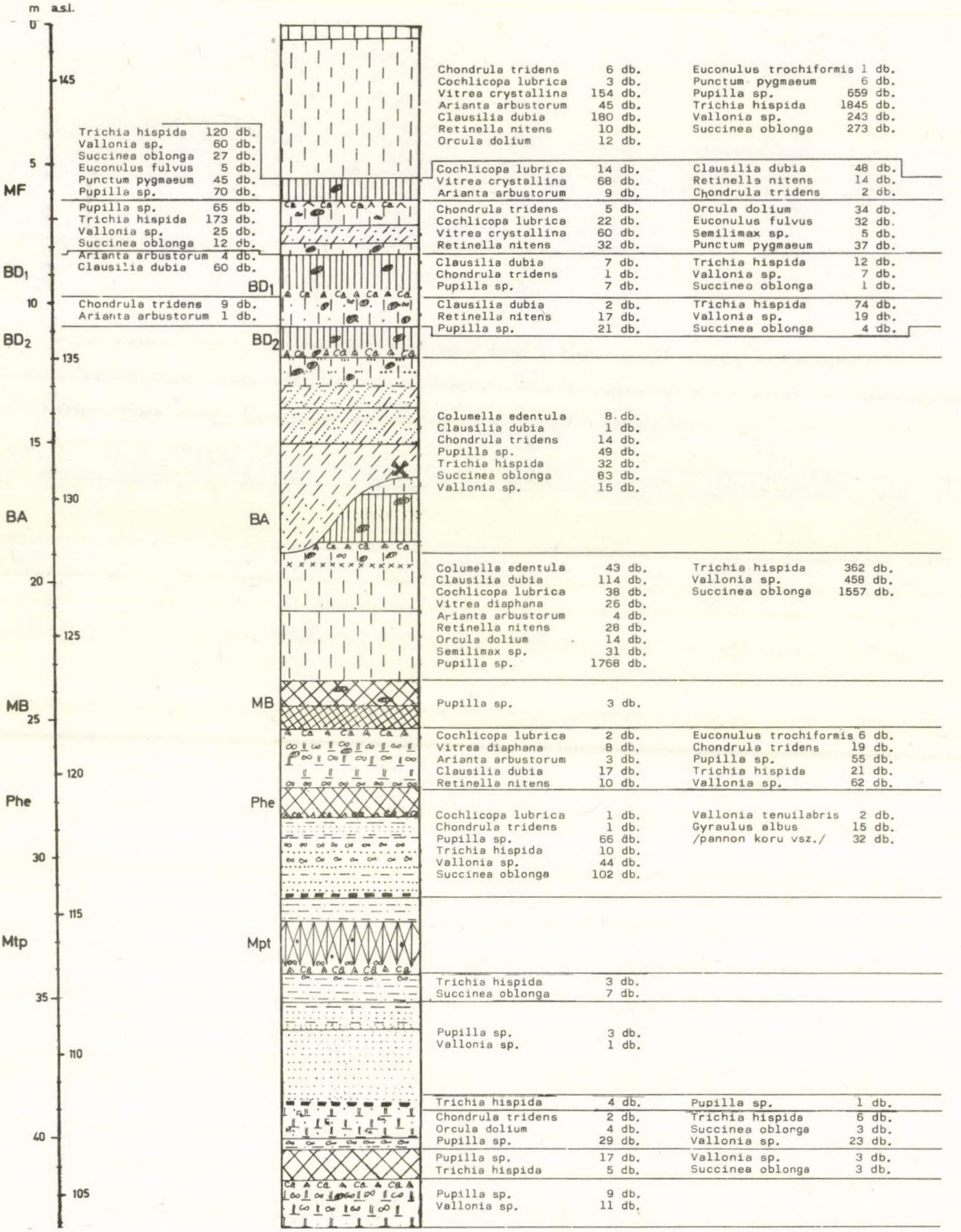


Fig. 1.: Molluscan fauna of the southern profile of the loess exposure at Paks brickyard /1971/.

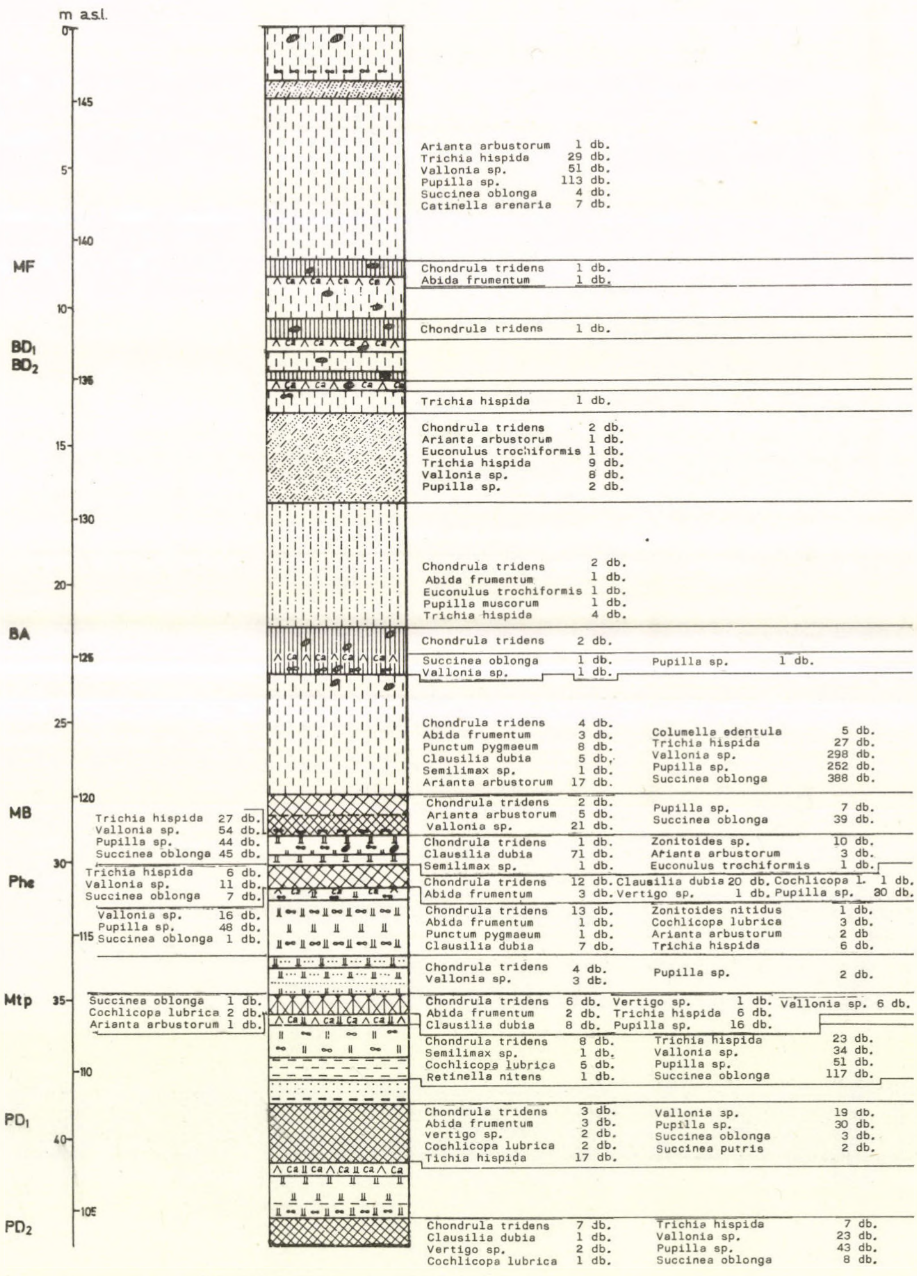


Fig. 2.: Molluscan fauna of the northern profile of the loess exposure at Paks brickyard /1977/.

We have attempted to reconstruct former climatic conditions by analysing the molluscan assemblages present in the loess profiles:

- In those cases where hygrophile species of moist woodlands dominante in a stratigraphic horizons during the process of sedimentation relatively moist, cold, climatic conditions predominanted.

- If thermophile species occur together with hygrophile species of open country, a moist, warmer steppe climate may be reconstructed.

- In the loess layers where thermophile species prevail loess accumulated under warm, relatively dry steppe climate.

- Cold, dry climatic conditions must have predominate during the formation of those loess strata in which the number of mollusca present is radically reduced.

Often there are no sharp boundaries in the profiles and transitional zones have also been taken into account.

According to our latest investigations /M. Wagner,1978/ ubiquitous gastropods may also be used as climate indicators /Figs. 3., 4./. We have concluded that the ubiquitous animals can also be classified on the basis of their ecological requirements. We may therefore differentiate between those species and genera that favour moist, warm, dry, or tolerate cool ecological environments because of their ubiquitous characteristics /they are not steno animals/, nevertheless they usually occur in large number in those areas where ecological conditions approach the optimum for their development. By comparing the percentage ratio of the four different types of ubiquitous gastropods within a stratigraphic horizon, the relative dominance of those species can usually be demonstrated for which climatic conditions at the time were most favourable.

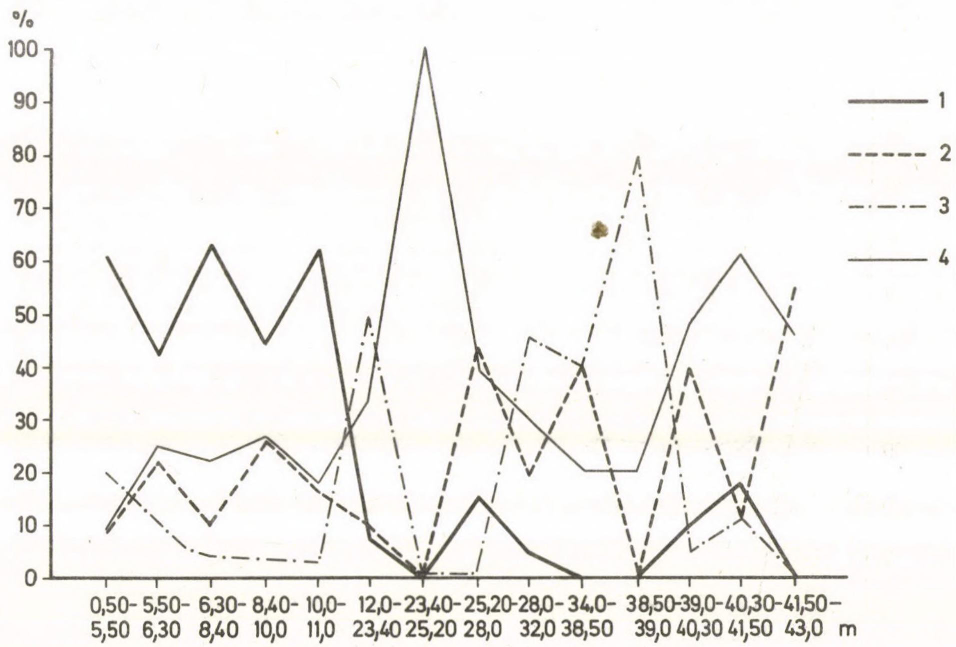
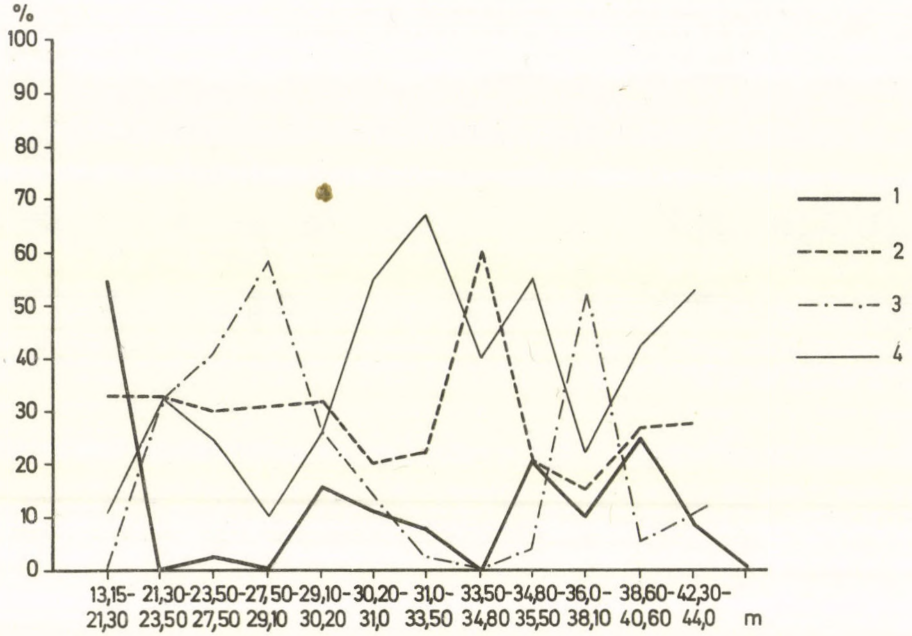


Fig. 3.: Percentage distribution of ubiquitous gastropods in the southern profile at Paks
1 = Trichia hispida; 2 = Vallonia sp.; 3 = Succinea oblonga; 4 = Pupilla sp.



<u>Fig. 4.</u>: Percentage distribution of ubiquitous gastropods in the northern profile at Paks /see legend for Fig. 3. also/

Analysis of the molluscan fauna in the stratigraphic sequences of the profiles

In the southern profile the horizons between 44.oo - 28.7 m /Fig. 1./ contained much fewer molluscan specimen that the corresponding layers in the northern profile /Fig. 2./. Conclusions about former climatic conditions could be drawn at both places and our findings coincided.

Vallonia and Pupilla species were found in the southern profile in the older loess horizons between 43.1o - 41.5o m. Loess contains large calcium carbonate concretions in these layers. In the northern profile /between 44.o - 42.3o m/ 8 different species were discovered in the "Paks-Lower" Double Soil Complex. From among these species an exceptionally high number of Pupilla and Vallonia individuals were recovered from the soil horizons. This seem to underline the basic similarity that exists in the two loess profiles. The gastropods indicate that a warmer climate prevailed during the period of soil formation.

The loess band interbedded in between the two horizons of the "Paks-Lower" Double Soil /between 42.3o - 4o.6o m/ in the northern profile contained no molluscan fauna. In the southern profile between 41.5o - 4o.3o m the forest soil contained ubiquitous snails. The composition of the assemblage of ubiquitous species seems to indicate a moister and warmer climate /no other species were present/.

Between 4o.3o - 39.oo m in the southern profile, and 4o.6o - 38.6o m in the northern profile the upper horizon of the "Paks-Lower" Double Soil in the older loess, an exceptionally high number of Pupilla and Vallonia species occur. These signal a warmer, drier climate with less precipitation. The layers presently discussed contain other species in both profiles, namely Chondrula and Abida molluscs both of which also indicate a warmer climate.

In the layer overlying the upper part of the Paks-Lower Double Soil Complex in the northern profile Succinea putris and Cochlicopa lubrica were identified. Their presence support the proposition that fluvial redeposition occurred at this stage as indicated by the coarse sandy layers that lie on top of the fossil soil.

Few gastropods were recovered from the older loess series /between 38.6o - 39.oo m/ in the southern profile,yet the fact that Trichia hispida was found led us to the conclusion that cool, cold climatic conditions prevailed.

Both the southern /between 38.6o - 34.o m/ and the northern profile /between 38.1o - 36.oo m/ contain several meter thick sandy and silty layers; their mode of accumulation indicate alluvial deposition. From the southern profile only ubiquious species were collected while from the northern profile other species, although only few specimen, were also recovered. The 5 individuals of the Chochlicopa lubrica must be mentioned which have an exceptionally large size. The ratio of Succinea oblonga to the rest of the ubiquitous species was around 5o per cent in both profiles.

Intercalated in the sandy layers that continue to predominante in both profiles at this stage there is a hydromorph marshy forest soil. It is situated between 34.oo - 32.oo m in the southern profile and between 36.oo - 34.8o m in the northern profile. It is interesting to note that the hydromorph soil contains no molluscs in the southern profile, while in the northern profile specimen of 1o species were found, none in large quantity. Chondrula tridens and Pupilla muscorum dominate, they indicate a warmer climate. The presence of Clausilia dubia and Cochlicopa lubrica imply the former existence of wooded flood plains.

In the southern profile a further 4 m thick sandy strata was registered /between 32.oo - 28.oo m/ in the northern profile it is only 1.3o m thick /between 34.8o - 33.5o m/. The sandy strata of the southern profile contains fragments of marine molluscs in large quantity; their identification was not possible. Illuviation proves the presence of water. Further evidence is provided by the unusually high ratio /8o per cent/ of hygrophile Succinea oblonga species among the ubiquitous gastropods. In the northern profile /between 34.8o - 33.5o m/ among the ubiquitous species Vallonia predominate. Individuals of two other species were also found including Chondrula tridens which together with the Vallonia prefer a warmer, drier climate.

The sandy strata of the southern profile are overlain by a well developed older loess band /between 28.oo - 25.2o m/ which is situated immediately below the "Mende-Base" Soil Complex. The distribution of the molluscan fauna is quite interesting, thermophile Chondrula species occur in large number together with Clausilia and Retinella. These latter molluscs typically occur on wooded flood plains. The climate at this time must have been relatively moist and warm.

The older loess /between 33.5o - 29.1o m/ is divided into three parts /33.5o - 31.oo m; 31.oo - 3o.2o m; 3o.2o - 29.1o m/ by a poorly developed forest soil in the northern profile. The loess then is overlain by the "Mende-Base" Soil Complex. The three components of the older loess exhibit a great variety of molluscan species and a large number of individuals. The ratio of hygrophile species increases upward. The relative dominance of the hygrophilous Succinea oblonga increases upward towards the "Mende-Base" Soil Complex. Their ratio in the respective layers is as follows: 1.4 per cent, 12.9 per cent, 26.4 per cent and it is 58 per cent in the "Mende-Base" Soil Complex. In addition each layer contains forest species /Clausilia, Arianta, Euconulus, Vertigo/. The presence of Chondrula and Abida species indicate a warmer climate favourable for soil development.

In both profiles the "Mende-Base" Soil Complex has only a few molluscan species and individuals, although hygrophile and thermophile species, which characterize soil formation are present in both cases.

The molluscan fauna of the younger loess series /i.e. upward from the "Mende-Base" Soil Complex/ exhibit a closer resemblance in the two profiles. The high ratio of Succinea oblonga among the ubiquitous species proves a relatively moist and cold climate during the deposition of the younger loess series. This is evident in both profiles. The ratio of Succinea oblonga is 49.6 per cent in the southern, and 3o.9 per cent in the northern profile. Underlying the "Basaharc-Base" soil which is poor in molluscan species, the loess band contains Columella edentula in both profiles. This is a rare species that indicates a cold climate. Semilimax sp., also prefers cold, moist, climatic conditions.

In the southern profile Columella edentula,a glacial climatic indicator was found in a severel meter thick loess band interbedded in between the "Basaharc-Base" Soil and the "Basaharc-Double" Soil Complex.

Only the upper horizon /BD_1/ of the "Basaharc-Double" Soil Complex contains molluscan fauna of these, the southern profile exhibits a richer selection. Thermophile Chondrula species that mark soil formation occur in both profiles. The rich fauna of the southern profile enabled us to construct a graph to demonstrate the ratio of specific ubiquitous species in the soil. The Pupilla and Vallonia species show maximum development /compared to the other species/ and indicate the existence of warmer ecological conditions during this time, favourable for soil development /Fig. 1./.

Interbedded in between the two soils of the "Basaharc-Double" Soil Complex there is a loess band. It is situated between 11.o - 1o.o m in the northern profile and 12.4o -

11.2o m in the southern profile. Only this latter contained molluscs. Retinella, Clausilia, Arianta species are all characteristic reprezentatives of loess forming periods and among the ubiquitous specimen Trichia hispida are in relative dominance /61.7 per cent/. They favour a cool and moist climate.

A loess band is situated on top of the "Basaharc-Double" Soil at 8.4o - 6.3o m in the southern, and 1o.6o - 9.3o m in the northern profile. The southern profile was rich in cold tolerant species while the northern one contained no molluscs. 576 specimen of 12 species were recovered from the southern profile and from among these 173 were Trichia hispida, an ubiquitous species that usually indicates a moist, cold climate.

Similarly, the "Mende-Upper" Double Soil is also much richer in molluscan remains in the southern profile /between 6.3o - 5.5o m/ than in the northern profile /between 9.3o - 8. 4o m/. Faunistic evidence from both places indicate a warm climate suitable for soil development. The sample from the "Mende-Upper" Double Soil contained 481 specimen of 12 species. The abundance of molluscan species is similar to that of the underlying loess. A further resemblance can be demonstrated by the fact that ubiquitous species constitute a high percentage /in the underlying loess and in the "Mende-Upper" Double Soil/ in both horizons.However,it must be pointed out tha in the loess formation 63.2 per cent of the ubiquitous species consist of hygrophilous Trichia specimen, while in the soil Pupilla and Vallonia species predomina These latter snails occur under widely differing climatic conditions, yet their dominance may be observed only under warm, dry climatic conditions.

The loess of the upper part of the southern profile /5.5o - o.oo m/ may be subdivided into four units on the basis of faunistic evidence.

The layer 5.5o - 3.7o m has the richest molluscan assemblage. Apart from the ubiquitous species several forest species /Arianta, Clausilia, Orcula, Punctum/ were also found. This type of molluscan population usually develops in a moist environment with forest vegetation.

In the layer 3.7o - 3.1o m there are much fever gastropods, together with Clausilia and Punctum species ubiquitous snails occur. These signal the arrival of a drier and colder climate.

The number of Trichia specimen significantly increases in the layer between 3.1o - 1.9o m. The abundance of species may indicate a colder climate. In addition each sample contain Clausilia dubia forest species and from some samples Arianta arbustorum was recovered. Vitrea crystallina also prefer a forested environmnet.

The layer between 1.9o - o.oo m has the least number of molluscs, only a few ubiquitous specimen were found. It seems that during this time the climate became once more much cooler and drier.

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PALEOMAGNETISM OF THE PAKS BRICKYARD EXPOSURES

P. Márton

Method

Seventy-eight pairs of specimen were collected from the northern profile of the loess exposure in the Paks brickyard. The section sampled is 45.8 m thick. Another 11 specimens also in pairs, were taken from a 2.5 m deep pit dug immediately at the foot of the section. In situ susceptibility measurements were also carried out.

The samples were measured using the technique of AF-cleaning. Demagnetization was carried on in steps until a single stable component of magnetization could be isolated, usually at AF-amplitudes between 35 - 5o mT /see Fig. 1. orthogonal demagnetization diagram; Zijderveld, 1967/.

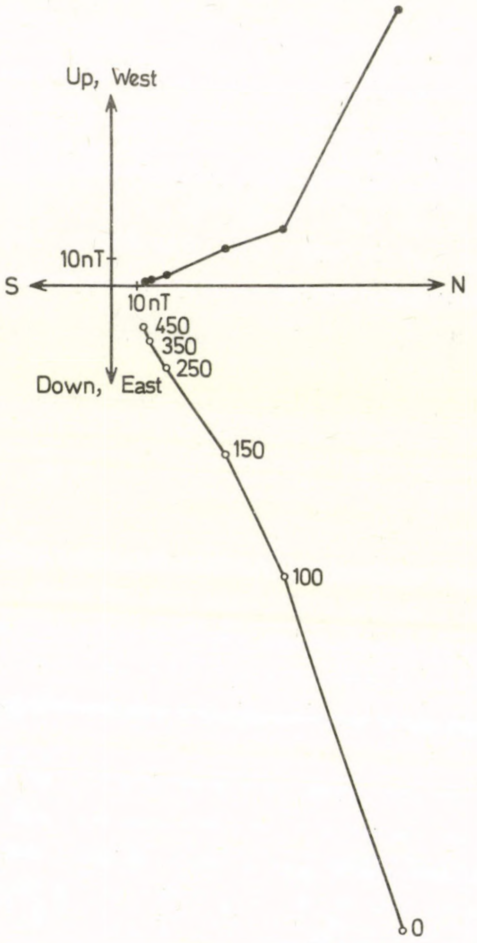
The direction of stable magnetization was defined by the mean of the cleaned directions. Four magnetic directions were averaged, three measurements form the first, and one from the second specimen, the latter having been cleaned in one step only at 3o or 4o mT. Thus, a confidence interval both for declination and inclination could be computed:

$$dD = \frac{\alpha_{95}}{\cos I}, \quad dI = \alpha_{95}$$

where α_{95} is Fisher's measure of confidence at the 95 per cent level /Fischer, 1953/.

Results

Paleomagnetic results are presented in a combined lithological and magnetic section /Fig. 2./. On Fig. 2. the depth



<u>Fig. 1.</u>: Orthogonal demagnetization diagram of a red clay soil sample for Paks

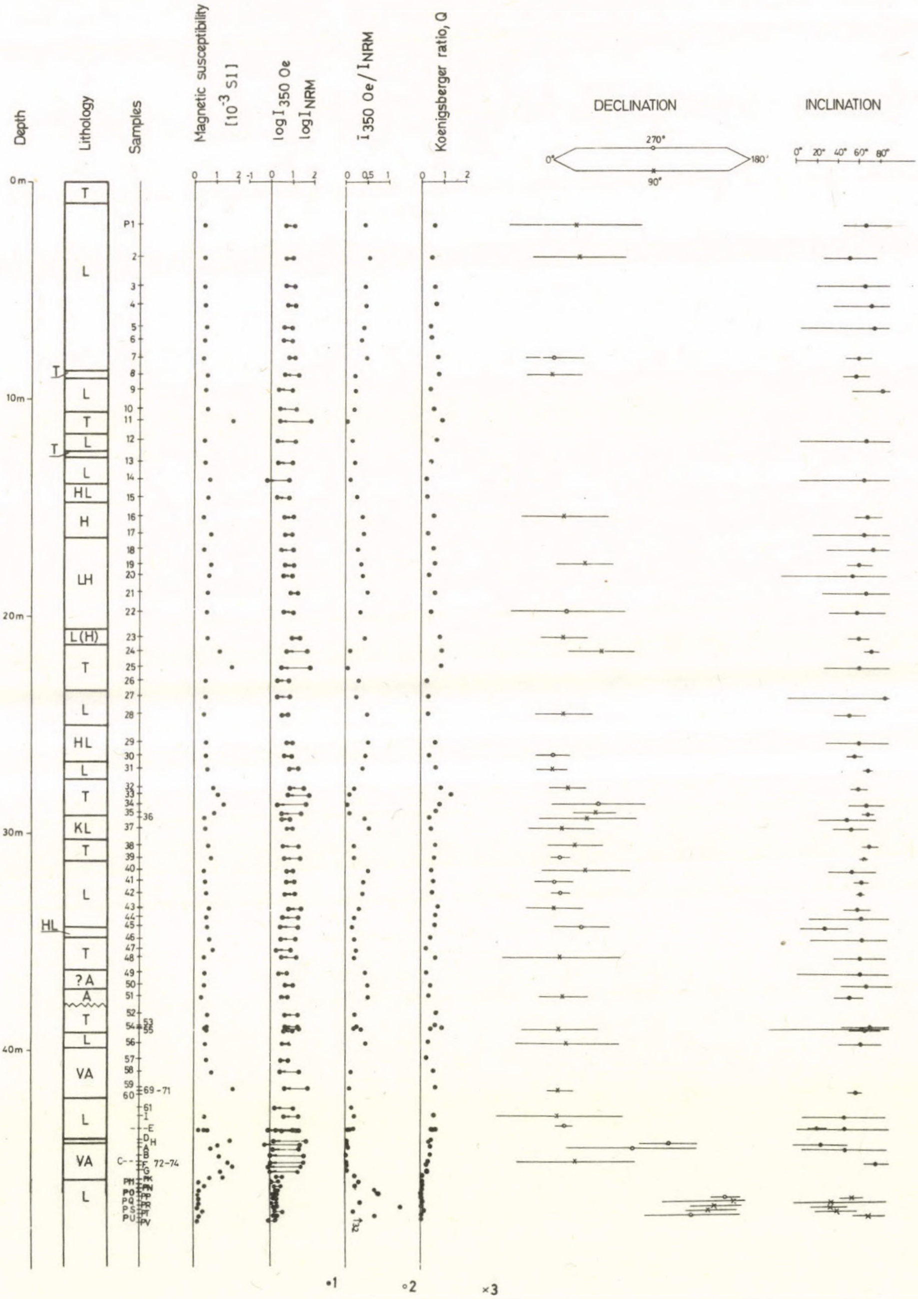

Depth
Lithology
Samples
Magnetic susceptibility [10^-3 SI]
log I 350 Oe
log I NRM
I 350 Oe / I NRM
Koenigsberger ratio, Q
DECLINATION
INCLINATION
0m
10m
20m
30m
40m
•1
◦2
×3

Fig. 2.

Fig. 2.: Mean directions /D, I/ of stable remnance for the Paks brickyard profile. Horizontal bars indicate 95 per cent confidence intervals /dD, dI/. Other parameters are explained in the heading

T = soil; L = loess; H = sand; HL = sandy loess; KL = loess with concentrations. A = clay; VA = red clay.

1 = in the declination column $180^o < 0 < 360^o$

2 = in the inclination column $I > 0^o$

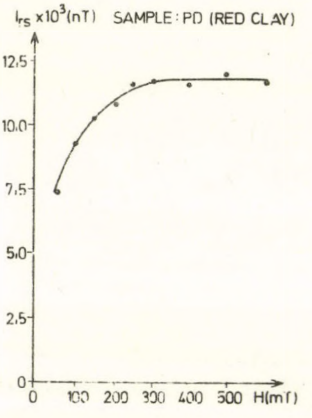
3. = in the declination column $0^o < D < 180^o$

4 = in the inclination column $I < 0^o$

scale and the lithological column are drawn according to Mrs Szebényi's personal communication. The declination /D/ and inclination /I/ of stable magnetization are plotted with their confidence interval /dD, dI/ /horizontal bars/. Dots and crosses are positive and negative inclinations, respectively. Missing /D, I/ data are due to unstable or inconsistent magnetization . If only D is missing it means that the declination is uncertain.

The mean value of suspectibility throughout the profile above ground level /to 45.6 m/ is o.71 x 10^{-3} SI units, but on average it is greater in certain fossil soils interbeddings /up to 1.8 x 10^{-3} SI/ and smaller in the loess and loess-like layers /$\sim$ o.5 x 10^{-3} SI/. The initial intensity of magnetization shows positive correlation /$0.34 < R < 0.78$/ while the "cleaned" magnetization displays weak negative correlation /$-0.16 < R < -0.69$/ with susceptibility, where R is the correlation coefficient. This is because the magnetization with strong initial intensity /and susceptibility/ is reduced to a greater extent on cleaning than the magnetization with average initial intensity. The Koenigsberger ratios /Q-values/ indicate the predominance of the induced remanence over the initial remanence.

Microscopis studies and IRM curves /up to 6oo mT/ /Fig. 3./ indicate that the carrier of magnetization is magnetite. Its volume percentage is estimated to be o.2 per cent in loesses and o.o4 - o.o6 per cent in fossil soils /P. Márton, 1977/.



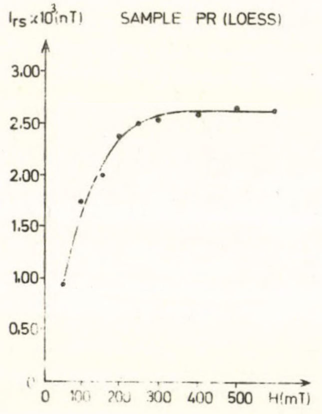


Fig. 3.: IRM acquisition curves for a red clay and a loess specimen from Paks brickyard

Table 1. Mean directions of stable magnetization with statistical parameters for the various layers of the Paks brickyard exposure. In computing the overall average the reversed magnetization of the formation No.13 was converted to normal.

	Depth /m/	Formation	Number of specimens	Mean: Declination $\bar{D}^o$	Mean: Inclination $\bar{I}^o$	Statistical parameters: K	$\alpha_{95}=dI^o$	$dD^o=\frac{\alpha_{95}}{\cos I}$
1.	o.o - 8.7	L	7	15.1o	68.51	31.75	1o.88	29.7o
2.	14.7 - 2o.6	H,LH,L/H/	8	14.o2	65.76	55.76	7.48	18.22
3.	21.3 - 23.4	T/BA/	3	3o6.o3	7o.89	11.58	38.oo	
4.	23.4 - 27.5	L,HL,L	5	4.o5	65.56	36.53	12.83	31.o1
5.	27.5 - 29.2	T/MB/	4	2.46	66.31	31.31	16.68	41.51
				Average of 1-5				
6.	9,o - 29.2		25	3.84	68.51	36.o4	4.89	13.35
				Continuation				
7.	31.2 - 34.3	L	5	6.o7	61.63	88.42	8.18	17.22
8.	34.8 - 36.3	T	3	355.16	66.82	72.15	14.62	37.14
9.	37.9 - 39.2	T	4	19.o1	66.46	67.51	11.26	28.19
1o.	39.9 - 42.2	T/VA/	5	8.79	59.28	6o9.48	3.1o	6.o7
11.	42.2 - 44.o	L	5	8.7o	43.28	19.63	17.61	24.19
				Average of 7-1o				
12.	29.2 - 44.o		37	1o.oo	59.57	37.75	4.18	8.25
				Continuation				
13.	46.8 - 47.8	L	5	184.12	-5o.44	9.61	26.oo	4o.9o
				Overall average				
14.	o - 47.8		11	4.21	63.19	51.8o	6.4o	14.19

Discussion

The polarities of stable magnetizations recorded from the top of the profile down to ground level /45.8 m/ including the PD-soils complex are all normal.

In the older loess /46.2 - 48.2 m/ underlying the PD-soil at least one specimen from each pair of the eleven samples collected exhibits a stable reversed magnetization. The reversed directions of magnetization displayed at the bottom of Fig. 2. are obtained from those five samples in which both specimens were shown to possess a stable reserved magnetization.

These results are in full agreement with those reported by M. Pécsi and M. A. Pevzner /1974/ who analysed different profiles /open exposures and bore holes/ paleomagnetically at the same locality using an one /or two/ step thermal cleaning to get rid of the viscous component of magnetization.

Thus, the normal magnetic polarity above the PD-soil complex and the reversed one in the loess beneath are confirmed. It has been proved that the same loess horizon in at least two different outcrops nearby /also possesses reversed magnetization /M. Pécsi, 1974, P. Márton, 1979/.

M. Pécsi has suggested /M. Pécsi, 1974/ that the polarity change N→R recorded at Paks is the boundary between the Brunhes and Matuyama epochs inferring that it is an important marker in the absolute chronology of the Hungarian loesses and loess-like deposits.

Table 1. compiles the mean directions of magnetization /D, I/ with statistical parameters /k, dD, dI/ for the different layers of the Paks profile. Lithology is indicated in the third column /L: loess, T: soil, VA: red clay/. Fig. 4. depicts the same data on a stereographic projection.

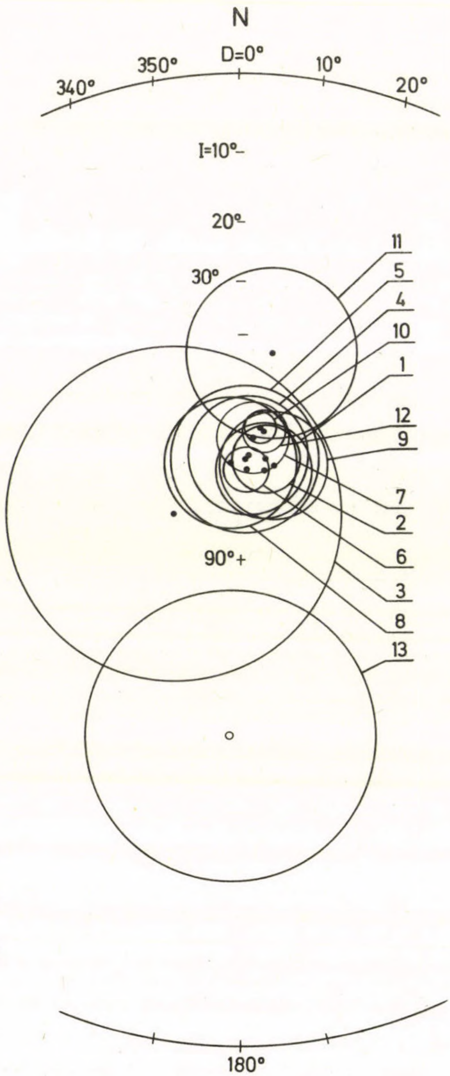


Fig. 4.: Mean directions of stable magnetization with confidence circles /95 per cent/ in the various layers of the Paks brickyard exposure /stereographic projection/
1 = positive inclination; 2 = negative inclination; 3. identifying numerals used here are the same as in table 1.

The mean magnetic directions shown /Table 1. and Fig. 4./ are rather uniform expect those of layers No. 3 /BA-soil/ and No. 11 /loess/. Unfortunately, the mean direction of layer No. 3 is too uncertain, however, that of layer No. 11 significantly differs from the overall average direction of magnetization in the profile at a 95 per cent level.

A statistical comparison of the paleomagnetic directions of the parallel formations from the Paks and Mende profile was carried out based on data available from Table 1. of the Paks and Table 1. of the Mende paper respectively. The aim of this test was to see wether identical formations at different localities can be expected to possess similar directions of magnetization. It has been found that the overall average direction of magnetization in the Mende profile is significantly different from that of the parallel section in the Paks profile, at a 95 per cent level. In spite of this, the mean magnetic direction of the MB-soil complexes are statistically the same, and so are those of the loess layers interbedded between the BA-, and MB-soil complexes in both exposures. However, the mean direction of magnetization of the Mende-BA-soil, - which is different from that of the Mende MB soil - is the same as the magnetic direction of the Paks MB soil but is different from the direction of the Paks BA-soil complex. /Note large uncertainty of the mean direction of the Paks BA soil./

The discrepancy of the overall average directions of magnetization in the two exposures, is due to differences in declinations which cannot be attributed to local magnetic field differences because of the short distance /~ 12o km/ between the two localities. Subsequent gravitational transport is suggested as an explanation but the effect of secondary magnetization cannot be ruled out entirely.

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LITHOLOGICAL, PEDOLOGICAL AND PALEOMAGNETIC ANALYSIS OF THE DUNAKÖMLŐD 1977/1 BOREHOLE

M. Pécsi - Gy. Scheuer - E. Szebényi - M.A. Pevzner - P. Márton

Our investigations of the loess bluff at Dunaföldvár /M. Pécsi - M. A. Pevzner, 1974; M. Pécsi 1975, 1979/ were encouraging enough to continue the exploration of the stratigraphic sequence below the lowest horizon known from the exposure at Paks brickyard. As a first attempt several bores were drilled in 1977 and also in 1978 between Dunakömlőd and Paks[1]. We had hoped to find below the lowest horizon of the old loess /i. e. below the "Paks Loess Complex"/ the still older formation of the "Dunaföldvár Complex". Former analysis had shown that the lowest horizon of the "Paks Loess Complex" indicated reversed magnetization /M. Pécsi - M. A. Pevzner, 1974/. In accordance with our expectations we discovered in the Dunakömlőd 1977/1 borehole six ochre-brown, ochre-red or red coloured fossil soils interstratified with clayey /4o - 6o per cent/ and silty sediments. The lithological and paleopedological characteristics of this sequence were almost identical in development with the stratigraphical sequence described in the borehole profile of 1974/1 Dunaföldvár, located near the "Kálvária hill" /M. Pécsi 1975, 1979/.

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1. The Dunakömlőd 1977/1 borehole was drilled at the foot of the loess bluff /near the 1o5 km post of the main road/ and included a stratigraphic sequence from 96 m a.s.l. to a depth of 56 m a.s.l. /Fig. 1./.

1. Lithological and paleopedological analysis

Ochre-red soil No. 1.

Situated below clayey sand strata rich in mica there was a pale ochre-red fossil soil between 1.8o - 2.8o m in the profile /Fig. 1. D_{v1}/.

The grain-size composition of the soil consisted dominantly of clay and silt respectively. The A horizon had been eroded, and the BC horizons had a neutral ph value. The carbonate content of the C horizon was 3o per cent and contained large concretions.

Description of the section between o.8 - 4.1 m in the borehole profile

o.8o - 1.oo m	slightly pink clayey sand
1.oo - 1.8o m	yellow stratified fine sand at the bottom $CaCO_3$ concretions, their size: o.5 - 1.o cm Ø
1.8o - 2.1o m	light ochre-red coloured BC horizon of a forest soil with neutral ph value
2.1o - 2.4o m	gradually lighter yellow Cca horizon with concretions and carbonate veins
2.4o - 2.85 m	a lighter yellow Cca horizon with large concretions at the bottom
2.85 - 3.1o m	yellow silty clay with a carbonate content, with mica and shell fragments
3.1o - 4.1o m	yellow silt rich in mica, the ratio of sand and mineral particles around 1o per cent.

Ochre-red soil No. 2. /Soil Complex/

The second ochre-red fossil soil in the profile was a double forest soil, situated between 5 - 8 m /88.2 - 9o.4 m a.s.l./ /Fig. 1. DV_2/. The ratio of the clay fraction in the soil was around 5o per cent, the sand fraction was low, only 8 - 1o per cent. This latter consisted mostly of silt-aggregates, carbonate concentration and shell fragments. Both formations of the soil complex had a typically high carbonate content. They may be reconstructed as a soil type characteristic of Mediterranean mixed forests. The B horizons had been

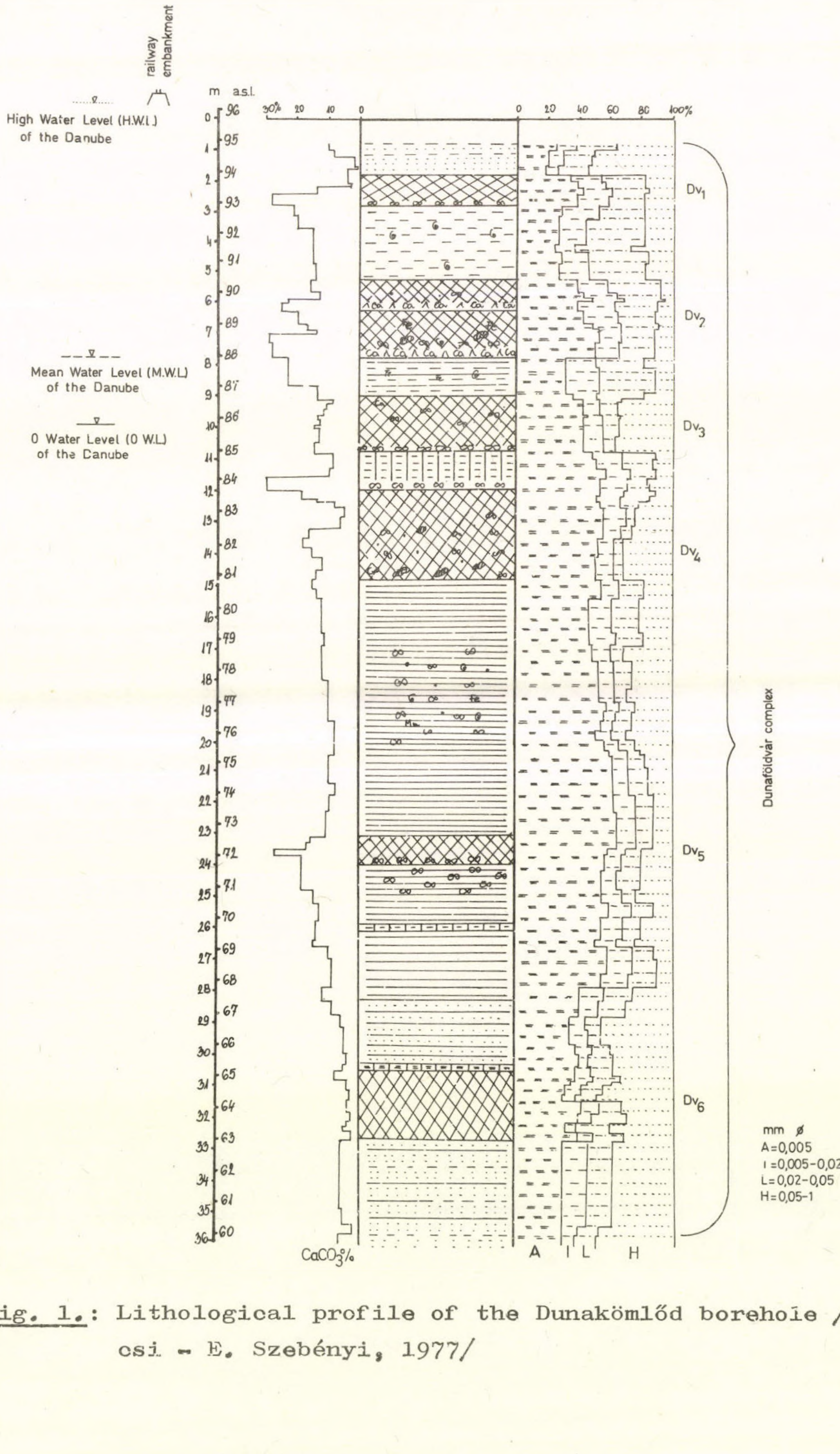

Fig. 1.: Lithological profile of the Dunakömlőd borehole /M.Pécsi - E. Szebényi, 1977/

eroded, their colour gradually fades in the lower levels,however, they still retain an ochre-red tint. The underlying "bedrock" of the soil was sandy silt, poor in mica, slightly oxidized. Red-coloured forest soils in similar development to this soil complex had been found in the borehole profiles 1974/1 and 1971/1 drilled in the brickyard at Paks. In those profiles they were situated between 95 - 93 m and 89 m.a.s.l. respectively.

Description of the section between 4.1o - 8.95 m/ Fig. 1.

4.1o - 5.3o m yellow clayey, sandy silt with mica

5.3o - 5.75 m ochre coloured /1o YR 7/4/ BC horizon of a clayey forest soil

5.75 - 6.35 m ochre-brown soil /1o YR 5/6/ gradually became lighter in the lower levels. In the bottom the Cca horizon contains small concretions, the sand fraction was abundant in shell fragments

6.35 - 7.o5 m B, BC horizon of an ochre-red clayey forest soil; it became gradually lighter in the lower levels. It was rich in Fe and Mg grains

7.o5 - 7.8o m Cca horizon gradually became lighter; many large and small Cca concretions, iron aggregates in the sand fraction. Micas were few, apart from quartz grains silt aggregates and Cca concretions dominated

7.8o - 8.95 m clayey silt

Red soil No. 3. with an alluvial clay soil at the base

The third fossil soil at a depth of 8.9 - 1o.8o m/between 84.9 - 86.8 m a.s.l. Dv_3/ was a sandy red clay soil situated directly on top of a 1 m thick gleyey alluvial clay soil. The red clay soil was about 2 m thick with a 1o - 13 per cent carbonate content. The dominant grain-size fractions were clay /4o - 42 per cent/ and sand /3o - 38 per cent/. Its colour 1o YR 5/6 became a slighty lighter in the lower levels. The soil contained shell fragments, Fe and Mg concretions. The granulometric composition of the whole formation is almost uniform with an even distribution of carbonate content. Carbonate precipitated in concretions, the size of 1o - 15 cm Ø in the C horizon. It must be noted that within the 2 m thick

B horizon the ratio of the clay fraction did not notably increase.

The carbonate content of the gleyey alluvial soil below the red soil was the same as the amount observed in the B horizon of the forest soil. At the bottom of the clayey alluvial soil calcium carbonate concretions had formed and calcium hydroxide precipitated.

Description of the section between 8.95 - 12.5o m

8.95 - lo.8o m	ochre-red /lo YR 5/6/ sandy clay soil with Fe and Mg grains. The colour became slightly paler in the lower levels
at 9.lo m	many small Cca and Mg concretions
at 9.25 m	a more intensive precipitation of Fe /7.5 YR 6/4/
9.6o - 9.75 m	Cca concretions, size: 2o cm Ø
lo.o5 - lo.8o m	the Cca horizon was mottled with spots, iron and gley
lo.3o - lo.8o m	yellow Cca concretions, size 15 cm Ø
lo.8o - 12.2o m	alluvial clay soil with Cca concretions at the bottom, size 5 - 6 cm Ø
from 11.6o m	brownish-yellow coloured with a high Cca and carbonate hydroxide content; the lowest horizons were mixed with the underlying red clay

The sand fraction of the ochre-red sandy clay soil consisted mostly of quartz. The parent material during the formation of this soil had probably been a sandy deposit. We have observed that the sandy red soil generally had a brighter red colour than the more clayey red soils.

The percentage ratio of mica increased lower down in the B horizon. During the process of soil formation it had been weathered in the upper horizon. The lower horizon contained more shell fragments.

The parent material of the sandy red clay soil was completely different from that of the underlying alluvial soil. They must have developed from two different types of deposits. The original characteristics of the alluvial soil had undoubtedly been slightly altered by the superimposition of sandy deposits which were gradually transformed into a red forest soil.

Red soil No. 4.

The best developed red soil of the borehole profile was situated between 12 - 15 m /8o.5 - 83.5 m a.s.l. Dv_4/. This red clay soil had the darkest colour /5 YR 5/6/ among the red soils and it may be subdivided into B - BC - Ca horizons.

The three meter thick formation gradually became lighter lower down, however, it had retained its red colour throughout. In a moist state the colour had a purple tint. The soil had a high clay content /5o - 6o per cent/. During the process of soil formation the clay mineral content must have increased by more than 1o per cent. The ratio of the sand fraction was also significant /22 - 32 per cent/, however it consisted mostly of Fe and silt aggregates and Cca concretions. After all these particles had been removed, the ratio of remaining quartz sand was only 1o - 15 per cent.

Description of the section between 12.2o - 2o.2o m

12.2o - 12.3o m	the red soil was mixed with the overlying alluvial soil
12.3o - 13.25 m	B horizon of a bright, dark-red clay soil /5 YR, 6/6, 5/6/ with Cca concretions in some places. The darker and brighter coloured spots marked former Krotovinas
13.25 - 13.85 m	BC horizon of the red clay mottled with carbonate spots and changed to /7.5 YR 6/4/ in the lower levels
13.85 - 14.85 m	the colour of the C horizon gradually changed to pink; it contained small Cca concretions and precipitates and krotovinas
14.85 - 15.45 m	dark-yellow clay with Cca veins and precipitates
15.45 - 16.5o m	lighter yellow silty clay with Fe spots and Cca veins
16.5o - 17.45 m	greyish-yellow, friable, silty clay with mica and Cca nodules
17.45 - 18.35 m	the reddish coloured clay obtained its colour because of the abundance of Fe precipitates; it contained Fe and Cca nodules and shell fragments. At some places it had a brownish tint. Most probably it had been an alluvial clay
18.35 - 2o.2o m	it was very similar to the above described formation only it contained more mica and shell fragments

The development of <u>Red soil No. 4.</u> was followed by the formation of an alluvial soil /between 84.o - 85.9 m a.s.l./ which might indicate the intermittent occurence of subsidence.

The physical and chemical characteristics of the 8 m thick clayey formation below red soil No. 4. were almost uniform throughout. Towards the middle part the Fe nodules, Cca concretions and micas became more abundant, the Fe and Mg precipitates more common. Due to the presence of Mg the clay obtained a brownish tint. Molluscan shell fragments were discovered in large quantity which would indicate that the material had been deposited in a marshy environment, probably on a flood-plain.

<u>Red soil No. 5.</u>

The fifth red clay soil formation was situated between 23.1 - 24 m in the profile /Fig. 1. Dv_5/ and interrupted the development of the above outlined clayey-marshy-alluvial sequence. The horizon of this forest soil had been eroded and only the BC and Ca horizons could be reconstructed. Its clay content was more than 6o per cent. Its parent material had been rich in clay, gley and Cca concretions.

Description of the section between 2o.2o - 28.2o m

2o.2o - 23.1c m	pale-brownish-yellow heavy clay with grey gleyey spots, shell fragments, a low carbonate content and few micas
23.1o - 23.5o m	lower BC horizon of the light ochre-coloured forest soil /Dv_5/
23.5o - 24.8o m	pale ochre-coloured Ca horizon with concretions, size 3 cm Ø
24.8o - 26.45 m	gleyey heavy clay with brown Fe spots
26.45 - 26.6o m	a 15 cm thick black clay horizon /most probably meadow soils/
26.6o - 28.2o m	clay with mica, interlayered with thin sandy strata

Red soil No. 6.

A more than two meter thick fossil soil was found at a depth of 3o.6 - 32.8 m in the borehole profile /63 - 65.1 m a.s.l.; Fig. 1. Dv_6/. In the soil profile sand and clay fraction dominated. This red clayey sandy soil was situated in between such stratified deposits, in the grain size composition of which sand was also the dominant constituent. Directly on top of red soil No. 6. an incomplete profile /2o cm thick/ of a black meadow /marshy/ soil had been discovered. It was probably eroded during the deposition of the sands. The sand fraction in the red soil was 48 per cent but it consisted mostly of aggregates, Fe nodules, carbonate and silt concretions. The soil had no well developed Cca horizon. Directly below the red soil stratified sand layers /4o - 8o per cent/ were found. The clay content and distribution of carbonates was the same throughout the soil profile. Thermal analysis revealed that the soil was rich in organic matter /o.6 per cent/.

Description of the section between 28.2 - 36.5 m

28.2o - 28.7o m	yellowish stratified sandy clay with mica and Fe spots
28.7o - 3o.35 m	yellowish stratified clayey sand with mica Fe, Mg nodules /size 3 cm Ø and carbonate concretions
3o.35 - 3o.65 m	black meadow clay with dolomite and Mg nodules
3o.65 - 32.75 m	red clayey sandy soil that gradually attained a lighter colour in the lower levels; neutral ph value /D_{v6}/
32.75 - 36.1o m	yellow, stratified clayey, silty sand. Fe nodules and aggregates. Micas were found among the quartz grains; medium size sand grains dominated
36.1o - 4o.oo m	supposedly Upper-Pannonian stratified fine sand with a high carbonate content

The stratigraphic sequence described from the Dunakömlőd 1977/1 borehole showed a striking resemblance to the sequence found in the bore drilled on the Danube flood-plain at the foot of the Dunaföldvár loess bluff. Hence we consider them to be chronologically of the same age /o.8 - 2.2 million years

B. P./. There are, however, some local differences. In the Dunaföldvár profile /at the present day water level of the Danube 89 - 85 m a.s.l./ a 2 m thick black-grey carbonate meadow soil was discovered. In the Dunakömlőd profile the red soils are interstratified with thick layers of sedimentary deposits. Here the clay and silt strata between the D_{v5} and D_{v6} soils were interrupted by two thin meadow soil horizons. Both the Dunaföldvár and the Dunakömlőd profiles exhibited a silty, clayey stratigraphic sequence with six fossil red soil interbeddings. In both places these formations overlie laminated, finely stratified sand rich in mica, probably Upper Pannonian sediment formation in a similar development.

2. Paleomagnetism of the Dunakömlőd 1977/1 borehole

The exposure in the high loess bluff at Paks displays the whole stratigraphic sequence of the young loess series and an incomplete series of the old loess. The oldest formation known from the foot of the exposure is the so called "Paks-Lower" Double Soil Complex /PD/. According to former paleomagnetic analyses /M. Pécsi - M. A. Pevzner, 1974; P. Márton,1977/ this soil and the overlying 4o m thick series have a normal magnetic polarity.

At about 1.5 km north of Paks, loess may be studied in natural outcrops along the Danube. Thus, the lower stratigraphic sequences /about 6 - 7 m/ of the old loess could be examined near Dunakömlőd /opposite the 1o5 km post on the main road/. Apart from the topmost layer, all samples collected from here /Fig. 2./ showed a reversed magnetization according to M. A. Pvzner /M. Pécsi - M. A. Pevzner, 1974/.

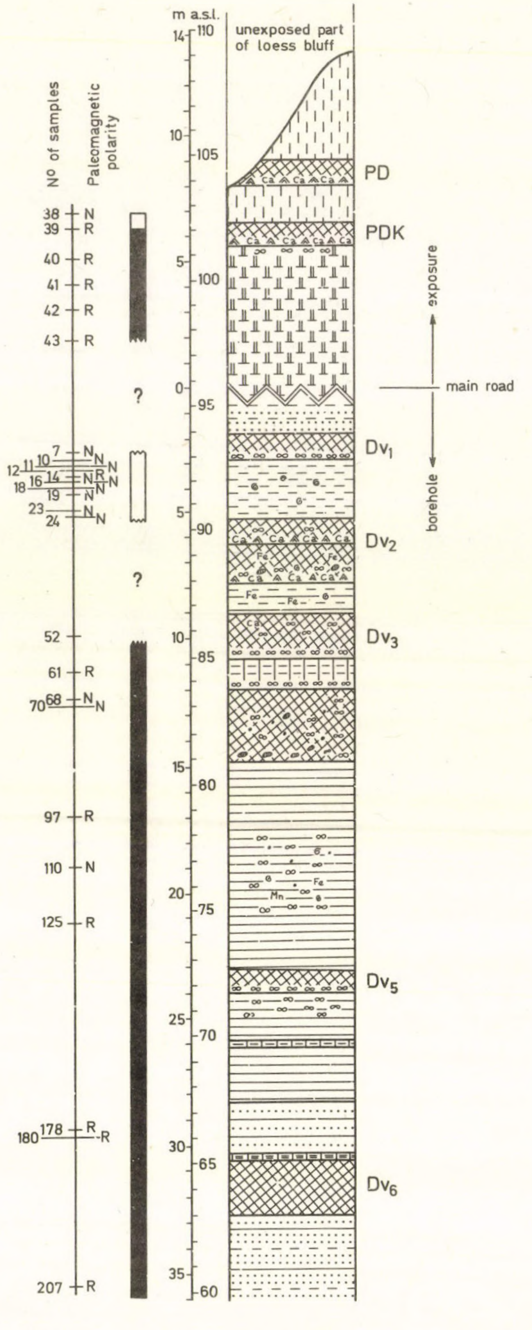

Fig. 2.: Paleomagnetic profile of the Dunakömlőd borehole /M. Pécsi - M.A. Pevzner - P. Márton - E. Szebényi; 38 - 43 samples analysed by M.A. Pevzner, 7 - 2o7 samples analysed by P. Márton/

M. Pécsi and Gy. Scheuer arrived at the conclusion that a 3o - 4o m deep borehole drilled at the foot of the loess bluff near Dunakömlőd should reveal a similar stratigraphic sequence to that described as the "Dunaföldvár Complex" /M. Pécsi et al. 1977/. Earlier investigations around Paks indicated in some borehole profiles the existence of Pannonian sands directly below the loess series /P. Kriván, 196o/.

Each core was cut into two along its vertical axis and inspected whether it had been disturbed by the drilling operation. Unfortunately the majority of cores had to be discarded due mainly to infiltrating mud along bedding planes that caused differential rotation of thin bands in the core.

The 2o cores selected for sampling were apparently free from such effects /Table 1./.

As each paleomagnetic sample consisted of two specimens both were demagnetized in AF-fields at 8o, 16o, 25o Oe and one also at 4oo Oe. The magnetization of the core specimens is generally softer than the magnetization of similar samples from open exposures; however, a relatively stable component could be isolated after demagnetization between 16 to 4o mT peak fields. Further demagnetization in higher fields usually resulted in magnetic noise only.

The magnetic polarities of the core samples /see in Table 1./ are plotted below ground level /i. e. below 96 m a.s.l.; Fig. 2./. The polarities plotted above ground level are those obtained by Pevzner /1974/ from the open exposure at the same site.

In the upper 5.2 m thick section of the borehole profile only one sample had a reversed magnetization which, however, is inconsistent with the normal magnetization of the surrounding eight samples. Between 16.8 and 35.4 m one normal and five reversed magnetizations were recorded, but the presence of a normal magnetic polarity in this section seems to be anomalous.

Table 1. Location of samples in the Dunakömlőd 1977/1 borehole profile selected for paleomagnetic analysis

Sample code	Location of sample in the profile /depth in m from present-day surface/	Formation
7	2.45--2.55	carbonate soil horizon /Dv_1/
1o	2.85—2.95	silty clay
11	2.95—3.1o	"
12	3.1o—3.25	"
14	3.35—3.5o	"
16	3.6o—3.75	"
18	3.95--4.1o	"
19	4.15—4.3o	clayey sand
23	4.5o--5.o5	"
24	5.o5—5.2o	"
52	9.75—9.9o	sandy clay soil
61	11.15—11.3o	alluvial clay soil
68	12.2o—12.35	"
7o	12.5o—12.65	clay
97	16.8o—16.95	silty clay
11o	18.75—19.oo	clay
125	21.1o—21.25	clay
178	29,15—29.3o	clayey sand
18o	29,45—29.6o	"
2o7	35,25—35.4o	clayey, silty sand

Between 9.75 m and 12.65 m samples display a transitional direction /I∼ 0/ at 9.75 - 9.9o m, a reversed direction at 11.15 - 11.3o m, and normal directions at 12.2 - 12.35 m and 12.5 - 12.65 m, respectively.

However, the dominant component of these normal magnetizations is an order of magnitude stronger than that of the other cores and this is probably of viscous origin. Thus, as a first interpretation of the borehole results the presence of only two polarity epochs, an upper normal and a lower reversed, is suggested here. As the 6 m thick loess layer above ground level has been correlated, because of its reversed magnetic polarity, with the old loess below the PD soil at Paks brickyard M. Pécsi, 1977/, the polarity sequence on Fig. 1. is thought to represent the youngest Matuyama epoch /R/, the Jaramillo-event /N/ and the Matuyama-epoch /R/ preceding the Jaramillo.

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THERMAL ANALYSIS OF FOSSIL RED SOILS FROM THE DUNAKÖMLŐD 1977/1 BOREHOLE

Mrs. Pécsi, É. Donáth

The samples of the "ochre-coloured" fossil soil marked Dv-1. in the core /Fig. 1./ contain several types of clay minerals, illite, montmorillonite, kaolinite and chlorite in smaller quantities. Their total clay mineral content amounts to 45 per cent on the average. The quantity of illite exceeds that of montmorillonite. Dolomite and calcite content is 4 per cent, the quantity of hydrous oxides of iron 1.3 per cent is relatively high, and there is a considerable amount of organic matter /about o.5 per cent/ present. In the course of soil formation the clay mineral content may have increased by about 15 per cent.

In the double red soil /soil complex/ marked Dv-2. /Fig. 1./ montmorillonite predominates but a remarkable quantity of kaolinite /lo per cent/ and chlorite are also found. In three samples taken from this soil the quantity of kaolinite is around lo per cent and they also contain chlorite.The total clay mineral content is about 48 per cent. Calcite is abundant and the quantity of dolomite increases with depth, but in the lowest horizon it decreases once more. The quantity of pyrite decreases downwards, in the lowermost horizon, no pyrite was found. Hydrous oxides of iron can be considered to have a constant medium quantity in these samples /1.17 per cent/. Organic matter, however, was found in greater amount only in the lower horizon of the double soil /o.3 per cent/.

In the "red soil" marked Dv-3 /9.1 - 9.75 m/ the amount of montmorillonite hardly exceeds that of illite. The total

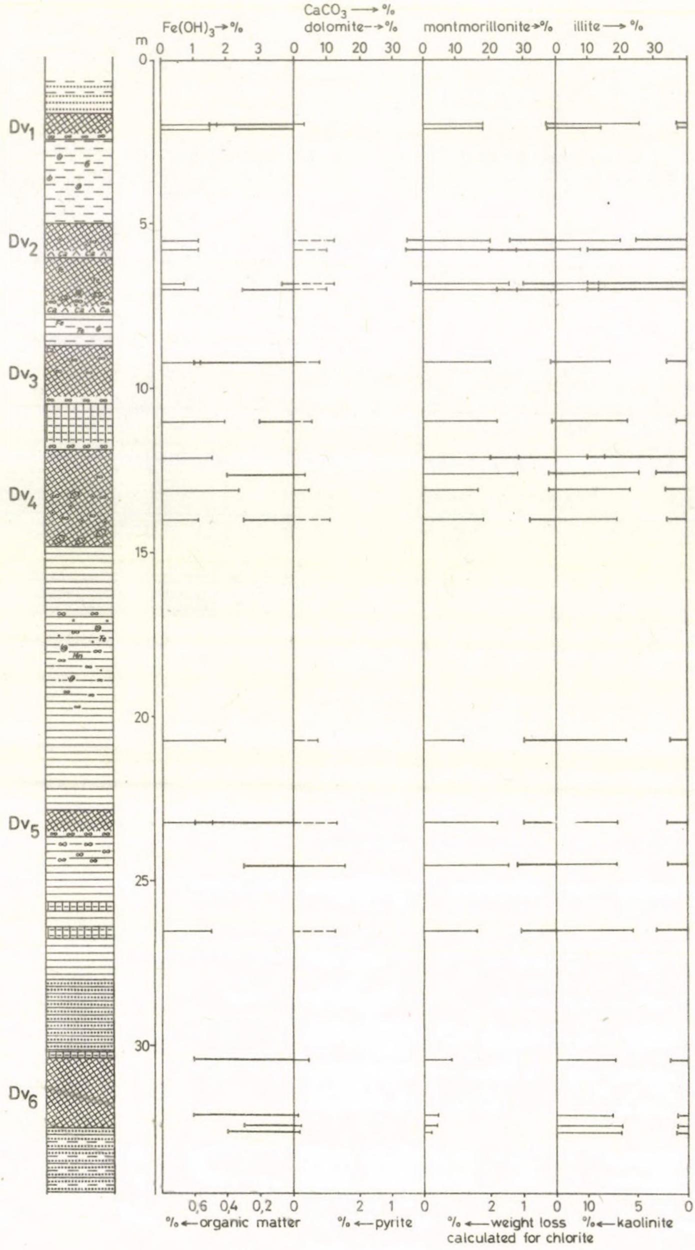

Fig. 1.: Thermal analysis of the fossil red soils of the Dunakömlőd borehole

clay mineral content is around 43 per cent, of which illite is 19 per cent and montmorillonite is 22 per cent. Kaolinite is less, /1 to 2 per cent/ and the quantity of chlorite is also small. The amount of dolomite and calcite are relatively high /10.4 per cent on the average/, while the quantity of hydrous oxides of iron is high /1.4 per cent/. Among all the red soils the highest organic matter content /0.6 per cent/ was found in the upper part of the B-horizon of this soil.

The total clay mineral content in the sample collected from the "alluvial soil" /11.0 - 11.3 m/ is about 44 per cent, illite predominates /22 per cent/, it is also rich in montmorillonite /21 per cent/. The quantity of kaolinite / 1 per cent/ and of chlorite /0.1 per cent/ is generally low. Similarly, dolomite and calcite are also present in only a small quantity /6 per cent/. However, the quantity of hydrous oxides of iron is high /1.97 per cent/ and the relatively small amount of organic matter /0.2 per cent/ relates to weaker soil formation.

Four samples were obtained from the approx. 3 m thick "red clay soil" marked Dv-4. /12.05 - 12.2 m; 12.5 - 12.8 m; 13.1 - 13.25 m; 13.85 - 14.15 m/. The total clay mineral content of the samples proved to be of about 48 per cent. The proportion of illite is 25 per cent, that of montmorillonite about 22 per cent. Kaolinite occurs in a quantity of 2 to 10 per cent and much chlorite was also found. The clay mineral content of the soil slightly decreases downwards. The amount of hydrous oxides of iron is significant /1 to 2 per cent/and is exceptionally high /2.3 per cent/ in the middle part of the soil; the quantity of calcite is low /2 to 4 per cent/. In the upper part of the soil dolomite and calcite are more abundant /11 per cent/. Organic matter was found in the 2nd and 4th sample of the soil profile /0.3 to 0.4 per cent/.

Only one sample was analysed from the "red soil" marked Dv-5. /23.1 - 24.8 m/. The total clay mineral content is about 59 per cent, of which illite is 25 per cent and montmorillonite about 32 per cent. The quantity of kaolinite is about 2 per cent, weight loss indicating chlorite content amounts to 1.7 per cent. The ratio of dolomite and calcite represents about 1o per cent. The amount of hydrous oxides of iron is 1.6 per cent and an extremely high organic matter content was found /o.6 per cent/.

Between the red soils marked Dv-4 and Dv-5 a nearly homogenous layer is found about 8 m /15.1 - 23.1 m/, it is a pale brownish-yellow gleyey clay with grey spots and is poor in mica and rich in molluscan shell fragments. The total clay mineral content of the sample from this layer /2o.5 - 2o.95 m/ amounts to about 49 per cent; from this illite is 23,montmorillontie 12, kaolinite about 2 per cent. No organic matter was found. The quantity of hydrous oxides of iron is much /2 per cent/, chlorite is of medium quantity.

The red soil marked Dv-5 is underlain by a clay formation of 4 m thickness, interrupted by a 15 - 2o cm thick black meadow clay soil /between 26.4 - 26.6 m/. The clay horizon is underlain by a 2 m thick stratified sand which is separated from the underlying 6th red soil Dv-6 by a thin black meadow clay soil /3o.35 - 3o.55 m/. The two black soils were thermally analysed for comparison.

The total clay mineral content of the first black soil is about 44 per cent, that of the second black soil is about 29 per cent.

The proportions of the different clay and other minerals are the following:

	26.45 - 26.6 m	30.35 -30.55 m
Illite /%/	24.36	19.00
Montmorillonite /%/	16.00	8.00
Kaolinite /%/	3.00	2.5
Chlorite /%/	1.1	-
Calcite /%/	11.92	4.6
Hydrous oxides of iron /%/	1.58	-
Organic matter /%/	-	0.6

The essential difference between the two black soils is that the first does not contain organic matter but contains a considerable amount of hydrous oxides of iron. It can be assumed that the lack of organic matter is caused by intensive oxidation.

The total clay mineral content of the "red clay" marked Dv-6 /32.0 - 32.75 m/ is 24 per cent on average, i.e. less than that of the overlying "black meadow clay". Illite is present in a much higher quantity /about 20 per cent/ and the montmorillonite content is relatively low: only 5 per cent on average. Kaolinite is also less than 1 per cent, chlorite is absent. Calcite is 1.9 per cent, the organic matter content is high: 0.4 to 0.6 per cent. In all red fossil soils of the borehole profile considerable amount of hydrous oxides of iron have been found, however, it could not be determined in the sample from soil Dv-6. The iron is probably present in the form of oxides.

In all samples taken from the red soils and intercalated silty-clayey strata of the Dunakömlőd 1977/1 borehole the illite, montmorillonite and kaolinite could be found. Kaolinite occurs in most samples, it is of 1 to 2 per cent, except in the fossil red clay soils marked Dv-2 and Dv-4 in which its quantity proved to be almost 1o per cent. It is to be emphasized that in all red soils a considerable amount of organic matter could be identified /o.3 to o.6 per cent/. Pyrite, however, could be determined in a small quantity only in the red soils marked Dv-2. In the red soils lying deeper than this horizon it could not be found. On the other hand in all fossil soils of the Paks loess exposure, pyrite could be identified. This phenomenon can be interpreted by the fact that the conditions of formation of red soils promoted the oxidation of iron to its ferric form consequently, during the formation of red soils seasonally wet and warm, but generally dry climatic conditions predominated.

MINERALOGICAL COMPOSITION OF THE DUNAKÖMLŐD PROFILE

V. Codarcea

For each sample 1oo gr raw material was used, washed in running water on a o.o6 mm sieve. The residue on the sieve was alternatively boiled in water and HCl /17 per cent concentration/ and then dried and sieved, classified into four granulometric fractions: o.5o - o.25 mm; o.25 - o.16 mm; o.16 - o.1o mm and o.1o - o.6 mm. Each fraction was weighed and separated by bromoform; the residue was weighed again and fixed in Canadian balsam.

One sample /No. 3o3o/ contains lamellibranchiate remnants.

From the granulometric point of view /Table 1./ the following conclusions can be drawn:

- out of nine samples collected from the intercalated paleosoil, in four the predominance of the granulometric fractions smaller than o.16 mm could be observed; in three samples the coarse fractions are found in quantities equal to the fine ones and the fractions coarser than o.16 mm predominated only in two samples;
- the granulometric fraction occurs in almost equal quantities in the sandy intercalations;
- the fine granulometric fractions predominate in the clayey intercalations;
- the coarse granulometric fractions are absent in loesses;
- the two coarser fractions are poorer in heavy minerals;
- the weights obtained as the result of the separation with bromoform are very small.

Table 1. Results of granulometric measurements from the Dunakömlőd 1977/1 borehole

Investigated profile	Sample number	Sample weight	Granulometrical classes	Weight of sandy fraction	Weight of heavy fraction	Weight percentage of heavy mineral fraction related to sand fraction
Dunakömlőd	3007	100 gr	0,50-0,25	1,8624 gr	0,0636 gr	3,41
			0,25-0,16	1,5002 gr	0,0296 gr	1,97
			0,16-0,10	1,7601 gr	0,0532 gr	3,02
			0,10-0,06	13,0046 gr	0,2506 gr	1,92
"	3015	100 gr	0,25-0,16	2,7432 gr	0,0620 gr	2,26
			0,16-0,10	2,5640 gr	0,0402 gr	1,56
			0,10-0,06	12,0098 gr	0,0801 gr	0,66
"	3020	100 gr	0,16-0,10	0,5027 gr	0,0710 gr	14,12
			0,10-0,06	4,0012 gr	0,2300 gr	5,74
"	3031	100 gr	0,50-0,25	4,1573 gr	0,2854 gr	6,86
			0,25-0,16	9,3765 gr	0,1136 gr	1,21
			0,16-0,10	9,4293 gr	0,2752 gr	2,91
			0,10-0,06	9,1243 gr	0,4178 gr	4,57
"	3040	100 gr	0,50-0,25	1,2074 gr	0,0688 gr	5,69
			0,25-0,16	3,1305 gr	0,0166 gr	0,53
			0,16-0,10	3,1442 gr	0,0376 gr	1,19
			0,10-0,06	7,7998 gr	0,1912 gr	2,45
"	3047	100 gr	0,50-0,25	3,0574 gr	0,0162 gr	0,52
			0,25-0,16	4,4356 gr	0,0693 gr	1,56
			0,16-0,10	5,9805 gr	0,0681 gr	1,13
			0,10-0,06	3,4967 gr	0,0375 gr	1,07
"	3052	100 gr	0,50-0,25	4,0572 gr	0,0492 gr	1,21
			0,25-0,16	11,6053 gr	0,0281 gr	0,24
			0,16-0,10	10,2103 gr	0,0772 gr	0,75
			0,10-0,06	8,0458 gr	0,2391 gr	2,97
"	3061	100 gr	0,50-0,25	4,5471 gr	0,0302 gr	0,66
			0,25-0,16	8,1639 gr	0,0216 gr	0,26
			0,16-0,10	7,4050 gr	0,1201 gr	1,62
			0,10-0,06	7,3016 gr	0,1300 gr	1,78
"	3066	100 gr	0,50-0,25	3,0475 gr	0,0602 gr	1,97
			0,25-0,16	5,2698 gr	0,1110 gr	2,10
			0,16-0,10	6,0054 gr	0,1496 gr	2,49
			0,10-0,06	7,0304 gr	0,1806 gr	2,56
"	3072	100 gr	0,50-0,25	1,1762 gr	0,0884 gr	7,51
			0,25-0,16	2,2498 gr	0,0568 gr	2,52
			0,16-0,10	3,3572 gr	0,0262 gr	0,78
			0,10-0,06	4,1346 gr	0,1370 gr	3,31
"	3077	100 gr	0,16-0,10	3,1456 gr	0,0502 gr	1,59
			0,10-0,06	10,6210 gr	0,1208 gr	1,14
"	3081	100 gr	0,50-0,25	1,2136 gr	0,0469 gr	3,86
			0,25-0,16	2,1475 gr	0,0526 gr	2,45
			0,16-0,10	4,2980 gr	0,0868 gr	2,01
			0,10-0,06	6,6431 gr	0,2582 gr	3,88
"	3086	100 gr	0,16-0,10	5,4302 gr	0,0623 gr	1,15
			0,10-0,06	9,5423 gr	0,1423 gr	1,49
"	3090	100 gr	0,50-0,25	4,0702 gr	0,0511 gr	1,25
			0,25-0,16	11,5687 gr	0,0082 gr	0,07
			0,16-0,10	14,3124 gr	0,1801 gr	1,26
			0,10-0,06	10,0045 gr	0,2106 gr	2,10
"	3099	100 gr	0,50-0,25	1,5312 gr	0,0602 gr	3,93
			0,25-0,16	13,0574 gr	0,0944 gr	0,72
			0,16-0,10	16,1452 gr	0,1602 gr	0,99
			0,10-0,06	10,7501 gr	0,3686 gr	3,42
"	3103	100 gr	0,50-0,25	1,0987 gr	0,0906 gr	8,25
			0,25-0,16	6,0052 gr	0,3226 gr	5,37
			0,16-0,10	9,1007 gr	0,2336 gr	2,56
			0,10-0,06	13,1219 gr	0,0506 gr	0,38
"	3107	100 gr	0,50-0,25	1,4037 gr	0,1647 gr	11,73
			0,25-0,16	2,2354 gr	0,0164 gr	0,73
			0,16-0,10	3,0375 gr	0,2431 gr	8,00
			0,10-0,06	3,0503 gr	0,2766 gr	9,06
"	3112	100 gr	0,50-0,25	4,5207 gr	0,0692 gr	1,53
			0,25-0,16	9,5062 gr	0,0623 gr	0,65
			0,16-0,10	40,6700 gr	0,0638 gr	0,15
			0,10-0,06	14,0043 gr	0,1622 gr	1,15

From the mineralogical point of view /Table 2./ the two granulometric fractions proved to be not too rich in heavy minerals:

- the fractions finer than o.16 mm are more abundant concerning both the number of heavy minerals and the mineral types;

- the greatest quantity of opaque minerals /represented by magnetite, hematite, limonite, and seldom ilmenite/ is found in the upper part of the profile, depending on the lithological composition of the sediment /loess, clays or sands/;

- garnets /almandine and grossularite varieties/ and the epidote-zoisite group predominate among the minerals of the heavy fraction. The greatest quantities of garnets were determined mainly in the o.16 - o.1o mm fraction /except the samples of the clayey intercalations, i. e. sample No. 3o61, 3o81/. Garnets accumulate in coarse fraction in percentages ranging from 23.8o to 43.24 per cent. The greatest percentage value - 48.19 per cent - for the whole profile was found in the loess sample /No. 3o15/, in the same o.16 - o.1o mm fraction representing the highest average value of the whole profile; the basal sands /sample No. 3112/ contain very small quantities of garnets, in case of paleosoils average values were registered.

The epidote-zoisite group shows the lowest values in clays, except the o.16 - o.1o mm fraction, the clayey sample /No. 3o86/, where the grain percentages are of 61.78 per cent. The lowest quantitative accumulation, 9.37 per cent, was observed in the loess sample 3o15.

The circulations of solutions with cations which is more intense in paleosoils than in loesses, promotes the weathering of minerals. The minerals which are resistant to chemical influences accumulate in paleosoils. The marked accumulation of epidote and zoisite in paleosoils can be explained either

Table 2. Results of granulometric and micromineralogical analysis of the Dunakömlőd 1977/1 borehole. Fragments of lamellibranchiate were found in sample No.3040, chloritoide was only found in sample No.3072 /in fraction size 0,10-0,06 mm/

Sample number	Depth /m/	Granulometric classes /mm/	opaques	corundum	rutile	brookite	garnets	zircon	monazite	kyanite	staurolithe	titanite	epidote-zoisite	tourmaline	pyroxenes: augite-hypersthene	antophyllite	actinolite	hornblende	glaucophane	sillimanite	biotite	chlorite
3007	2,1-2,75	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	22	-	-	-	31	-	-	7	7	-	24	2	-	-	2	-	-	-	-	-
		o,16-o,1o	18	-	-	-	3o	-	1	8	3	-	24	2	-	-	-	4	-	-	-	-
		o,1o-o,o6	26	-	6	-	24	1	-	7	5	1	27	2	-	-	-	12	-	1	-	-
Bulk analysis			22	-	2	-	28,3	o,2	o,3	7,3	5	o,3	25	2	-	-	-	6	-	o,3	-	-
3015	4,45-4,08	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,16-o,1o	9	-	-	1	48	1	5	7	3	-	5	3	-	1	-	16	-	1	-	-
		o,1o-o,o6	23	-	9	-	26	2	2	9	2	1	14	4	1	-	1	7	-	1	-	-
Bulk analysis			16	-	4,5	o,5	37	1,5	3,5	8	2,5	o,5	9,5	3,5	o,5	o,5	o,5	11,5	-	1	-	-
3020	6,05-6,35	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,16-o,1o	-	-	-	-	33	-	-	-	17	-	33	-	17	-	-	-	-	-	-	-
		o,1o-o,o6	22	-	-	-	22	-	-	11	6	-	22	-	-	-	-	12	-	-	-	6
Bulk analysis			11	-	-	-	27,5	-	-	5,5	11,5	-	27,5	-	8,5	-	-	6	-	-	-	3
3031	9,25-9,40	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	8	-	-	-	19	-	-	6	1o	-	28	-	-	-	2	15	-	3	-	-
		o,16-o,1o	11	-	2	-	28	1	-	17	12	1	2o	-	-	1	-	6	1	-	-	1
		o,1o-o,o6	17		4		22	7	1	9	5		27	2	-	-	-	5	-	-	-	-
Bulk analysis			15	-	2	-	23	2,5	o,3	1o	9	o,6	25	o,6	-	o,3	o,6	9	o,3	1	-	-
3040	11,-11,3	o,5o-o,25	33	-	-	11	11	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-
		o,25-o,16	2o	-	2	-	16	-	-	2	2	-	4o	4	-	-	-	4	-	2	-	-
		o,16-o,1o	11	-	2	-	24	2	-	1o	11	2	28	2	2	-	-	2	-	-	-	1
		o,1o-o,o6	21	1	4	1	17	2	1	7	5	1	32	2	1	-	-	-	-	1	-	5
Bulk analysis			21	o,2	2	3	17	1	o,2	5	4	o,5	28	2	1	-	-	2	-	1	-	2
3047	12,5-12,8	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	12	-	-	-	3o	-	-	17	14	4	21	-	-	-	-	2	-	-	-	-
		o,16-o,1o	-	-	3	-	41	-	-	2	8	3	32	5	-	-	-	5	-	-	-	-
		o,1o-o,o6	15	-	6	-	17	1	-	1o	7	1	29	1	1	-	-	1	-	-	-	-
Bulk analysis			9	-	3	-	29	o,3	-	9	13	3	27	2	o,3	-	-	3	-	-	-	-

Table 2. /Continuation/

Sample number	Depth /m/	Granulometric classes /mm/	opaques	corundum	rutile	brookite	garnets	zircon	monazite	kyanite	staurolithe	titanite	epidote-zoisite	tourmaline	pyroxenes: augite-hyperstene	antophyllite	actinolite	hornblende	glaucophane	sillimanite	biotite	chlorite
3052	13,85-14,15	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	7	-	2	-	27	-	-	15	5	-	42	2	-	-	-	-	-	-	-	-
		o,16-o,1o	11	-	1	-	24	-	1	14	12	1	32	-	-	-	1	2	-	-	-	-
		o,1o-o,o6	8	-	6	-	28	2	1	1o	5	1	37	1	-	-	-	-	-	-	-	-
Bulk analysis			8	-	3	-	26	o,7	o,7	13	7	o,7	37	1	-	-	o,3	o,6	-	-	-	-
3061	17,45-18,05	o,5o-o,25	-	-	-	-	43	-	-	14	-	-	14	-	-	-	-	14	-	14	-	-
		o,25-o,16	11	-	-	-	47	-	1	13	1o	-	11	3	-	-	-	1	-	3	-	-
		o,16-o,1o	25	-	1o	-	27	2	1	17	1o	-	7	2	-	-	-	1	-	-	-	-
		o,1o-o,o6	15	-	3	-	24	-	-	13	16	2	23	4	-	-	-	3	-	-	-	-
Bulk analysis			12	-	3	-	35	o,5	o,5	14	9	o,5	13	2	-	-	-	5	-	4	-	-
3066	19,00-19,30	o,5o-o,25	-	-	-	-	25	-	-	-	-	-	5o	-	-	-	-	25	-	-	-	-
		o,25-o,16	7	-	-	-	3o	-	-	19	15	-	11	11	-	-	-	4	-	-	-	-
		o,16-o,1o	8	-	3	-	31	1	-	25	17	-	11	-	-	-	-	3	-	-	-	-
		o,1o-o,o6	16	-	7	-	22	1	2	12	12	-	26	3	-	-	-	3	-	-	-	-
Bulk analysis			8	-	2	-	27	o,5	o,5	14	11	-	24	3	-	-	-	8	-	-	-	-
3072	20,95-21,40	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	1o	-	-	-	33	-	-	12	24	-	12	2	-	-	-	7	-	-	-	-
		o,16-o,1o	5	-	2	-	31	-	-	18	1o	-	2o	2	-	-	-	9	1	1	-	-
		o,1o-o,o6	11	-	5	-	31	4	1	12	14	-	18	1	-	-	-	2	-	2	-	-
Bulk analysis			9	-	2	-	32	1	o,3	14	16	-	16	2	-	-	-	6	o,3	1	-	-
3077	23,1-23,35	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	-	-	37	-	-	11	5	-	47	-	-	-	-	-	-	-	-	-
		o,16-o,1o	1o	-	3	-	28	-	-	8	24	-	22	1	-	-	-	4	-	-	-	-
		o,1o-o,o6	11	-	7	-	28	5	2	9	7	-	28	2	1	-	-	1	-	-	-	-
Bulk analysis			7	-	3	-	31	2	o,7	9	12	-	32	1	o,3	-	-	2	-	-	-	-
3081	24,2-24,80	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	-	-	43	-	5	19	19	-	8	-	-	-	-	5	-	-	-	-
		o,16-o,1o	13	-	2	-	24	-	-	18	14	-	25	-	-	-	-	3	1	-	-	-
		o,1o-o,o6	8	-	4	6	25	6	-	8	6	-	27	-	-	-	-	1o	2	-	-	-
Bulk analysis			7	-	2	2	31	2	2	15	13	-	2o	-	-	-	-	6	1	-	-	-

Table 2. /Continuation/

Sample number	Depth /m/	Granulometric classes /mm/	opaques	corundum	rutile	brookite	garnets	zircon	monazite	kyanite	staurolithe	titanite	epidote-zoisite	tourmaline	pyroxenes: augite-hyperstene	antophyllite	actinolite	hornblende	glaucophane	sillimanite	biotite	chlorite
3086	26,60-27,05	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,16-o,1o	2	-	-	-	12	-	-	1o	1o	-	62	2	-	-	-	3	-	-	-	-
		o,1o-o,o6	7	-	8	-	15	2	1	1o	1o	1	41	4	-	-	-	1	-	-	-	-
Bulk analysis			4	-	4	-	13	1	o,5	1o	1o	o,5	51	3	-	-	-	2	-	-	-	-
3090	28,25-28,70	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	-	-	3	-	31	-	-	19	12	-	25	2	-	-	-	3	-	3	2	-
		o,16-o,1o	12	-	-	1	22	-	1	15	1o	1	38	1	-	-	-	-	-	-	-	-
		o,1o-o,o6	24	-	7	-	24	3	-	8	1o	1	2o	2	1	-	-	2	-	-	-	-
Bulk analysis			12	-	3	o,3	26	1	o,3	14	11	1	27	2	o,3	-	-	2	-	1	1	-
3099	31,10-31,25	o,5o-o,25	-	-	13	-	38	-	-	-	-	-	38	13	-	-	-	-	-	-	-	-
		o,25-o,16	15	-	-	-	15	-	2	17	15	-	32	2	-	-	-	2	-	2	-	-
		o,16-o,1o	12	1	7	-	12	-	-	11	13	1	4o	1	-	-	-	1	-	-	-	-
		o,1o-o,o6	19	-	2	1	19	1	-	4	8	-	35	1	-	-	-	2	-	-	-	-
Bulk analysis			12	o,2	5	o,2	21	o,2	o,5	8	9	o,2	36	4	-	-	-	1	-	o,5	-	-
3103	32-32,15	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	18	-	9	9	9	-	-	9	9	-	36	-	-	-	-	-	-	-	-	-
		o,16-o,1o	14	-	3	-	14	1	2	14	7	-	37	5	-	-	-	2	-	1	-	-
		o,1o-o,o6	16	-	7	-	9	5	-	6	7	1	45	1	-	-	-	1	-	-	-	-
Bulk analysis			16	-	6	3	11	2	o,6	1o	7	o,3	39	2	-	-	-	1	-	o,3	-	-
3107	32,6-32,75	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	15	-	-	-	-	-	-	6	21	-	47	-	-	-	-	9	-	3	-	-
		o,16-o,1o	17	1	2	1	8	1	1	14	11	1	42	2	-	-	-	-	-	1	-	-
		o,1o-o,o6	21	-	9	-	9	2	3	6	6	2	37	1	-	-	-	2	-	1	-	-
Bulk analysis			17	o,3	4	o,3	6	1	1	8	12	1	42	1	-	-	-	4	-	2	-	-
3112	36,35-36,8	o,5o-o,25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		o,25-o,16	2o	-	-	-	33	7	-	13	-	-	7	7	-	-	-	-	-	-	7	7
		o,16-o,1o	22	-	3	-	12	-	-	22	6	-	29	-	-	-	-	4	-	-	-	1
		o,1o-o,o6	18	-	5	-	3	-	5	23	9	-	19	1	-	-	-	15	-	-	-	-
Bulk analysis			2o	-	3	-	16	2	2	19	5	-	18	3	-	-	-	6	-	-	2	2

by a special abundance of materials rich in these minerals, or by less intense weathering from paleosoils, being rapidly covered by deposits. As a proof we may quote the highest average value of hornblende /11.49 per cent/ found in the loess deposits /sample No. 3o15/. Generally, the hornblende appears in low percentage along the profile due to the scarcity of minerals and not to the alteration of hornblende. Most of epidote derives from metamorphic rocks. /The supposition is also confirmed by the presence of polysynthetic twins of feldspars./

Regarding the kyanite-staurolite group their quantity increases in the sandy intercalations /19.49 per cent - sample No. 3112 and 2o.4o per cent - sample No. 3o9o/; while in the paleosoils their quantity is less than average. Clays contain average amount of these minerals.

The abundance of minerals of mesometamorphic origin /garnets, hornblende, epidote, zoisite, kyanite and staurolite/ can be generally observed, the rest of the minerals of the same origin is poorly represented /actinolite, anthophyllite, sillimanite, biotite/.

Within the group of minerals of eruptive origin /rutile, zircon, monazite, titanite and brookite/ only rutile shows slight percentage increase in paleosoils and clays, and zircon was recorded in three samples /loess sample No. 31o4 and sample No. 3o31 and clays sample No. 3112/ of 2,24, 2.57 and 2.22 per cent. The amount of monazite is very low within the profile with the exception of a sandy sample /No. 3o.81, fraction o.25 - o.16 mm/, it was 5 per cent and 4.93 per cent in the paleosoil sample /No. 3o15, fraction o.16 - o.1o mm/.

Pyroxenes occur rarely, in one sample it is 16.66 per cent /fraction o.16 - o.1o mm/ in the basal paleosoil intercalation it is usually lacking. Pyroxenes belong to the alterable mineral group within the system of multicomponent heavy minerals. The exception mentioned above is probably due to the enrichement of pyroxenes in the source material; the pyroxenes derive from Neogene pyroclastic eruptions. The pyroxenes, though in a small, amount occur relatively frequently in loesses and sands, where the weathering processes are less active.

The same can be said of biotite and chlorite appearing also in very low percentages; they are usually more frequent in loesses and sands.

Other minerals as brookite, tourmaline, actinolite, anthopyllite, corundum, glaucophane, sillimanite and chloritoid scarcely appear.

The shapes of the heavy minerals are shown on Table 3.

The shape of the quartz are shown on Table 4.

Some important problems are as follows:

- the determination of the possible origin of the source material which participated in the formation of this profile, and the initial mineralogical content of that material;

- the establishment, the direction of transport of the material, and the composition of the original material /by methods of statistical mathematical computation in FORTRAN language/;

- the reconstruction of the paleoclimatic conditions during soil formation, that would explain the presence of considerable quantities of epidote-zoiste

- the investigation of the possible correlation between this and other similar profiles.

A composition of the present drainage network with the changes of the hydrological system since the Early Quaternary.

Table 3. Shapes of heavy mineral grains from Dunakömlőd samples /fraction 0.10-0.06 mm./[x]

sample number	opaques			garnets			epidote + zoisite			staurolithe			kyanite			rutile			zircon			tourmaline		
	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered	perfect crystals	rounded	cornered
3007.	-	-	+++	+	+	++	-	+++	-	-	++	-	+	+	-	-	+	-	-	++	-	-	+	-
3015.	-	+++	+	-	+	+	-	++	-	-	+	++	+	++	-	+	+	-	-	+	-	+	-	-
3020.	-	+	+	-	+	+	-	++	-	-	+	+	-	++	-	+	+	-	+	+	-	-	-	-
3031.	+	++	+	+	+	++	-	+++	+	-	+	+	+++	+	-	+	+	-	++	+	-	+	-	-
3040.	-	+++	-	-	+++	+	+	+++	-	-	++	+	++	+++	-	-	++	-	-	+	-	+	-	-
3047.	-	+++	-	+	+++	-	+	++	-	-	+	+	++	++	-	+	-	-	++	+	-	+	-	-
3052.	-	++	++	-	+++	+	++	+	-	-	+	++	+	++	-	+	+	-	-	+++	-	+	+	-
3061.	-	+++	-	-	+++	+	+	+++	-	-	+	+++	+++	+	-	-	++	-	-	+++	-	+	-	-
3066.	-	++	+	-	+++	-	+	++	-	-	+	+	++	+	-	+	++	-	+	++	-	+	+	-
3072.	-	+++	+	-	+++	+	+	+++	-	-	++	+	+	+++	-	+	++	-	+++	+	-	+	-	-
3077.	+	++	+	-	+++	+	+	+	-	-	+	+	+	++	-	+	++	-	+++	-	-	+	-	-
3081.	-	+++	-	-	+++	-	+	++	-	-	++	+	+	++	-	-	+++	-	-	+++	-	-	-	-
3086.	-	+++	+	-	+++	+	+	+++	-	-	++	-	+++	+	-	-	++	-	+++	-	-	+++	+	-
3090.	-	+++	-	+	++	-	+	+++	-	-	++	+	++	+	-	-	++	-	++	+	-	+	+	-
3099.	-	++	-	+	+++	-	+	+++	-	-	+++	-	+++	+	-	+	+	-	+	+	-	+	-	-
3103.	+	+++	-	+	++	-	+	+++	-	-	+	+++	++	+	-	-	++	-	+	+	-	+	+	-
3107.	-	+++	-	-	++	+	-	+++	-	-	+	++	+++	+	-	+	++	-	++	+	-	++	+	-
3112.	-	++	-	-	+	-	+	++	-	-	-	++	++	+	-	+	+	-	-	++	-	+	++	-

+ less frequent
++ more frequent
+++ very frequent
- absent

x we have excluded:
1. the granulometric fractions 0.50-0.25; 0.25-0.16 and 0.16-0.10 mm. which are poor in heavy minerals.
2. the biotite and the chlorite, which appear in basal sections.
3. the hornblende and the pyroxenes group, which usually are in elongated prismatic forms.
4. the monazite and the titanite, usually occuring in grains well rounded, originate from igneous rocks /granites/
5. minerals appearing in a small quantity.

Table 4. Shapes of quartz grains and their weight percentage

Sample number	class	Shapes: rounded	Shapes: subrounded	Shapes: cornered	% ratio of quartz	Average
3007	0.50-0.25	+ +	+++	+ +	88	86
	0.25-0.16	+	+ +	+++	87	
	0.16-0.10	+	+ +	+ +	84	
	0.10-0.06	+	+ +	+++	85	
3015	0.50-0.25	+++	+ +	+	70	59
	0.25-0.16	+++	+ +	+	68	
	0.16-0.10	+++	+	+ +	52	
	0.10-0.06	+	+++	+ +	48	
3020	0.50-0.25	+	+	+++	93	82
	0.25-0.16	+	+	+++	90	
	0.16-0.10	+	+ +	+ +	78	
	0.10-0.06	+	+ +	+ +	66	
3031	0.50-0.25	+	+++	+	90	77
	0.25-0.16	+	+++	+	78	
	0.16-0.10	+	+ +	+ +	70	
	0.10-0.06	+	+ +	+++	72	
3040	0.50-0.25	+++	+ +	–	48	51
	0.25-0.16	+++	+ +	–	48	
	0.16-0.10	+++	+ +	–	48	
	0.10-0.06	+++	+ +	–	60	
3047	0.50-0.25	+ +	+	+++	82	53
	0.25-0.16	+	+ +	+++	60	
	0.16-0.10	+	+ +	+ +	65	
	0.10-0.06	+	+	+++	66	
3052	0.50-0.25	+++	+	+	87	81
	0.25-0.16	+	+	+++	80	
	0.16-0.10	+	+ +	+++	78	
	0.10-0.06	+	+ +	+++	78	
3061	0.50-0.25	+++	+ +	+	53	51
	0.25-0.16	+	+ +	+++	62	
	0.16-0.10	+	+++	+	40	
	0.10-0.06	+++	+ +	+	50	
3066	0.50-0.25	+++	+ +	+	52	47
	0.25-0.16	+++	+ +	+	48	
	0.16-0.10	+++	+	+ +	45	
	0.10-0.06	+	+++	+ +	49	
3072	0.50-0.25	+++	+ +	+	50	48
	0.25-0.16	+++	+ +	+	45	
	0.16-0.10	+++	+	+ +	49	
	0.10-0.06	+	+++	+ +	55	
3077	0.50-0.25	+	+++	+ +	89	87
	0.25-0.16	+	+++	+ +	88	
	0.16-0.10	+	+ +	+++	93	
	0.10-0.06	+	+ +	+ +	79	
3081	0.50-0.25	+++	+ +	+	53	55
	0.25-0.16	+++	+ +	+++	59	
	0.16-0.10	+ +	+ +	+	60	
	0.10-0.06	+++	+++	+	49	
3086	0.50-0.25	+++	+ +	+	50	51
	0.25-0.16	+++	+ +	+++	47	
	0.16-0.10	+++	+++	+	57	
	0.10-0.06	+++	+++	+	51	
3090	0.50-0.25	+++	+	+	56	56
	0.25-0.16	+ +	+ +	+++	52	
	0.16-0.10	+ +	+ +	+	58	
	0.10-0.06	+++	+++	+	60	
3099	0.50-0.25	+ +	+ +	+++	86	82
	0.25-0.16	+	+ +	+++	87	
	0.16-0.10	+	+ +	+++	85	
	0.10-0.06	+	+++	+ +	82	
3103	0.50-0.25	+	+ +	+++	87	86
	0.25-0.16	+	+ +	+++	85	
	0.16-0.10	+	+ +	+++	84	
	0.10-0.16	+	+ +	+++	88	
3107	0.50-0.25	+ +	+++	+	59	62
	0.25-0.16	+ +	+ +	+	69	
	0.16-0.10	+ +	+++	+	61	
	0.10-0.16	+ +	+++	+	60	
3112	0.50-0.25	+++	+	+	68	63
	0.25-0.16	+++	+++	+	60	
	0.16-0.10	+++	+ +	+	62	
	0.10-0.06	+	+ +	+ +	64	

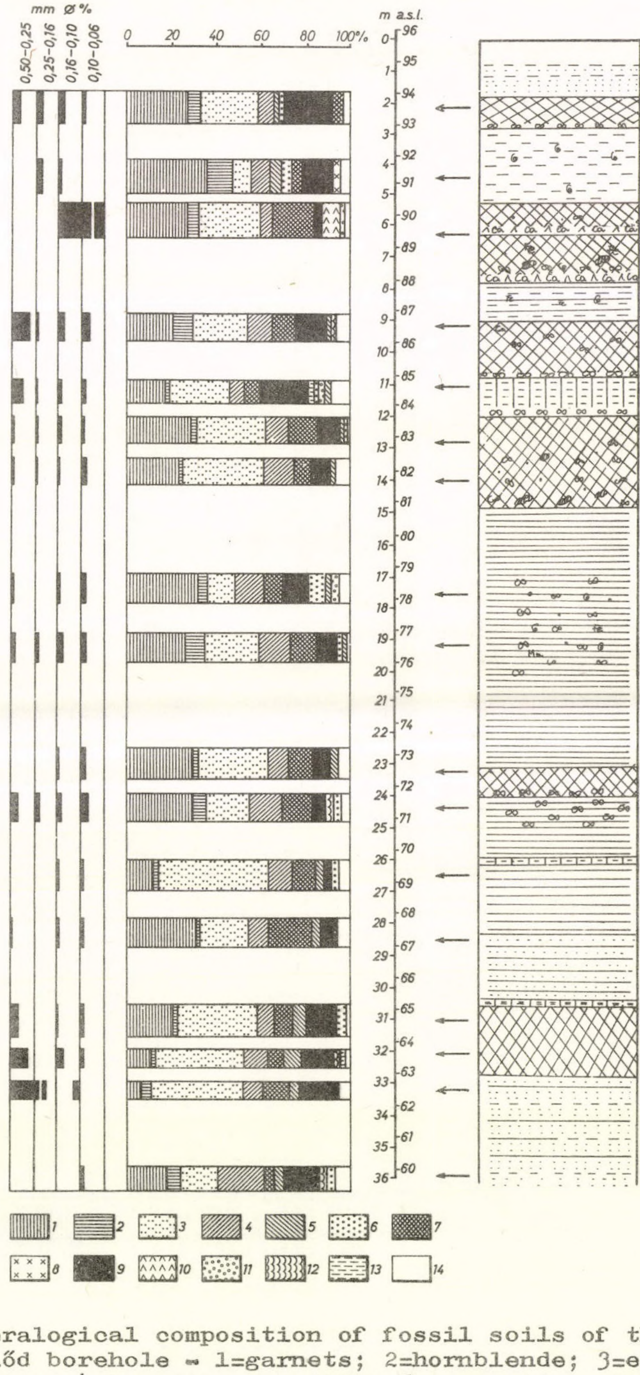

Fig. 1.: Mineralogical composition of fossil soils of the Dunakömlőd borehole - 1=garnets; 2=hornblende; 3=epidote-zoisite; 4=kyanite; 5=rutile; 6=tourmaline; 7=staurolite; 8=monazite; 9=opaques; 1o=pyroxene; 11=chlorite; 12=zircon; 13=brookite; 14=other minerals

MOLLUSCAN FAUNA FROM THE DUNAKÖMLŐD 1977/1 BOREHOLE

M. Wágner

From the 26o core samples 675 molluscs and 3 lamellibranchiates were recovered. The fragile shells of the snails mostly consisted of broken fragments, hence their determination was only possible under a microscope. During quantitative evaluation fragments of at least the size of an average shell were counted as one specimen.

Together with 456 individuals of ubiquitous gastropods 128 specimens of Chondrula and Abida were found. This is a relatively high ratio of thermophiles. In addition 2 hygrophile and 14 specimens of water species, a lamellibranchiate and 1 specimen of Catinella arenaria, a Pleistocene species now extinct, were also discovered.

The bore contained no molluscs in between 36.oo - 28.25 m.

12 Trichia hispida and 8 Vallonia specimen were found in the material between 28.25 - 24.oo m. These snails indicate the former existence of a cool climate.

The sample from the red soil between 24.oo - 23.oo m had only one Trichia individual and no inference about climatic conditions could be based on this evidence alone.

Faunistic evidence between 23.oo - 14.85 m seems to suggest the arrival of a moister period indicated by a gradual increase of the number and variety of species. Towards the middle of this profile /between 2o.1o - 16.85 m/ moderately warmer period may be registered marked by the presence of a greater number of Chondrula tridens specimen.

In the layers between 16.85 - 14.85 m together with the previously dominant Trichia species, Succinea and Anisus specimen also appear, both typically hygrophile species.

In the 4th red soil horizon fragments of the shells of 4 - 5 Anisus carinatus /water molluscs/ were found together with some terrestrial species /Trichia, Vallonia, Chondrula/. However, these latter shells showed signs of being rounded by water transport. Evidently the sediment was originally deposited on a flood plain.

The silty layer interstratified in between the 4th and 3rd red soils /between 12.oo - lo.75 m/ contained mixed thermophile species /Trichia, Vallonia, Pupilla/.

The molluscs found in the 3rd red soil /between lo.75 - 9.oo m/ also prove the existence of a former warm climate. Compared to the underlying silty layer the number of specimen in the sample has greatly increased /lo4 individuals/. Among the fossil soils this horizon has the richest assemblage of molluscan faunae. The presence of 12 individuals of Catinella aranaria species in this horizon must be mentioned with the comment that its specific ecological requirements are not known to the author.

The molluscan fauna of the silty layer between 9.oo - 7.77 m still show no sign of climatic change. Trichia, Vallonia, Chondrula, Pupilla and Abida species occur in almost the same number, although their total is only roughly half of that discovered in the 3rd red soil.

The 2nd red soil situated between 7.77 - 5.35 m contains the above listed 5 species.

In the silty layer located above the 2nd red soil /between 5.85 - 2.85 m/ apart from Trichia, Vallonia, Chondrula and Pupilla species Succinea and Cochlicopa are also present. This slight change in the composition of the molluscan assemblage indicates a change in climate, it had become moister and cooler. The fact that no thermophile Abida species were found seems to support our assumption.

In the 1st ochre-red soil of the bore /between 2.85 - 2.25 m/ the molluscan fauna indicate once more a warmer and drier climate. The soil contains only a few specimen /25/ of only 3 species, namely Vallonia Chondrula and Trichia, while the hygrophilous Cochlicopa species are no longer present in the sample.

Pleistocene type of molluscan fauna were recovered from the borehole at Dunakömlőd. The molluscs of the four red soils definitely prove the former existence of warm and dry climatic conditions. The molluscan species of the thick silt and clay bands indicate cooler, respectively warmer Pleistocene climatic periods. The stratigraphic sequence revealed by the bore is located directly below the older loess series outlined in detail in the Paks profile. Its lithostratigraphical development is very similar to the "Dunaföldvár" Complex described by M. Pécsi /1974/.

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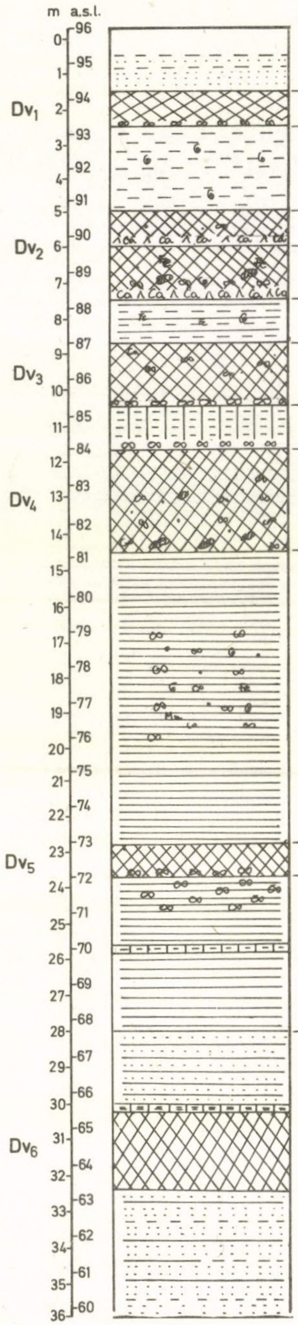

Trichia hispida	11 db.	Chondrula tridens	7 db.
Vallonia sp.	7 "		
Trichia hispida	20 "	Cochlicopa lubrica	2 "
Vallonia sp.	34 "		
Pupilla sp.	18 "		
Chondrula tridens	9 "		
Succinea oblonga	7 "		
Trichia hispida	66 "		
Vallonia sp.	17 "		
Pupilla sp.	24 "		
Chondrula tridens	2 "		
Abida frumentum	18 "		
Trichia hispida	9 "	Chondrula tridens	6 "
Vallonia sp.	9 "	Abida frumentum	9 "
Pupilla sp.	9 "		
Trichia hispida	29 "	Chondrula tridens	2 "
Vallonia sp.	22 "	Abida frumentum	3 "
Pupilla sp.	27 "	Catinella arenaria	12 "
Trichia hispida	5 "	Pupilla sp.	5 "
Vallonia sp.	3 "		
Trichia hispida	11 "		
Vallonia sp.	3 "		
Chondrula tridens	1 "		
Anisus carinatus	4-5 "		
Trichia hispida	62 "		
Vallonia sp.	43 "		
Pupilla sp.	52 "		
Succinea oblonga	9 "		
Chondrula tridens	69 "		
Anisus sp.	1 "		
Pisidium	3 "		
Succinea putris	2 "		
Trichia hispida	1 "		
Trichia hispida	12 "		
Vallonia sp.	8 "		

Fig. 1.: Molluscan fauna of the Dunakömlőd borehole samples

A ÇOMPLEX EVALUATION OF DUNAFÖLDVÁR LOESSES AND FOSSIL SOILS
/Bio- and lithostratigraphical, paleopedological, thermal and paleomagnetic investigation/

M. Pécsi - Mrs. Pécsi, É. Donáth - M. A. Pevzner - E. Szebényi - F. Schweitzer - M. Wagner

In Hungary the most suitable loess-profiles for studying loess complexes, especially the "old loess", are situated in Dunaföldvár along the high bluffs on the bank of the river Danube.

Southwards from the Dunaföldvár bridge landslides occurred in the steep loess bluff on several occasions /M. Pécsi, 1971, 1979/. After the landslide in 197o detailed geological study of the 5o m high loess bluff was needed for planning the defence constructions along the river bank.

For the purpose of ground mechanical investigation borehole drills were carried out in a network arrangement in the area affected by sliding at the top of the loess hills on the bank and bed of the Danube /Figs. 1., 2./.

Later, in 1974 a 33 - 37 m deep borehole was drilled for taking oriented samples for paleomagnetic investigation. Samples were taken at every 1o - 2o cm and a new, very detailed and exact profile could be drawn for the sequence below the Danube level.

In this paper the results of the investigations on fossil soils, loesses and non-loessial formations collected from four boreholes at Dunaföldvár /FTI[x] I/2, I/3, I/4 and MTA FKI[xx] 1974/I/ will be discussed.

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[x] Institute of Geodesy and Ground Mechanics; [xx] Geographical Research Institute of the Hungarian Academy of Sciences.

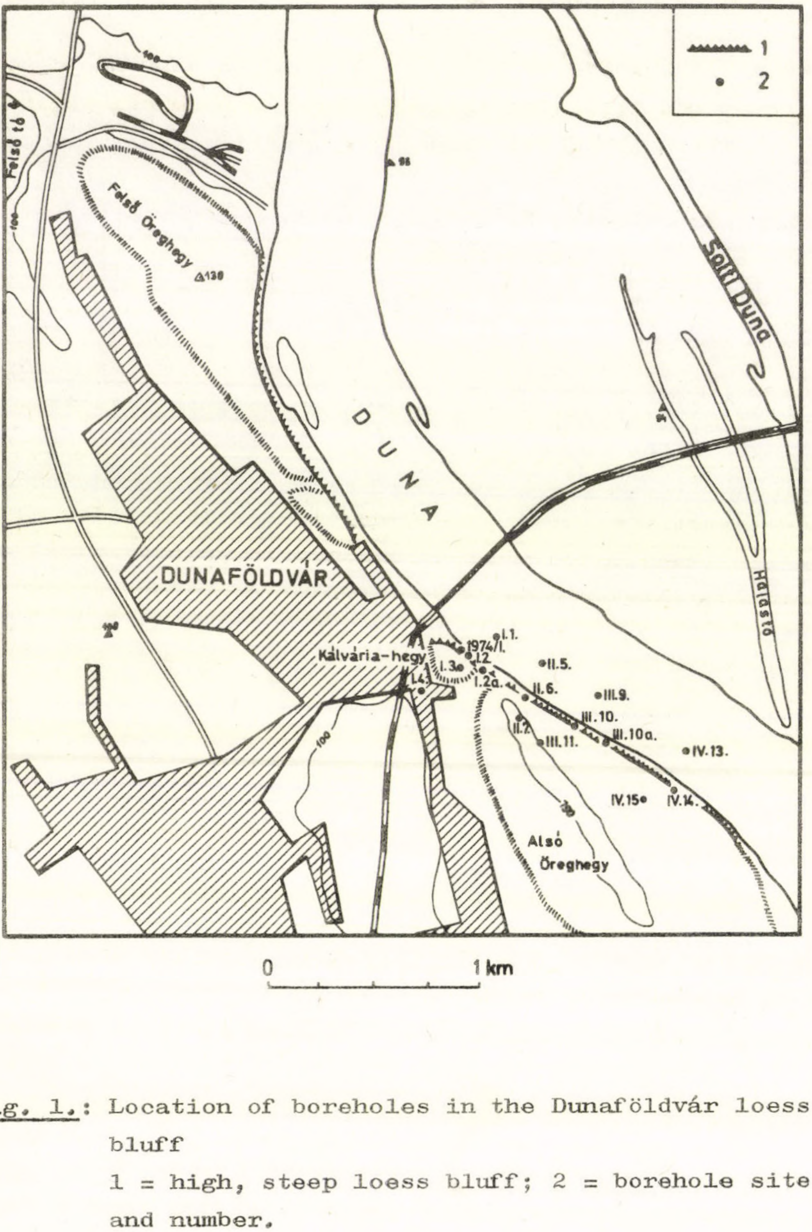
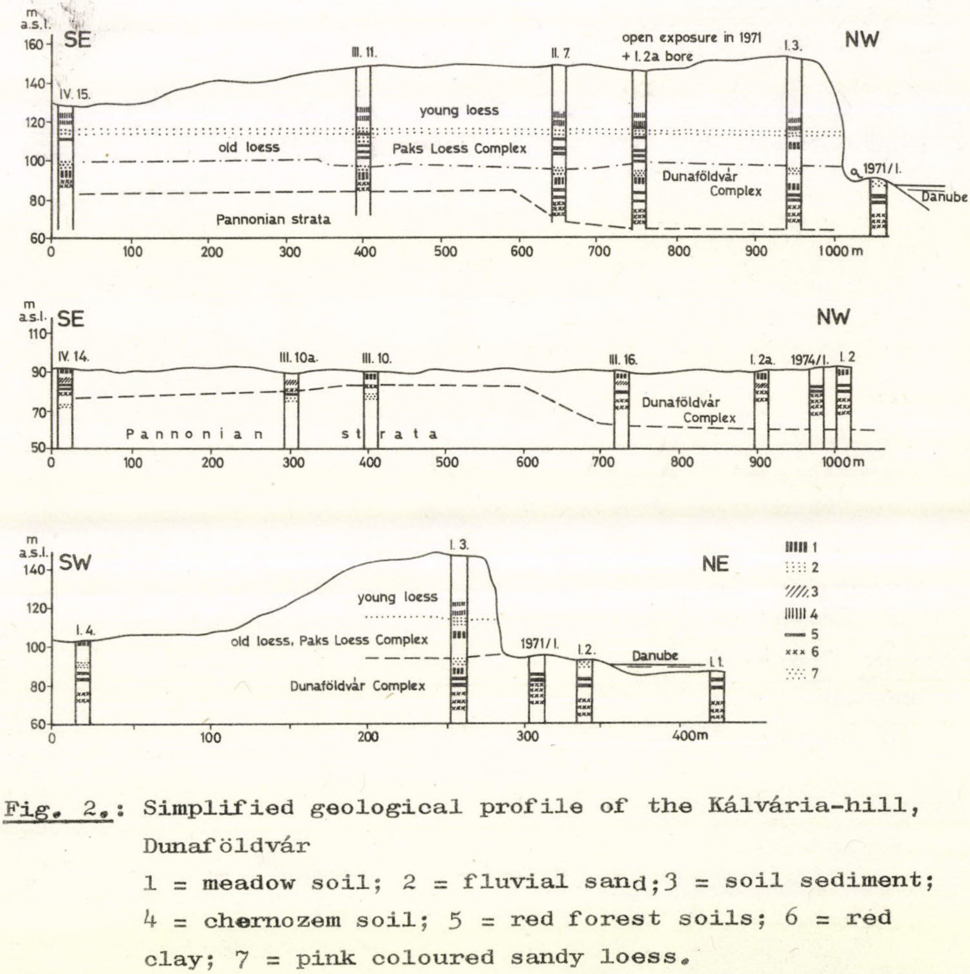


Fig. 1.: Location of boreholes in the Dunaföldvár loess bluff
1 = high, steep loess bluff; 2 = borehole site and number.



<u>Fig. 2.</u>: Simplified geological profile of the Kálvária-hill, Dunaföldvár

1 = meadow soil; 2 = fluvial sand; 3 = soil sediment; 4 = chernozem soil; 5 = red forest soils; 6 = red clay; 7 = pink coloured sandy loess.

Open exposure No. 1. at Dunaföldvár and paleomagnetic orientation /M. Pécsi - E. Szebényi - M. A. Pevzner/.

1. Upper Pleistocene Loess Complex

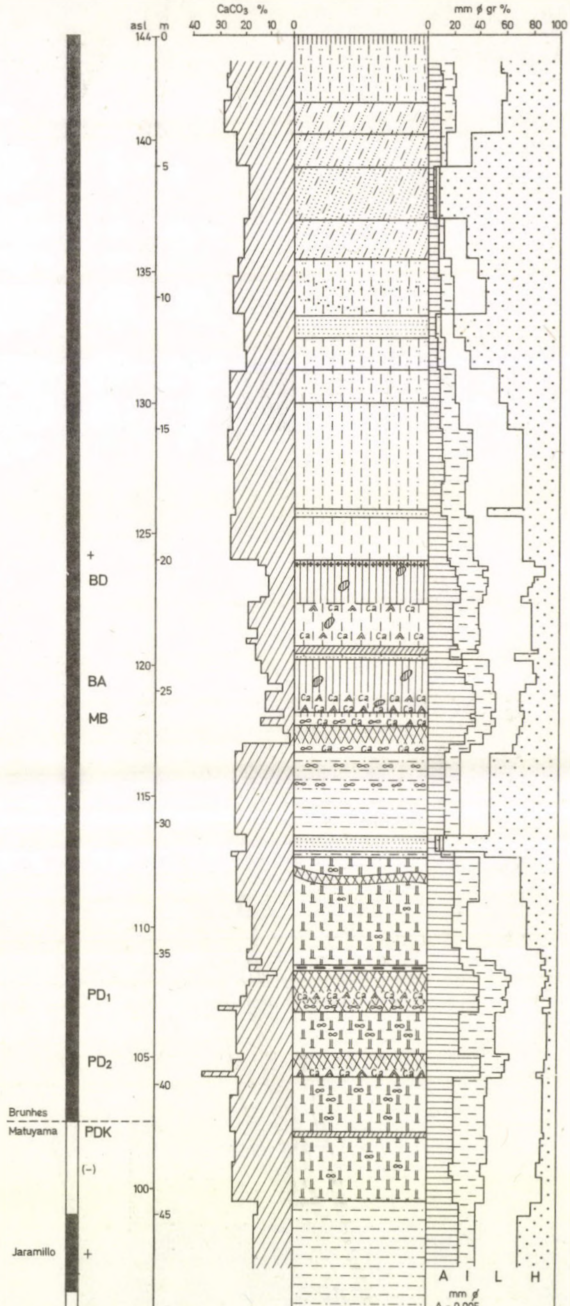
The development of the young loess in the profile on Kálvária hill, Dunaföldvár /Profile No. 1./ differes significantly from that of the other Upper Pleistocene loess sequences in Hungary.

The 1o m thick upper part of young loess in Hungary were described as the "Dunaujváros - Tápiósüly Complex" /M. Pécsi, 1972, 1975; Gy. Hahn, 1975/.Occurrence of sandy loess, loessy sand packets, two or three decimeter thick interbedded with light grey humic loess layers and some buried derasional valleys /dells/ filled with slope loess are characteristic of the uppermost 3 - 5 m thick part of this complex. The occurrence of the buried derasional valleys above each other may indicate 2 - 3 dell formation and accumulation phases.

- Mineralogically the sand fraction of the layers between 4 and 13 m in the profile on Kálvária hill consist of quartz sand in 5o - 9o per cent. Certain layers /at 5 - 9 m and 1o.8 - 11.5 m/ are definitely thick sand layers and some sandy loess and loessy sand beds /Figs. 3/a, 3/b/ /17 - 19 m/ are intercalated with a few centimeter thick sand strata representing denudation gaps. The stratigraphical position and the stratification of the intercalated sand layers indicate that they were deposited during derasional valley-formation and infilling, or were deposited by eolian processes during the time of sand movement.

In the profile on Kálvária hill the development of the "Mende-Basaharc" Loess Complex also differs from the complete development of the complex elsewhere. The "Mende-Upper" Soil Complex is certainly missing here. It might have been eroded during subsequent derasional valley formation. It is also uncertain which fossil soils of the Mende-Basaharc Loess Complex are represented in the section between 2o and 27 m at Dunaföldvár.

- The first fossil soil occurs between 2o and 23.2 m in the loess exposure at Dunaföldvár. This light brown,chernozem-



<u>Fig. 3/a</u>: Lithological and pedological profile No. 1. of the exposure with paleomagnetic polarity information /M. Pécsi - E. Szebényi - M. A. Pevzner/

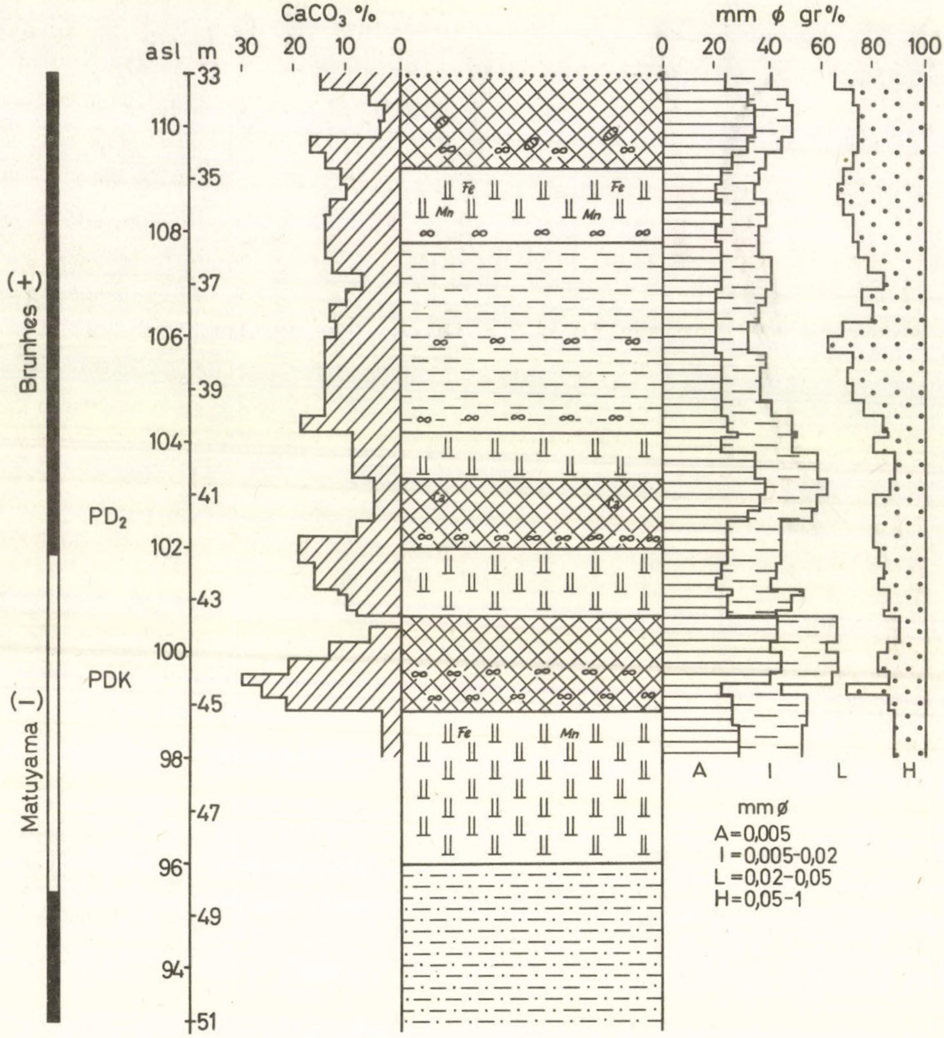


Fig. 3/b: Results of profile No. 2.

type soil rich in carbonates has a compact, friable structure with krotovinas /Fig. 3/a./. This soil is only slightly more clayey /26 per cent/ than the underlaying loess, its dominant clay mineral is illite /about 22 per cent/, the montmorillonite content increases from 1o per cent up to 16 per cent downwards from the AC horizon /Fig. 4./. The carbonate mineral of the soil is mainly calcite, while dolomite occurs in the under and overlying loess. In the uppermost horizon charcoal remains can be found. The soil becomes lighter downwards and contains little humus. The weakly humic "A" horizon is 1.3 m, the transitional A/C horizon is o.3 m thick. The yellow loess with krotovinas in the "C" horizon of the soil is also 1.6 m.

In the profile on Kávária hill the second fossil soil is a well developed, dark brown chernozem soil /fossil chernozem/ with compact, friable structure and small amount of carbonate minerals. It was found between 24 and 26 m /118 - 12o m a.s.l., Fig. 3/a./. In the A_1 and A_2 horizons calcite and dolomite, in two samples of the A/C horizon only calcite was detected. Organic matter is o.6 - o.8 per cent, pyrite is of average value, hydrous oxides of iron are present only in small quantity. The clay content of this soil /3o - 35 per cent/ is definitely more than that of the former soil. From among the clay minerals illite is 22 per cent in average, montmorillonite occurs with chlorite in an amount of about 12 per cent in the A_1 and A/C horizons.

The borehole I/3. was drilled at the top of Kálvária hill at 149 m a.s.l., 2oo m northwards from the exposure discussed above /Fig. 5./. The upper 26 m of the sediment sequence in the borehole generally resembles those formations observed in the exposure.

According to pedological investigations the light-brown chernozem-type, fossil soil with a compact friable structure rich in carbonates and krotovinas, between 26.4 and 29.o m in the borehole I/3., is similar to the BD soil in the open exposure. The thickness of the weakly humic horizon is 1.4 m. The transitional AC horizon is o.3 m thick, the carbonate containing C horizon is o.9 m. The total thickness of the soil complex is 2.6 m.

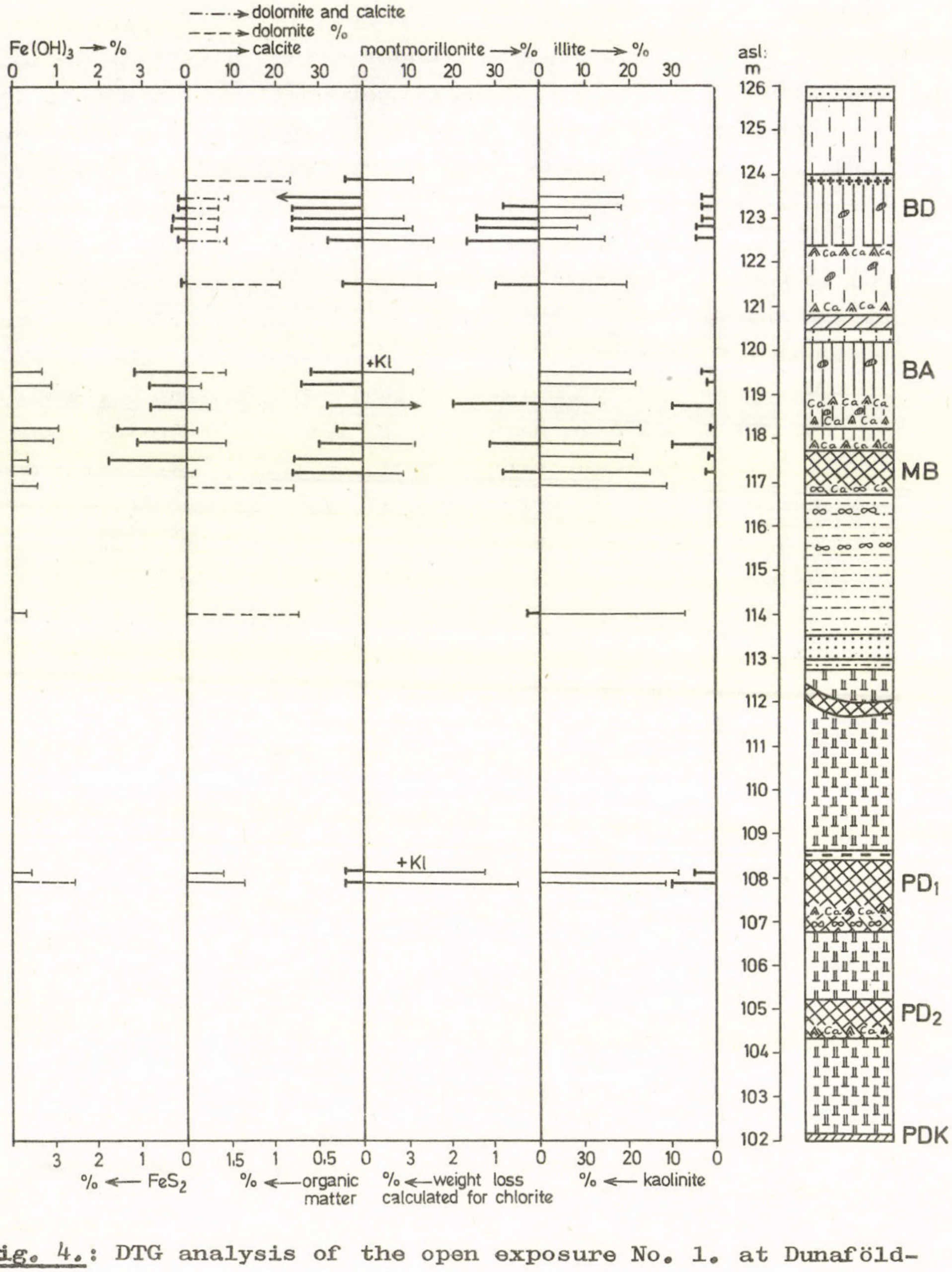


Fig. 4.: DTG analysis of the open exposure No. 1. at Dunaföldvár /Mrs. Pécsi, É. Donáth/

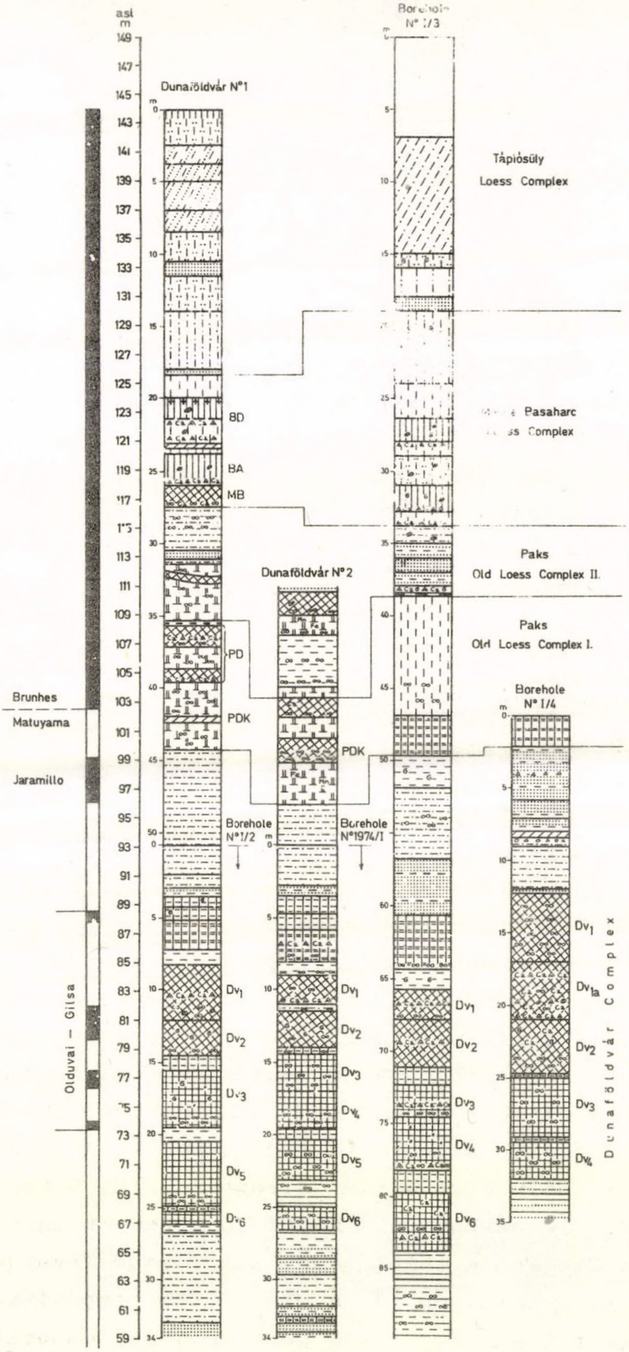


Fig. 5.: Correlation of the different exposures and borehole profiles at Dunaföldvár /M. Pécsi - E. Szebényi - M.A. Pevzner/

The chernozem-type fossil soils found in the 1971/K profile between 2o and 23 m /124 - 121 m a.s.l./ and in the borehole I/3. at the same height a.s.l. but between 26.5 - 29.o m below the surface, can be correlated with the Basaharc Double Soil Complex /BD/ or with its more or less eroded remains, which occurs repeatedly in Hungarian loess profiles.

Pedological analyses and the lithological position of the dark brown chernozem soils between 24 and 26 m /12o.5 - 118 m a.s.l./ in the 1971/K profile /Fig. 3/a /, and between 31 and 33.7 m /118 - 116.2 m a.s.l./ in the borehole I/3. indicate that they can be correlated with the Basaharc Base Soil Complex /BA/. The clay, iron-oxide and organic content of BA-type soils are characteristically greater than that of the BD-type steppe soils.

2. The "Mende-Base" Soil Complex in the open exposure on Kálvária hill

An about two meter thick incomplete fossil soil complex is found between 25.8 and 28 m /118.2 - 116 m a.s.l./ in the exposure /Fig. 3/a /. This soil complex consists of the following horizons: below a o.2 m thick brown, compact, friable B horizon the Cca horizon of a o.3 m thick yellowish, brownish yellow slightly carbonated steppe soil was found. Immediately below this soil the B horizon of a red brown forest soil is situated. The carbonate accumulation horizon of this soil contains dolomitic lime and many concretions. The o.7 m thick, slightly reddish brown coloured forest soil is clayey, it has a compact /polyhedron-like/ structure, the B horizon contains very little carbonate. The Cca horizon of this soil was formed on a 2.5 - 3 m thick sandy silt, sand layer which may be of fluvial origin, on the basis of its composition and bedding. The upper 1 - 1.5 m thick part of these deposits below the brown forest soil was slightly cemented into loessy sand. From among the clay minerals it contains only illite and from the carbonate minerals dolomite.

The presence of fluvial sand below the "Mende-Base" Soil Complex - found also in other sites - is typical and at the same time it is an important trait for the identification of soils. The fluvial, sand silt interbeddings can be found at almost the same height /111 - 116 m a.s.l./ in several exposures on the Kálvária hill and in the borehole profiles drilled on the crest of the hill. The upper boundary of this sandy, silty layer is at the same height /116 m a.s.l./ in all sections the lower boundary is uneven, with a definite erosional unconformity /Figs. 4., 5./.

The sand interbedding below the "Mende-Base" Soil Complex is not a local phenomenon, but it appears reginnally in other typical profiles. These fluvial erosional and depositional processes destroyed significantly the old loess, its surface was dissected by valleys. These processes operated for a long time, and their intensity varied in space.

It can be reconstructed that intensive forest soil formation /of brown forest soil/ occurred on the fluvial sand. The chernozem soil profile directly overlying the forest soil indicated that the climate became dry and the forest vegetation gradually changed into forest steppe and steppe.

3. <u>The old loess series on Kálvária hill</u> /in the so called <u>"Paks Loess Complex"/</u>

Below the silty sand and sand layers at the base of the "Mende-Base" Soil Complex /27 - 31 m; Fig. 3/a / stratified slope loess, old loessy sand and redeposited soils /semipedolite/ were found. The first fossil soil of old loesses is located between about 35.5 and 37 m /Fig. 3/a /. Directly above this soil a distinctly bounded 2o - 3o cm thick silty clay is situated with an average carbonate content and montmorillonite, indicating that the surface was flooded for a short time after the soil had been formed. The clay content of the ochre brown forest soil is much greater /42 per cent/, than that of typical old loess /26 per cent/ at the base. Both the content and distribution of carbonates 6 - lo per cent in the B. 17 - 19 per cent in the BC, and 29 per cent in the Cca horizon undoubtedly indicate a forest soil formation.

- The fossil soil mentioned above appears again between 38.8 and 39.7 m with almost the same characteristics.

The exact genetic types of the soils located close to each other cannot be determined precisely by pedological analyses of the soil profiles located close to each others. These loamy soils had been saturated by water after their formation and reduction processes connected with post-hypergenesis might have alterated the original colour of the soils. In the upper soil /35.5 - 37 m/ the mineralogical composition determined by thermal analysis shows illite 32 per cent, kaolinite 5 per cent, montmorillonite and chlorite together, in 28 per cent. The hydrous oxides of iron are present in 1.5 per cent; this is the most significant in this soil. The soil forming processes are undoubtely proved by the varied clay mineral composition, and the presence of montmorillonite indicates the effect of alkaline agents acting periodically. In general the organic matter is less in the older soils, but in this case it might have been caused by a less intensive soil forming process. By studying the soil profile between 35.5 and 37 m, it may be presumed that it is a fossil remain of a floodplain forest soil. The results of the mineralogical analyses of the soils do not contradict this supposition, indeed the composition of clay mineral assemblages seem to support our argument.

4. The Brunhes-Matuyama boundary in the old loess on Kálvária hill

From the two ochre brown, compact, loamy soils with an average carbonate content, developed under similar conditions, the lower soil /its position, type and structure/ /between 38.8 and 39.7 m, i.e. 1o5.2 - 1o4.5 m a.s.l./[x] resembles the lower member of the "Paks-Lower Double Soil Complex", developed at the base in the profile at Paks brickyard. In both cases a 4 - 5 m thick old loess with a compact structure and characteristic horizons with loess dolls underlie these soils. According to paleomagnetic analyses the loess has a reversed magnetization /Fig. 3/a /. The Brunhes-Matuyama paleomagnetic boundary was detected at almost the same stratigraphical /lithological/ position at /1o1.5 - 1o3.5 m/ above sea level in two separate profiles in both exposures at Paks and at Dunaföldvár /Figs. 3/a and 6./.

The above discussion indicates that the two fossil soils in the old loess in Dunaföldvár at 1o5.2 - 1o4.5 m and 1o7.o - 1o8.7 m a.s.l., although a precise genetic determination is lacking, developed in a similar stratigraphical position like the "Paks-Lower Double Soil Complex". The comparison can be made in spite of the slight differences in the characteristics of the soils at Paks and Dunaföldvár.

In the profile No. 1. in Dunaföldvár the "Paks Loess Complex" is terminated by a 4 - 5 m thick old loess with concretions, between 4o and 45 m. At 42 m /1o2 m a.s.l./ a few cm thick, bright redbrown soil sediment is interbedded in the old loess with a compact structure /Fig. 3/a /. According to

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[x]The heights above sea level are marked for easier comparison of the soil horizons in similar stratigraphical position. The depth of horizons below the surface are different because of relief configurations.

detailed investigations the soil sediment is a remnant of a former redbrown forest soil horizon in this stratigraphical position. The Brunhes-Matuyama boundary was determined at one meter above the soil sediment. Consequently both this soil and the old loess packet below it, were formed during the Matuyama reversed epoch. In profile No. 2. at Dunaföldvár a o.9 m thick light redbrown fossil soil developed at a similar stratigraphical position /1o1 m a.s.l.; Fig. 3/b./.

This fossil soil /PDK/ also has a reversed polarity and according to its position it can be identified as the "Paks-Dunakömlőd Soil" /PDK/. These data are not only similat but agree suprisingly well with our former analyses of the stratigraphical sequences of the profiles at Paks brickyard and Dunakömlőd /M. Pécsi - M. A. Pevzner 1974; P. Márton 1978/.

In Dunaföldvár the character of the sediment change completely below the old loess /at 45 m/. At the base of the section /99 - 94 m a.s.l.; Figs. 3/ b and 5./ on Kálvária hill a 5 - 6 m thick, stratified, pink coloured fine-grained sandy silt is situated rhytmically interrupted by interbedded sandstone concretions. This layer belongs to the so called "Dunaföldvár Complex".

5. The Dunaföldvár Complex

The recognition and characterization of the so called "Dunaföldvár Complex" became possible by the investigation of geological and soil mechanical boreholes drilled for the purpose of coastal defence constructions after the landslide of 197o at Dunaföldvár /Fig. 1./. In these boreholes we detected a more than 3o m thick clay, silt, red clay complex, which developed at the base of the 4o - 5o m thick loess bluff, overlying the Upper Pannonian sediments in Dunaföldvár /Figs. 2., 5./.

Two of the four boreholes drilled in the Danube bed penetrated the whole complex. In one bore the Pannonian sediments were reached below a few meter thick Danube gravel /borehole No. III/9./. The borehole No. IV/13. cut across two double red-brown soils and penetrated 18 m into the Pannonian sequence at the base.

Six boreholes were located at the bottom of the bluff in Dunaföldvár, at about the level of the Danube No. I/2, I/2a, III/6 are about 1oo - 15o m from each others to the northern edge of the landslide; No. III/1o, III/ and III/14 are 15o or 3oo m from each others on the slump part /Figs. 1., 2./. Near the borehole No. I/2 another drilling was carried out to take oriented core samples. This later borehole and the boreholes No. I/2a and III/6 penetrated into a 3o m thick complex with red soils above the Upper Pannonian sequence. The borehole at the top of Kálvária hill /No. I/3/ drilled into a sequence containing loess, silt and red clay beds, its total thickness being about 9o m.

5.1. "Stony loess" the closing strata of Dunaföldvár Complex

The lowest 5 - 6 m thick layer of the open exposure in Dunaföldvár between 45 and 5o m is not loess but a finely stratified, pale-pink coloured, slightly clayey sand, in which cemented sandstone and thin sandstone interbeddings occur rhytmically /Fig. 3/a./; therefore this formation was called "stony loess" /M. Pécsi 1972/.

The pink, stratified sandy sediment classified genetically as proluvium, its age could be determined from paleomagnetic data with good approximation. The upper part of this formation in the open exposure /between 98 and 96 m a.s.l./ has a normal magnetic polarity, while the samples taken from the lower part /between 95 and 94 m a.s.l./ showed reversed polarity /M. Pécsi - M. A. Pevzner 1974/. The packet between 98 and 96 m indicates a normal polarity event - presumably the Jaramillo /o.8 - o.9 MY B. P./ - inside the Matuyama reversed period.

The cores on Kálvária hill drilled for paleomagnetic study were carried out with the assistance of the Central Geological Office /Fig. 1. marked 1974. I./. Oriented samples taken from each ten cm were measured by M. A. Pevzner in the Geological Institute of the Academy of Sciences of the U.S.S.R. Evaluation of measurements were made simultaneously with pedological analyses.

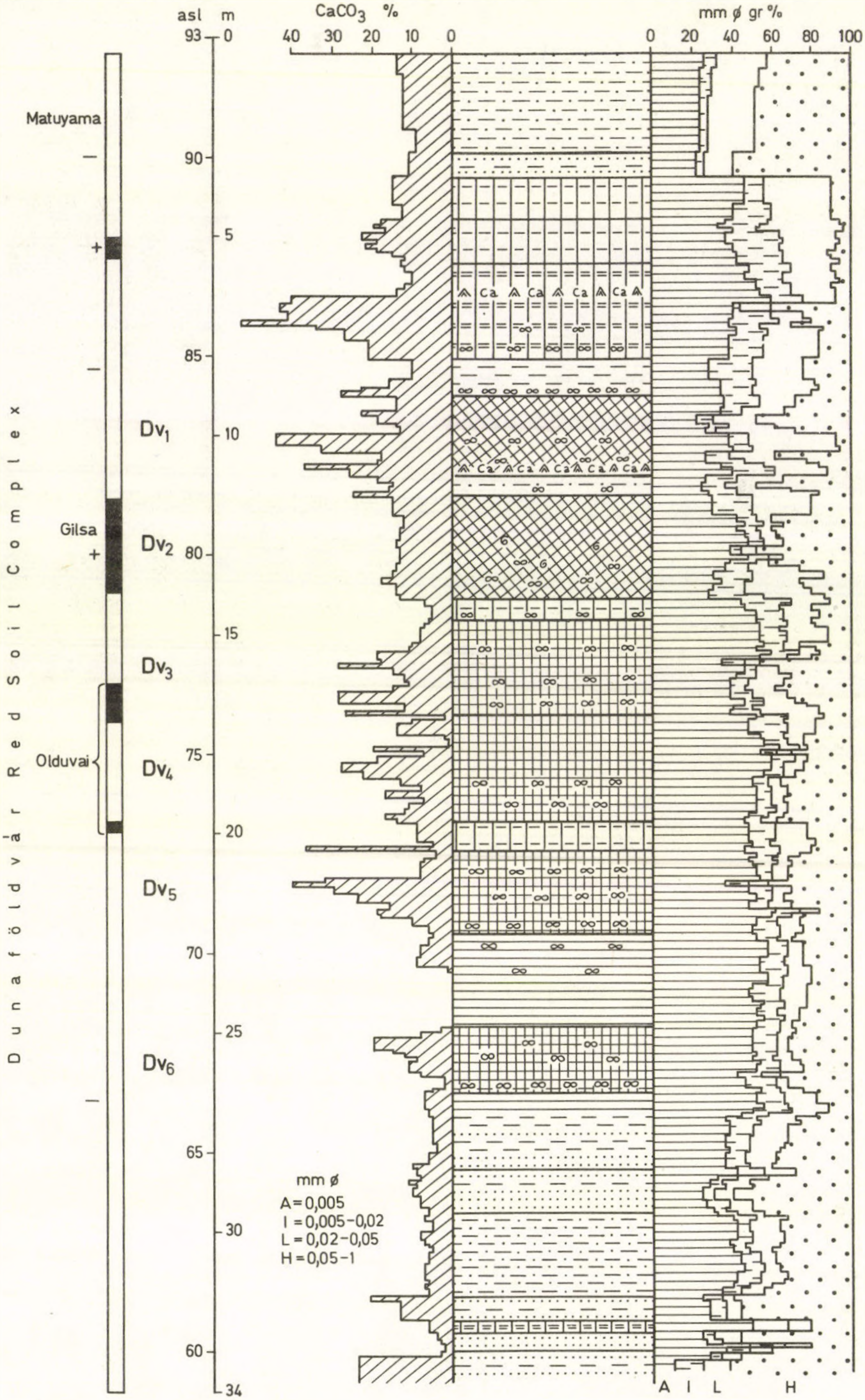


Fig. 6.: Geological and paleomagnetic profile of the 1974/1 borehole at Dunaföldvár /M. Pécsi - E. Szebényi - M. A. Pevzner/

In the borehole 1974/I. in Dunaföldvár /Fig. 6./ the "stony loess" described at the bottom of the exposure continued for another 3 meters. This pale-pink /1o/R 6/4/, stratified, sandy formation contains quartz sand in 4o - 5o per cent, clay minerals in 2o per cent. It has many sandstone concretions and a remarkably high iron content. Its specific colour seemed to have been obtained during the process of deposition and not during subsequent soil formation. Thus it cannot be considered as a fossil soil, however, its origin might be explained by the proluvial redeposition of a fossil red soil, it may be a semipedolite. The paleogeographical interpretation of sedimentation requires further detailed study, the conclusion could be drawn from the present observations, that this formation might have been formed during a warm Mediterranean-type climate with arid and humid seasons.

5.2. <u>Dark-grey meadow clay soil complex with carbonate content</u>

The complex of meadow soils situated on top of each other developed /between 89.6 and 85 m a.s.l./ at 3.5 - 8.1 m below the surface in the borehole profile. It can be also studied in an open profile that had been exposed during the landslide in 197o. This open exposure is located at about 3oo m southward from the borehole.

This dark soil complex may be observed in an exposure at the foot of the Kálvária hill, at about the "0" level of the Danube. Ground water seepage towards the Danube occurs in the sand layer overlying this clay soil complex.

According to pedological analyses this typical meadow clay contains more than two per cent humus between 5.73 and 6.54 m, at the bottom of which the carbonate content reaches 4o - 6o per cent, it is almost completely calcareous mud. The profile consists of larger dolomitic lime concretions, between 7 and 8 m.

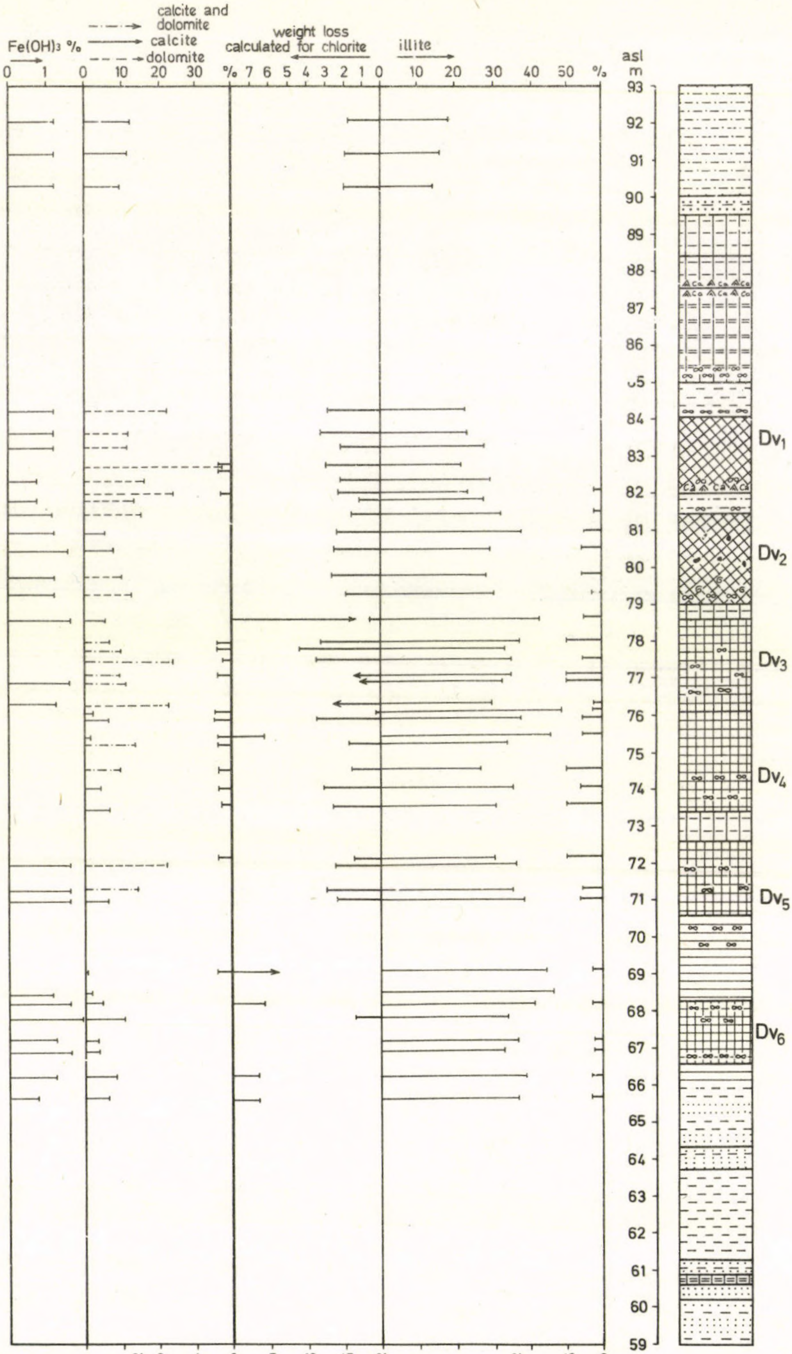


Fig. 7.:Results of DTG analysis of the 1974/1 borehole at Dunaföldvár /Mrs. Pécsi, É. Donáth/

In general the samples had reversed polarity, only specimens from between 4.75 and 5.25 m were normally magnetized. There are no data for radiometric age of this - presumably short - normally magnetized event inside the Matuyama reversed period because of a lack of analogous data. This event is certainly older than the Jaramillo event, mentioned above /o.8 - o.9 MY B. P./.

5.3. Ochre red soils

The 5 - 6 ochre red, red soils known from the boreholes at Dunaföldvár, below the meadow clay soil complex were marked provisionally by serial numbers from the top. As oriented samples had been taken continuously from the core of 1974./I, the sequence in this borehole was considered as a possible basis of correlation. Since the soils in the different boreholes /I/2, I/3, I/4/ do not exhibit the same development and thickness, and their stratigraphical position is also different, the serial numbers were introduced to distinguish them from one another.

Ochre Red Soil No. 1. in the Dunaföldvár complex was found between 9 and 11.o3 m /83.1 - 81.1 m a.s.l./ in the borehole 1974./I. /Figs. 5., 6., 7./. This type of soil in a similar position could be recognized in the boreholes I/2, I/3 and I/4, but the thickness of the fossil soil horizons differ in each soil. In these sand /38 per cent/ and clay /35 per cent/ dominate. The original material of the soil formation was sand, however, the sand fraction contains a lot of small carbonate concretions in addition to mineral components /quartz, mica, heavy minerals/, these are also present in the BC horizon of the soil. In the Cca horizon large carbonate concretions are common. This structure is characteristic of the BC, Cca horizons of pale red brown /ochre red/ Mediterranean-type forest soils, formed under dry forests with a poor undergrowth, during a climate with humid winters and dry summers.

The B horizon of the first red soil in the borehole 1974. I. had been partly eroded. The humus content, between 3 and 3.5 m, is remarkably high /o.8 per cent/. From among the clay minerals illite is 27 per cent, the amount of chlorite is average /2 per cent/, kaolinite /2 per cent/ appears in only the lowest part of the Cca horizon. According to DTG analysis the lower part of the BC horizon contains 14 per cent dolomite, while 37,7 per cent of the carbonate minerals is dolomite in the Cca horizon.

Red Brown Soil No. 2. of the Dunaföldvár complex lies between 11.5 and 14.11 m /81.6o - 79.o m a.s.l./ in the borehole 1974./I. /Figs. 5., 6./. It occurs in a similar position in the boreholes I/2, I/3 and in I/4. In this soil sand and clay fractions dominate. Clay content reaches 48 per cent in the upper part. The carbonate distribution is uniform it is 1o - 18 per cent. Larger carbonate concretions occur in the lower part of the soil. In the sand fraction a great amount of mica and fine-grained carbonate were found beside the quartz.

From among the clay minerals the illite content is 32 - 42 per cent, kaolinite is about 5 per cent, the chlorite /the weight loss for chlorite/ is uniformly medium in the profile /2.7 per cent/. It is characteristic that the carbonate mineral is mainly dolomite /1o - 14 per cent/. The iron oxide-hydroxide has an average amount of 1.17 per cent, increasing up to 1.56 per cent in the middle horizon of the soil. The humus content determined by pedological analyses is o.6 - o.o8 per cent, but this fossil soil has a very small amount of organic material, according to thermal analysis.

No specific horizons could be recognised in the more than two meter thick fossil soil in spite of detailed sampling. On the basis of these characteristics it may be supposed that the soil is the product of a redepositional process from well developed forest soil, or that it was thickened by the accumulation of semipedolites.

Specimens taken from between 11.3 and 14.3 m were normally magnetized. The paleomagnetic interpretation will be discussed later in the paper.

Red Clay Soil No. 3. is separated by only a o.4o m thick grey gleyed clay from the redbrown soil discussed above. The red clayey formation is 2.44 m thick /between 14.58 and 17.o2 m in the borehole 1974./I./ and it was found in almost the same position in borehole I/2, I/3 and I/4 in Dunaföldvár /Fig. 5./. The upper o.5 m thick B horizon of the soil profile is dark red, below this the prime colour is reddish with yellowish-red, brown and white stains. The horizons with calcareous concretions are also red. Small carbonate concretions /1 - 2 mm Ø/ can be found throughout the whole soil profile. Besides the three, carbonate rich /3o per cent/ horizons, the carbonate is finely dispersed and precipitated in patches in the soil. The probably double Cca accumulation horizon reaches a thickness of a meter and a half. According to thermal analysis the carbonate mineral of the sample taken from the bottom of this horizon is dolomite.

From among the clay minerals illite dominates in the whole profile. The ratio of kaolinite is between 5 and lo per cent, while the chlorite content is the highest /7 per cent/, where the amount of kaolinite is the smallest. The upper part of the B horizon contains montmorillonite as well. Organic matter were detected by thermal analysis in the whole profile, hydrous oxides of iron in the upper and lower part of the soil, respectively.

The structure and composition of the red clay No. 3. is a Mediterranean-subtropical type of soil which had been intesively weathered.

Red Clay No. 4. had the darkest colour /5YR 5/4/. The 2.74 m thick fossil soil becomes gradually lighter downwards, but the red colour remains. The upper B horizon has a purplishred colour in wet condition. From among the red soils this thin soil has the highest clay content, it exceeds 5o per cent in most parts of the profile. From among the clay minerals illite reaches an extremely high value /45 - 5o per cent/ in the B horizon, and 25 - 35 per cent in the lower horizons. The kaolinite content is also significant in the middle and lower horizons of the soil. Montmorillonite /4 per cent/ was detected in only one sample /between 17.61 - 17.78 m/. The amount of chlorite reaches 6 per cent in the upper and middle horizons. The organic matter content of the whole profile is o.65 - o.81 per cent.

Quartz constitutes 15 per cent of the sand fraction the rest is taken up by small soil particles, Ca-Fe-Mn-nodules and sometimes by broken shell fragments. Iron oolites /2 mm Ø/ occur in the whole profile, they are abundant in some soil horizons. Hydrous oxides of iron precipitated in patches, their quantity varies between 2 and 27 per cent in the profile. Characteristically the highest carbonate content is found in the middle part of the soil profile.

The intensity of weathering was also very significant in this soil, like in the Red Clay Soil No. 3. According to analythical data and comparative observations Red Clay No. 4. could have been formed during a subtropical climate. The considerable thickness of the soil indicates a long period of formation.

The lowest, 3o cm thick horizon of the soil profile shows normal polarity. The upper, larger part, has reversed magnetization just like the lowest section of the borehole profile /between 2o - 34 m/.

<u>Red Clay Soil No. 5.</u> was found below an 8o cm thick, gleyey, sandy, alluvial clay soil rich in iron-oolites in the boreholes 1974/1 and I/2 at Dunaföldvár. This soil is

about 3 m thick /between 2o.48 and 23.53 m, 72.6 - 79 m a.s. l./. The clay content is distributed uniformly throughout the whole profile. From among the clay minerals illite is 3o - 37 per cent, kaolinite is lo per cent in the upper 5o cm thick B horizon, below this, kaolinite could not be detected /or if present, it is in a new-crystalline form/. Its amount is 5 per cent in the lower part of the fossil soil profile. The upper part of the Cca horizon /at a depth of about 1 m/, where kaolinite is absent, has a medium chlorite content. Pedological analysis showed o.5 - o.86 per cent humus content in the whole profile, thermal analysis detected organic matter only in the B horizon, and hydrous oxides of iron in the lower two-third of the soil. The proportion of sand fraction reaches 3o per cent, of which quartz is only about lo per cent. In the sand fraction and particularly in the fraction of o.2 mm Ø there are red soil aggregates, carbonate concretions, iron oolites and occasionally shells of molluscs. It is characteristic, that the maximum amount /3o - 4o per cent/ of carbonate minerals, which appear as dolomite and calcite, is between 6o cm and 12o cm in the 3 m thick soil profile. Carbonate precipitation in the soil profile is characteristic of Mediterranean-type red, clayey, dry forest soils. Consequently the red clay soils No. 3., 4. and 5. are genetically similar to each others /Fig. 6./.

Red Soil No. 6. is covered by a more than 2 m thick gleyey clay with no carbonates, while at the base a nearly 6 m thick slightly calcareous sandy clay was found. Large carbonate concretions, and occasionally iron concretions, occur in the whole soil profile. The B horizon of this soil is thin, and carbonate accumulation can be observed in almost the whole soil profile with a maximum value in the upper two-third, between 35 and 6o cm. In this soil the dolomite content is small, although calcite is present. From among the clay minerals illite dominates, kaolinite is only 2 - 5 per cent, chlorite occurs in the carbonate accumulation horizon, some montmorillonite /4 per cent/ was detected in the upper part of the soil. The soil has remarkably high hydrous oxides of iron content /1.18 - 1.9o per cent/, while organic matter is o.5 - o.6 per cent. Montmorillonite occurs in small amount in the sandy, gleyey clay at the base, besides illite and kaolinite; the hydrous oxides of iron content decreases to o.7 per cent.

In the middle and at the base of the 6 m thick clayey sandy horizon sandy layers had been intercalated repeatedly. Below the sandy layer at the bottom a few decimeter thick pitch black clay was found, sand and grey alluvial silt with ochre stains are situated below each other and finally a stratified sand is the closing formation of the borehole 1974/I. This sand layer is probably of Upper Pannonian - Pliocene age according to analogies.

6. Paleopedological interpretation

The paleopedological, paleoecological interpretation of the Dunaföldvár fossil soils discussed above is not considered as completed, and further comparative investigations and the applications of new methods are needed. Regional correlations based on the present data indicate that the loesses and fossil soils in the Dunaföldvár exposures show some similar characteristics. In the upper 5 - 1o m thick packet, the so called "Dunaujváros-Tápiósüly Loess Complex" of Hungarian loess profiles only humic loess horizons can be found. These horizons are missing in the open exposures on Kálvária hill.

- Dark brown chernozem-type fossil soils and forest steppe soils are characteristic of the lower part of the young loess /the "Mende-Basaharc Loess Complex"/in the Dunaföldvár profiles. These soils were correlated with the Basahard Double

/BD/, and Basaharc Base /BA/ fossil soils. The chernozem and forest soil complex found at the base of the young loess series was identified as the Mende Base Soil Complex /Fig. 3/a. /.

- In the old loess /Paks Complex/ of the Dunaföldvár loess bluff ochre coloured and reddish brown forest soils were found. It proved difficult to determine their exact genetic types, for they were covered by limnic and later fluvial sediments after their formation, as was the case of the reddish brown forest soil between 35 and 37 m in the sequence. In the profiles of the reddish brown soils between 4o and 44 m, traces of gley formation could be observed and many specimens of aquatic /marsh/ molluscs were found /Figs. 8., 9./. According to comparative pedological, malacological investigations these soils had probably been formed under Mediterranean-type flood plain forests.

- In the "Dunaföldvár Complex" situated below the old loess, red soils and red clays occur characteristically. Hydromorph clay soils /meadow soils and gleyey clay soils/ can be also found. From among the red soils No. 3., 4. and 5. had undergone intensive weathering.

It is also characteristic of these soils that the carbonate content is extremely high in B_2 and Cca horizon of the soil profile. Hence it may be supposed that the red soils in the "Dunaföldvár Complex" are remains of a xerophyl forest soil formed during a Mediterranean-type climate. This conclusion may particularly apply to the red clay formed on the Upper-Pannonian clays /Fig. 2./

The red clayey soils developed on sandy sediments in general, i. e. fluvial deposition was repeatedly followed by red soil formation on 5 - 6 occasions. Silty sand and gleyey clay were deposited also 6 -7 times. All these indicate frequent changes of paleoecological conditions during the Lower Pleistocene.

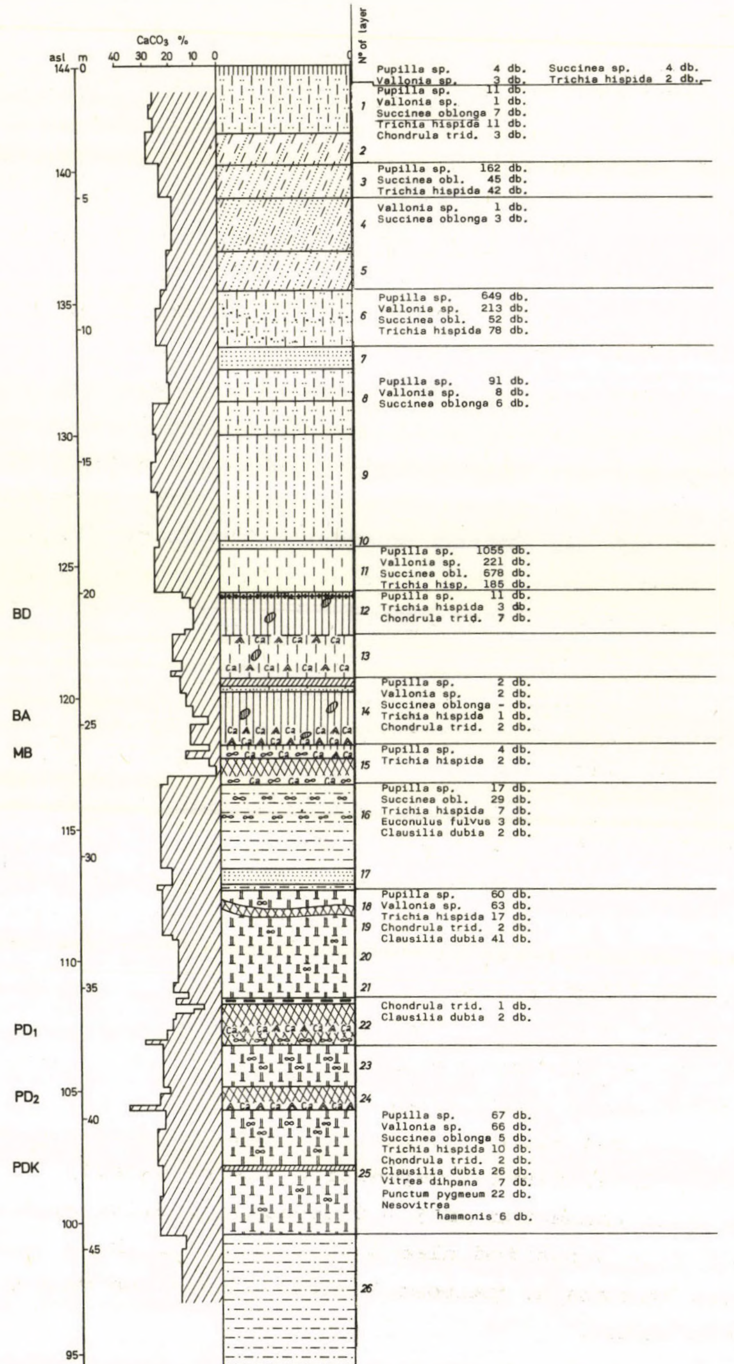
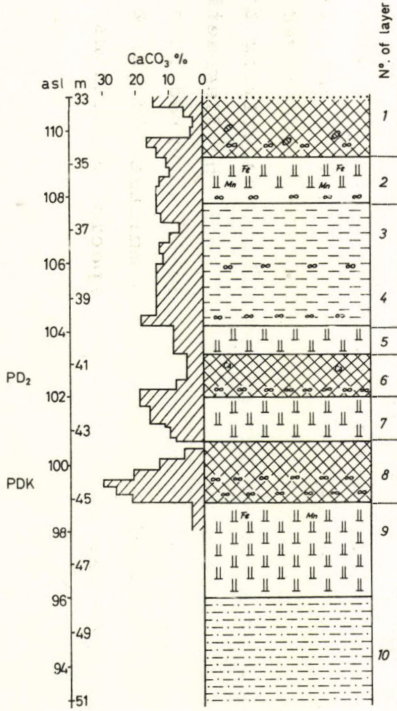


Fig. 8.: Molluscan fauna of the open exposure No. 1. at Dunaföldvár /M. Wagner/



N°. of layer				
1	Valvata cristata 5 db.	Anisus spirorbis 3 db.	Pisidium sp. 7 db.	
	Cincinnea pulchella 2 db.	Vallonia sp. 1 db.	Succinea oblonga 10 db.	
	Bythinia leachi 39 db.	Chondrula tridens 3 db.	Succinea sp. 2 db.	
	Planorbarius corneus 5 db.	Clausilia dubia 3 db.	Trichia hispida 5 db.	
	Planorbis planorbis 14 db.	Succinea pfeifferi 1 db.	Arianta arbustorum 2 db.	
2	Valvata cristata 3 db.	Vertigo sp. 1 db.	Trichia hispida 3 db.	
	Cincinnea pulchella-	Vallonia sp. 1 db.	Arianta arbustorum 2 db.	
	Bythinia leachi 57 db.	Stagnicola palustris 1 db.		
3	Valvata cristata 60 db.	Gyraulus albus 8 db.	Trichia hispida 6 db.	
	Cincinnea pulchella 18 db.	Armiger crista 9 db.	Arianta arbustorum 1 db.	
	Bythinia leachi 67 db.	Vallonia sp. 1 db.	Sphaerium 35 db.	
	Stagnicola palust. 20 db.	Chondrula tridens 4 db.	Pisidium sp. 26 db.	
	Planorbarius corn. 18 db.	Clausilia dubia 1 db.	Pisidium obtusale 77 db.	
	Anisus spirorbis 2 db.	Succinea pfeifferi 12 db.	Pisidium persona-	
4	Aplexa hypnorum 18 db.	Succinea oblonga 44 db.	tum 19 db.	
	Planorbis planorb. 15 db.	Succinea sp. 3 db.		
5	X			
6	Planorbis pl. 4 db.	Succinea oblonga 3 db.		
	Chondrula tridens 1 db.	Arianta arbustorum 2 db.		
7			Chondrula tridens 3 db.	
	Bythinia leachi 75 db.	Planorbis planorb. 1 db.	Succinea pfeifferi 1 db.	
	Stagnicola palustr. 2 db.	Anisus spirorbis 2 db.	Succinea oblonga 7 db.	
	Planorbarius corn. 4 db.	Clausilia dubia 12 db.	Trichia hispida 1 db.	
8	Valvata cristata 20 db.	Planorbarius corn. 2 db.	Armiger crista 4 db.	Succinea pfeifferi 12 db.
	Cincinnea pulchella 1 db.	Planorbis planorb. 30 db.	Segmentina nitida 1 db.	Succinea oblonga 65 db.
	Bythinia leachi 52 db.	Anisus spirorbis 12 db.	Pupilla sp. 8 db.	Nesovitrea hammonis 1 db.
	Stagnicola palustr. 1 db.	Clausilia dubia 16 db.	Vallonia sp. 2 db.	Pisidium sp. 6 db.
				Pisidium obtusale 4 db.
9	Planorbis pl. 1 db.			
	Gyraulus alb. 1 db.			
10				

X			
Valvata cristata	22 db.	Vallonia sp.	7 db.
Cincinnea pulchella	6 db.	Clausilia dubia	14 db.
Bythinia leachi	38 db.	Succinea pfeifferi	27 db.
Planorbis planorbis	4 db.	Succinea oblonga	23 db.
Armiger crista	32 db.	Trichia hispida	18 db.
Vertigo sp.	1 db.	Arianta arbustorum	2 db.
Pupilla sp.	11 db.	Sphaerium sp.	5 db.
Clausilia dubia	5 db.	Pisidium sp.	63 db.
		Pisidium obtusale	44 db.

Fig. 9.: Molluscan fauna of the borehole 1974/1 at Dunaföldvár /M. Wagner/

7. Molluscan fauna of the Dunaföldvár exposure

Samples were collected at 1o cm interval /1 dm³/ from two profiles of the Dunaföldvár exposures /Figs. 8., 9./.From the first profile 4o24 molluscs were obtained by washing; the majority of these /3898 specimen/ belong to four ubiquitous species, molluscs that tolerate cold, dry ecological conditions and aquatic species were also found.

From a few loess and sand layers /layer No. 5., 7., 13., 23., 26./ of the first profile /Fig. 8./ no molluscs were obtained, while the number of species was also small in the fossil soils. In the oldest fossil soil /PD_2/ the gastropods were absent.

Below the present-day chernozem soil in the sandy loess /to 3.8 m/ Pupilla and Trichia species dominate indicating a cold, dry paleoclimate, the presence of Succinea specimen may mark relatively more moist conditions.

The young loess of the Dunaföldvár exposures consist mainly of stratified sand layers /layer No. 4., 5., 7., 1o./ and of sandy loess /layer No. 6., 8., 9./ to about 18 m below the surface. In the sandy layers few or no molluscs were found. Although the stratigraphical position of the loess layers is such that they contain the cold maximum of the Würm, however, Columella species were not obtained from the profile. The large number of Pupilla specimen in some strata /No. 3., 6./ may indicate moderately warm loess steppe vegetation.

A remarkably great number of mulluscs could be counted in the loess layer between 18 - 2o m. This may be explained by favourable paleoecological conditions which is proved by the existence of a forest steppe soil /BD_2/ underlying this strata. After the formation of the BD_2 soil the diagenetic development of the loess /between 18 - 2o m/ occurred in a rich grassland. The presence of nearly 2ooo mulluscs in the 2 m thick loess layer may be due to some special conditions of fossilization and deposition. On the other hand selective fossilization could have been responsible for the few species and genera in the fossil soils BD_2, BA, MB. This may be the cause for the scarceness of molluscs in the above mentioned forest steppe and forest soils and hence for the insufficient evidence for paleoecological reconstruction of climatic conditions predominant during soil formation.

In the stratified old loess, loessy sand and stratified sand and silt sediment sequence /between 27 - 35.5 m/ interbedded between the MB and PD_1 fossil soils the molluscan assemblage is not particularly rich indicating alluvial sedimentation, moist woodlands on floodplains, and cool, humid climatic conditions. The presence of Euconulus and Clausilia species together seem to demonstrate these latter ecological conditions. In the second profile /Fig. 9./ in a layer in a similar stratigraphical position and development species and genera of different aquatic or marsh molluscs were found in a greater number, providing further evidence for our supposition.

In the first profile at Dunaföldvár just like in the Paks exposure few species of Chondrula and Clausilia were found in the PD_1 soil. The PD_2 soil contained no molluscs in this first profile, however, in the underlying old loess band /between 44.5o - 39.8o m/ a relatively large number of molluscs were preserved. Trichia hispida in this faunal assemblage may indicate a cold climate during loess formation, while the large number of Clausilia, Punctum and Nesovitrea species demonstrate ecological conditions characteristic of temporarily flooded flood plains with woodlands.

In the pink-coloured stratified sandy formation /between 45 - 53 m/ below the old loess no molluscs were found.

The second profile at Dunaföldvár /Fig. 9./ is situated 2oo m north of the first profile /at the 156.2 km post of the

Danube/ along the high loess bluff in the Kálvária hill. The exposure was steep, samples could only be collected from the old loess /between 33 and 51 m/.

The 2o m long section was rich in molluscan remains of which 1312 were determined, 1o58 of these were aquatic species.

The Mt soil /between 33.2 - 34.9 m/ was exceptionally rich in molluscs. The abundance of water species may mark the formation of forest soils on wooded flood-plains, while the Chondrula species indicate a moderately warm climate.

The silty sand underlying this soil is alluvial material of flood-plains, rich in shell fragments. Cold, cool climatic conditions may have prevailed as shown by the presence of Trichia species.

The development of the silty alluvial formation between 36 - 39.5 m have probably occurred on a seasonally flooded, occasionally dammed flood plain area according to the evidence provided by a rich assemblage of aquatic - marsh molluscan species and genera, under relatively favourable moderate climatic conditions. The lower part of this formation /between 38.5 - 39.5 m/ seems to have a soil structure, the Cca horizon is well developed /Fig. 3/b./.

Few molluscs had been fossilized in the PD_2 forest soil /between 4o.5 - 42 m/, the occurrence of Arianta and Chondrula species together indicate a warmer climate. The 1 m thick loess like layer directly overlying this soil has a faunal assemblage that must have lived in a cold, dry climate.

In the forest soil marked PDK /at 43.3 - 45 m/ an exceptionally high number of molluscs have been preserved. Different species of water molluscs and terrestrial molluscs are both frequent. Probably fenwood forests grew in the area for a relatively longer period and moderately warm, dry climatic conditions prevailed.

Only two water molluscs were found in the old loess silt between 45 - 48 m in the second profile /Fig. 9./. The pink-coloured silty sand between 48 - 51 m had no gastropods. The latter belongs stratigraphically to the so called "Dunaföldvár Complex", lithologically it is proluvium.

The importance of the second profile at Dunaföldvár is great because both the old loess formations and the enclosed fossil soils preserved a large number of molluscs, mostly water species of flood-plains. The molluscan assemblage found in this profile seems to underline M. Pécsi's statement /M. Pécsi, 1975/ that most of the layers in the old loess complex are alluvial deposits and continuous deposition was occasionally interrupted by repeated cycles of soil formation and erosion.

8. Chronological summary /based on paleomagnetic measurements/

Core samples from the borehole 1974/I and from the loess exposure on Kálvária hill in Dunaföldvár /Fig. 3/a./ we analysed paleomagnetically in order to provide a chronological interpretation of the sediment sequence of the "Dunaföldvár Complex" /Fig. 1o./.

As shown on Fig. 3/a. the loess sequence in the two Dunaföldvár exposures, exhibited normal magnetic polarity, in the upper 42 m /1o2 m a.s.l./ and thus it can be correlated with the Brunhes epoch. Layers below 42 m have dominantly a reversed polarity.

In the Matuyama reversed epoch several normally magnetized events are known. According to paleomagnetic measurements made by M. A. Pevzner, the normally magnetized part of the profiles between 45 and 48 m represented by the upper part of the pink, sandy formation may be considered as an indication of the Jaramillo event. The red soils No. 3. and No.

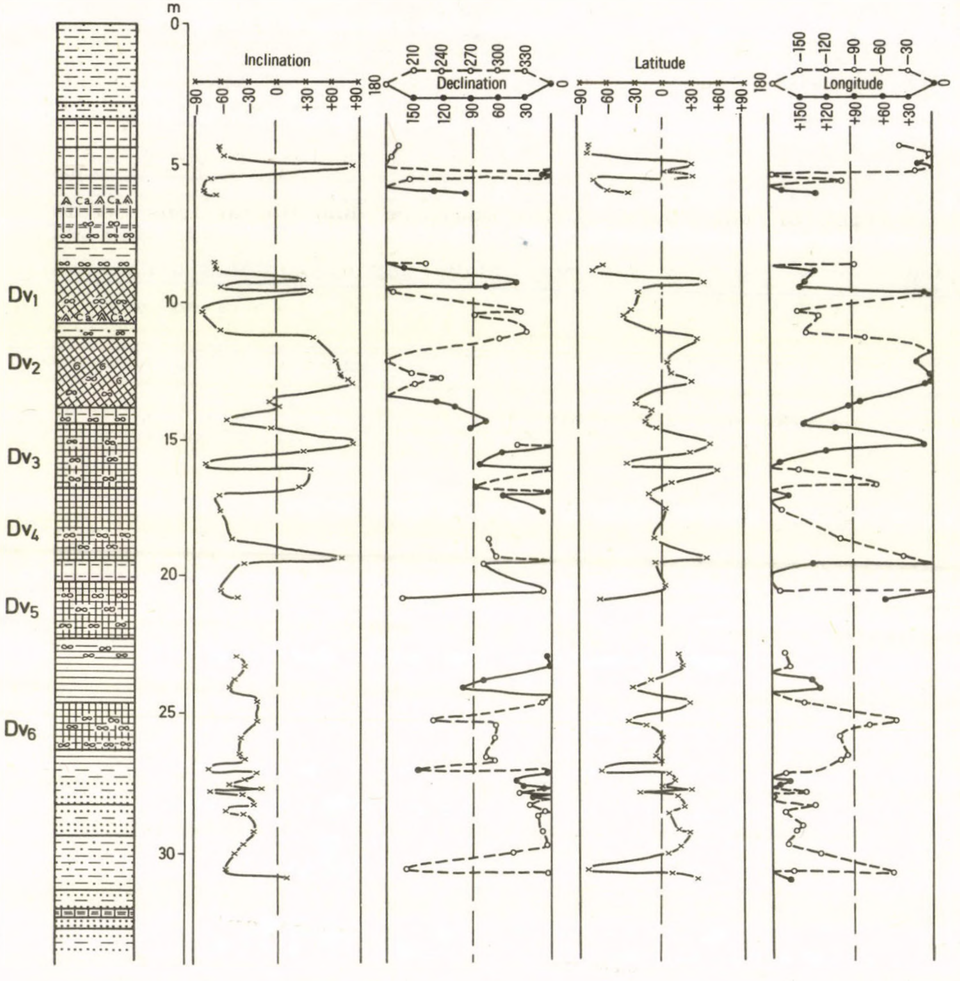


Fig. lo.: Paleomagnetic data obtained from fully oriented samples of the 1974/1 borehole at Dunaföldvár /M. A. Pevzner/

2. and the silt layer above the second red soil also have a normal polarity in the borehole 1974/I. at 82 and 76 m a.s.l. These two excursions may be correlated with the Gilsa-Olduvai events /1.7 - 1.8 MY B. P./.

Normally magnetized thin layers were also found in the meadow clay soil at 88 m a.s.l. and at the base of the red soil No. 4. /73.5 m a.s.l./. These layers may indicate a presumably unknown normally magnetized event in the Matuyama reversed epoch.

Based on paleomagnetic data it may be supposed that the deposition of the "Dunaföldvár Complex" had begun long before the Gilsa-Olduvai events - it can be probably dated as far back as the beginning of the Matuyama epoch. The deposition of the closing formation, the pink sandy silt, was probably completed immediately after the Jaramillo event. When compared to the paleomagnetic time scale the "Dunaföldvár Complex" had been deposited between 2.4 and o.9 million years B. P.

Considering that the Brunhes-Matuyama boundary /o.69 MY B. P./ was detected in the exposures both at Dunaföldvár and Paks in the lowest part of the old loess proper, the loessial sequences in Hungary are not older than o.8 - o.9 MY in the exposures analized by the paleomagnetic method.

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Készült az MTA Földrajztudományi Kutató Intézet házi sokszoro-
sitóján /rotaprint eljárással/. Példányszám: 4oo. A kiadásért
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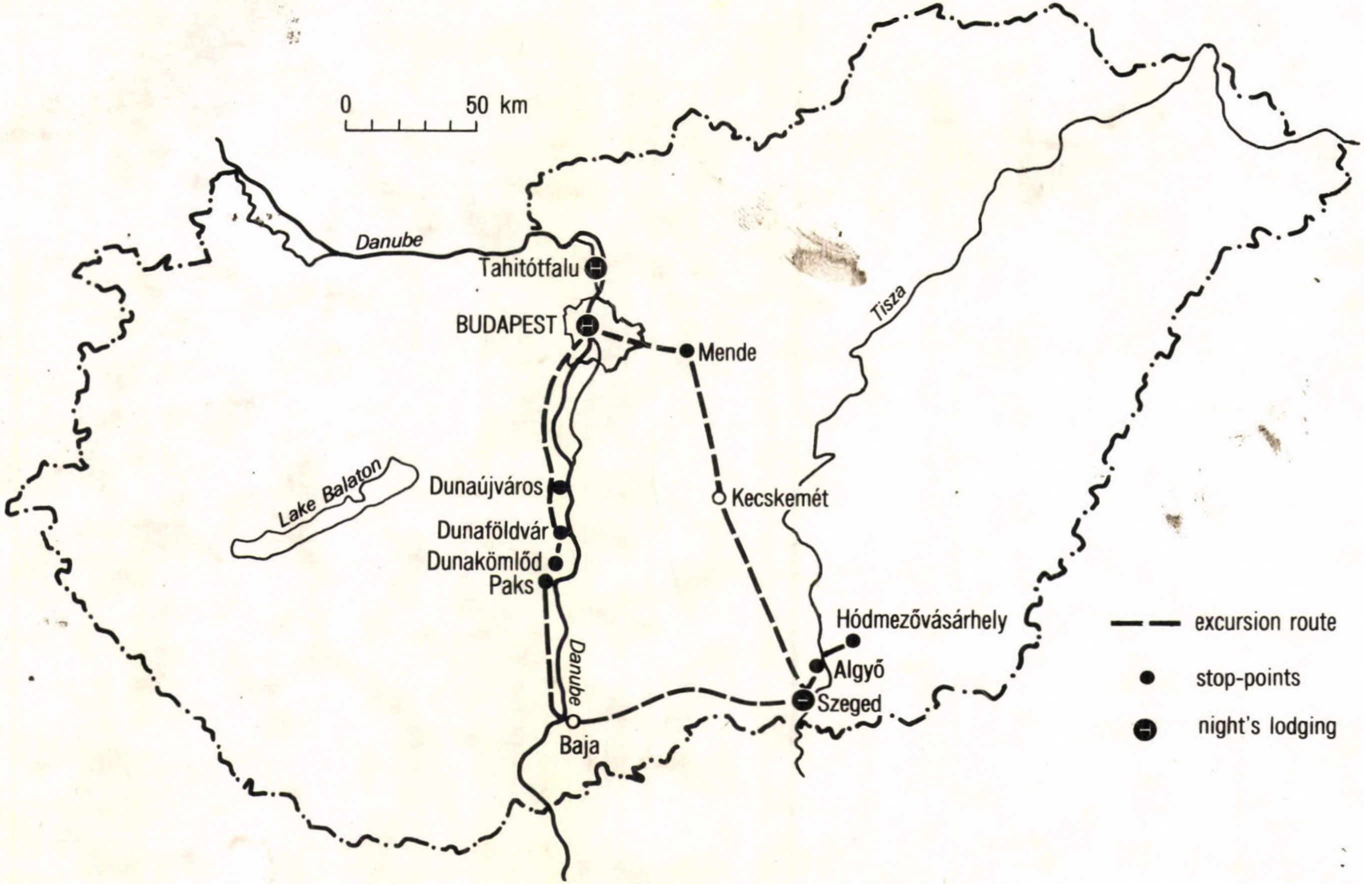
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Paks
Kecskemét
Danube
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Szeged
Baja
excursion route
stop-points
night's lodging