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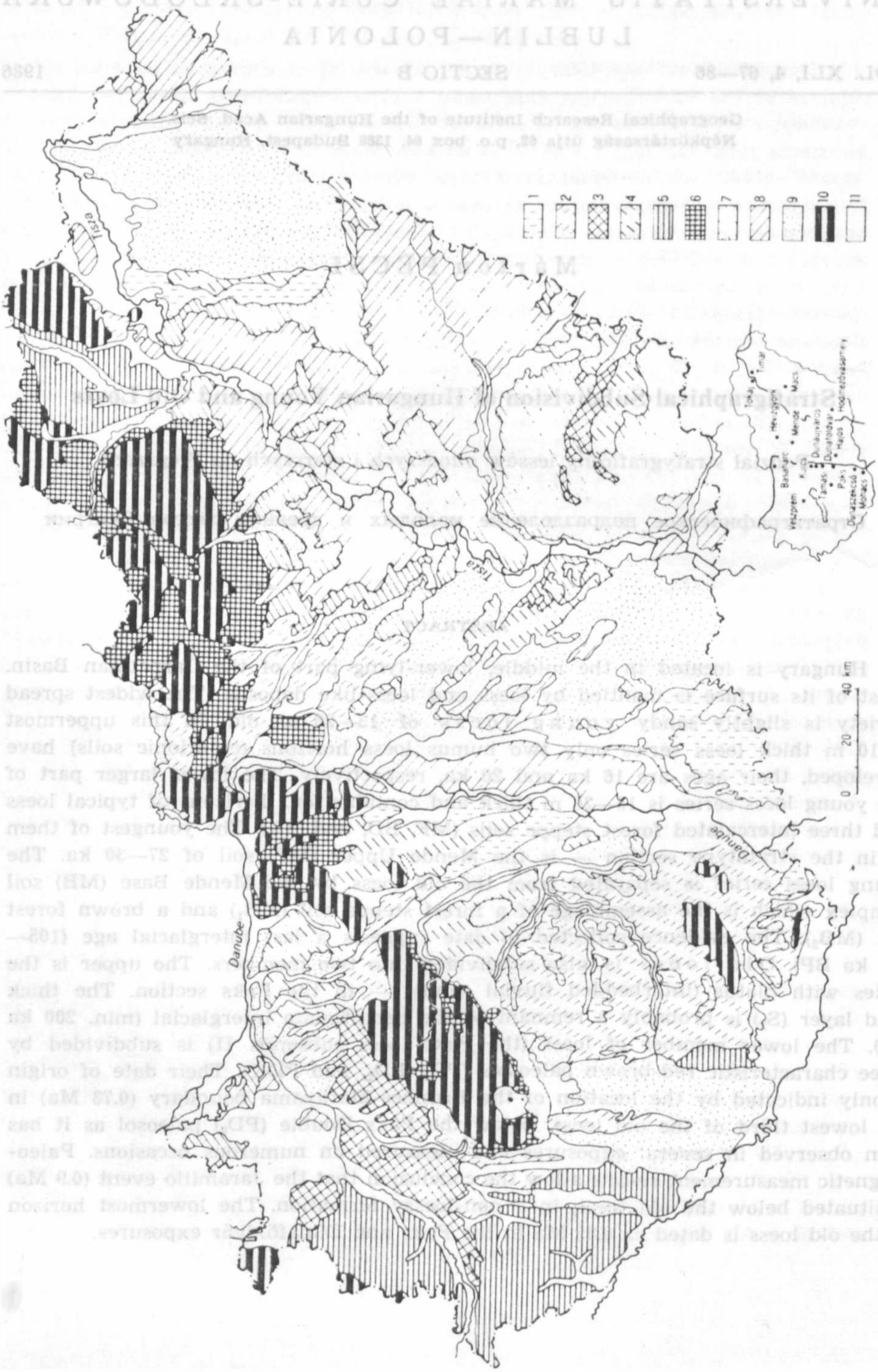
Stratigraphical Subdivision of Hungarian Young and Old Loess

Podział stratygraficzny lessów młodszych i starszych na Węgrzech

Стратиграфическое подразделение молодых и древних лёссов Венгрии

ABSTRACT

Hungary is located in the middle, lower-lying part of the Carpathian Basin. Most of its surface is mantled by loess and loess-like deposits. The widest spread variety is slightly sandy young loess of 13—26 ka old. In this uppermost 8—10 m thick loess series only two humus loess horizons (embrionic soils) have developed, their ages are 16 ka and 20 ka, respectively. The lower larger part of the young loess series is 15—20 m thick and contains four horizons of typical loess and three intercalated forest steppe soils (MF, BD, and BA). The youngest of them — in the stratotype section — is the Mende Upper (MF) soil of 27—30 ka. The young loess series is separated from the old loess by the Mende Base (MB) soil complex which is the assemblage of a forest steppe soil (MB_1) and a brown forest soil (MB_2). The evidence collected to date suggests a last interglacial age (105—125 ka BP). Old loess is also subdivided into two members. The upper is the series with hiatus (interbedded fluvial sands) — in the Paks section. The thick sand layer (S_2) is probably a remnant of the penultimate interglacial (min. 200 ka old). The lower member of loess (the Paks loess subseries II) is subdivided by three characteristic red-brown paleosols (PD_1, PD_2, and PDK). Their date of origin is only indicated by the location of the Brunhes-Matuyama boundary (0.73 Ma) in the lowest third of the old loess, below the Paks Double (PD_2) paleosol as it has been observed in several exposures and measured on numerous occasions. Paleomagnetic measurement results allow the conclusion that the Jaramillo event (0.9 Ma) is situated below the old loess, in a non-loessy formation. The lowermost horizon of the old loess is dated ca 0.85 Ma in the Paks and Dunaföldvár exposures.


1
2
3
4
5
6
7
8
9
10
11
Tisza
Tisza
Danube
Danube
0
20
40
Tokaj
Tímár
Hévízgyörk
Mácsa
Mende
Basaharc
Kulcs
Veszprém
Dunaújváros
Dunaföldvár
Tamás
Paks
Hajós
Hódmezővásárhely
Dunaszekcső
Mohács

REGIONAL DISTRIBUTION OF THE MAJOR LOESS VARIETIES

Regarding the Middle Danubian basin, the so-called lowland loess has the largest areal distribution (Fig. 1). It occurs on the flood--plains and low terraces along river system. Since the basin has undergone a considerable subsidence during the Quaternary, too, eolian and fluvial layers are superimposed one upon the other. The near-surface lowland loess is the youngest (13—24 ka BP); it is not typical loess, sandy or clayey varieties both occur alternating in space. For their origin, they are flood-plain silts (infusion loess) which became loess-like formations through diagenesis (M. Pécsi 1980).

Typical loess is characteristic on river terraces and alluvial fans unaffected by groundwater. In some favourable geomorphological positions, almost a complete series of young loess varieties has been preserved on the second flood-free Danubian terrace. It contains four of five well-developed intercalated chernozem-like paleosols. Loess in greatest thickness and most available for subdivisions overlie the older alluvial fans and are exposed along the erosion bluff of the Danube.

In the hill regions the extension and thickness of typical loess and stratified slope loess (up to 50 to 100 m thickness) is remarkable. They are characterized by the repeated alternations of unstratified typical loess and stratified sandy slope loess and by the intercalations of paleosols. The hilly regions are mostly mantled by young loess, but locally old loess of considerable thickness also occurs.

The loess in low mountains and on pediments also differ from the previous in their lithological character. Typical loess, loess detritus, stratified slope loess and brown loess alternate horizontally and vertically. Mountain loess may reach altitudes of 300 to 500 m. In more humid regions they are mostly of brownish colour and slightly loamy loess.

The spatial pattern of loess varieties is primarily controlled by relief configuration and the macroregional differences in climate. The oval shaped Carpathian basin lies in the temperate belt of westerly winds. The Atlantic air masses bringing precipitation result in more humid climate along the W margins of the basin, in the foreland of the E-Alps, while the centre of the basin is essentially more arid and

Fig. 1. Distribution of loess and loess varieties in Hungary
1 — typical loess; 2 — derasion slope loess; 3 — sporadic brown loess; 4 — sandy loess; 5 — brown loess; 6 — loess derivate, loessy loam; 7 — high flood-plain loess, silt; 8 — flood-plain loess, silt; 9 — blown sand; 10 — medium-height mountains; 11 — fluvial deposits

continental. As a consequence, along the basin margins, particularly in the W zone, so-called "brown loess", "brownearths" (Fig. 1) and loess--like loams of lesser lime content occur. Consequently, the differences between the particular loess varieties root back in climageomorphological influences. In contrast, in hilly regions heavily dissected by valleys, the so-called valley loess, i.e. derasion loess stratified parallel to slope and covering old valleys, is typical. (For them the term "derasion loess" was applied by M. Pécsi 1982).

STRATIGRAPHICAL SUBDIVISION OF LOESS

YOUNG LOESS SERIES

Among the loess types in Hungary and the Carpathian Basin, the most widespread is young loess and in several sections almost complete sequences can be studied. The 20—25 thick sequence of young loess is represented in sections most suitable even in Eurasian comparison for subdivision. Among them several stratotypes with nearly identical sequences have been investigated (Basaharc, Dunaujváros, Mende, Tamási, Tápiósüly, etc.). By the investigations of the Hungarian stratotypes and additional profiles applying several methods, young loess can be subdivided stratigraphically as follows (Fig. 2).

The Dunaujváros subseries. The packets of more or less sandy loess (of 8—10 m thickness) are only divided by two humic loess horizons. Recent soil (R_s): chernozem and/or brown forest soil. First loess horizon (l_1) of 2—5 m thickness, sandy loess with fragments of reindeer bones, its age is cca 13—16 ka. Humic loess (h_1), embrionic soil with charcoal fragments of *Pinus cembra* and *Larix*, age cca 16 ka (at Tápiósüly). Loessy sand and sandy loess (l_1^1) of 1,5—3,0 m thickness, with traces of dell formation subsequently filled and with fragments of reindeer bones, age cca 17—20 ka. Second humic loess (h_2), embrionic soil, with charcoal fragments of *Pinus* sp. and *Larix*, age cca 20—21 ka (at Dunaujváros, Dunszekcsó and Lovasberény). Second sandy loess packet containing dell fill (l_2', l_2'', l_2), 2—5 m thick, with skeleton remains of young form of *Elephas primigenius* in l_2, dated 21—26 ka.

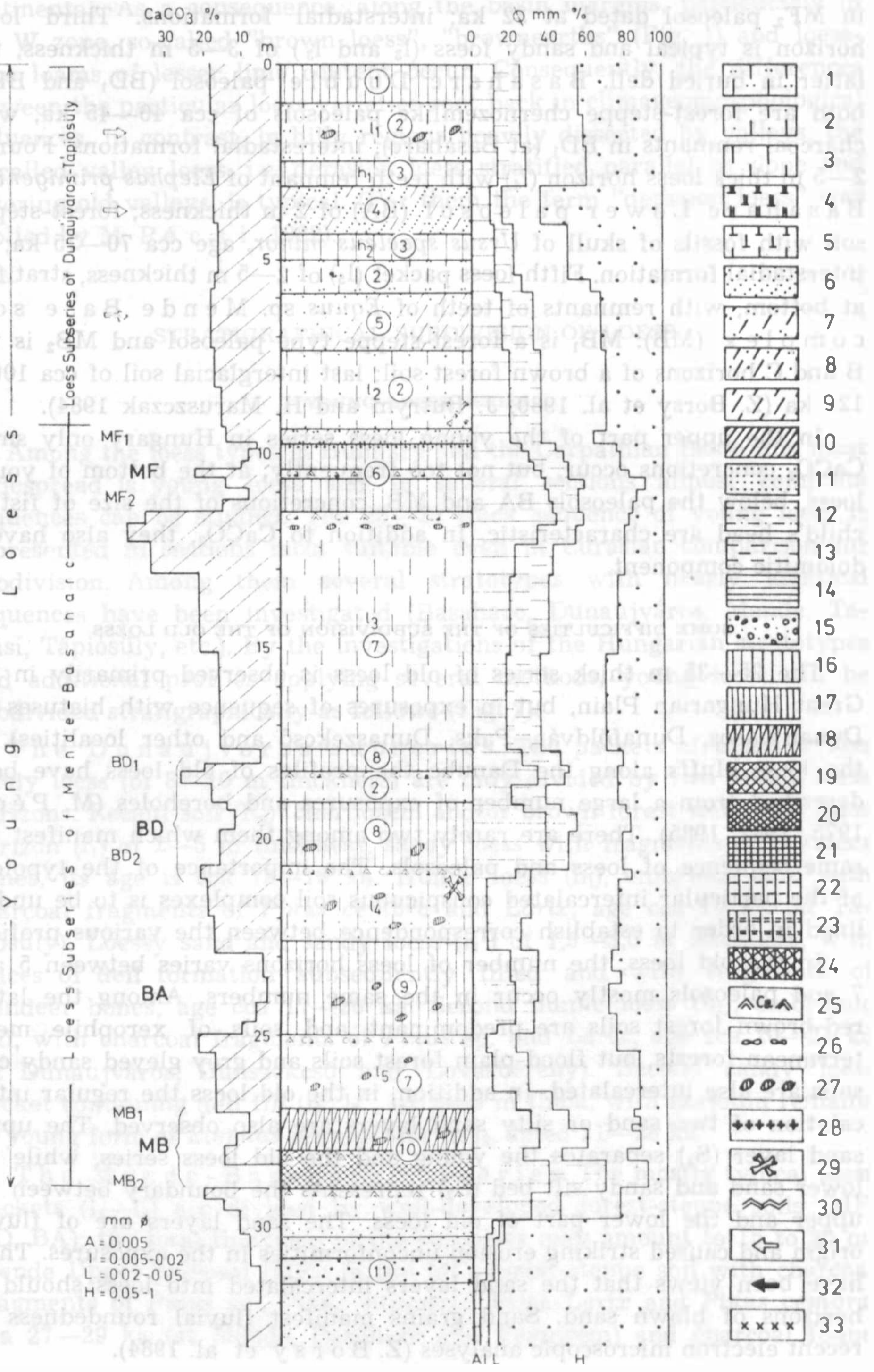
The Mende-Basaharc subseries. The mostly typical loess packets (l_3—l_5) are divided by well-developed forest-steppe soils (MF, BD, BA); the total thickness of the subseries may amount to 15 to 20 m. Mende Upper paleosol (MF): in the MF_1 forest-steppe soil with charcoal fragments of *Pinus sp., Pinus silvestris, Picea-Larix* and *Pinus cembra,* cca 27—29 ka (at Mende, Basaharc and Veszprém) and charcoal found in MF_2 paleosol dated at 32 ka; interstadial formations. Third loess horizon is typical and sandy loess (l_3 and l_3') of 3—5 m thickness, the latter in buried dell. Basaharc Double paleosol (BD_1 and BD_2), both are forest-steppe chernozemlike paleosols of cca 40—45 ka, with charcoal remnants in BD_1 (at Basaharc); interestadial formations. Fourth, 2—5 m thick loess horizon (l_4) with teeth remnant of *Elephas primigenius*. Basaharc Lower paleosol (BA) of 2 m thickness; forest-steppe soil with fossils of skull of *Ursus spaeleus minor*, age cca 70—75 ka; an interstadial formation. Fifth loess packet (l_5) of 2—5 m thickness, stratified at bottom, with remnants of teeth of *Equus* sp. Mende Base soil complex (MB): MB_1 is a forest-steppe type paleosol and MB_2 is the B and C horizons of a brown forest soil; last interglacial soil of cca 100—125 ka (Z. Borsy et al. 1980, J. Butrym and H. Maruszczak 1984).

In the upper part of the young loess series in Hungary only small $CaCO_3$ concretions occur, but not too frequently; at the bottom of young loess, below the paleosols BA and MB, concretions of the size of fist or child's head are characteristic. In addition to $CaCO_3$, they also have a dolomitic component.

SOME DIFFICULTIES OF THE SUBDIVISION OF THE OLD LOESS

The 25—35 m thick series of old loess is observed primarily in the Great Hungarian Plain, but in exposures of sequence with hiatuses (at Dunaujváros, Dunaföldvár, Paks, Dunaszekcső and other localities). In the loess bluffs along the Danube the profiles of old loess have been described from a large number of exposures and boreholes (M. Pécsi 1975, 1982, 1985). There are rarely two among them which manifest the same sequence of loess and paleosols. The importance of the typology of the particular intercalated conspicuous soil complexes is to be underlined in order to establish correspondence between the various profiles.

In the old loess, the number of loess horizons varies between 5 and 7 and paleosols mostly occur in the same numbers. Among the latter red-brown forest soils are predominant and soils of xerophile mediterranean forests, but flood-plain forest soils and grey gleyed sandy clay soils are also intercalated. In addition, in the old loess the regular intercalation of two sand or silty sand layers are also observed. The upper sand layer (S_1) separates the young and the old loess series, while the lower sand and sandy silt bed (S_2) represents the boundary between the upper and the lower part of old loess. The sand layers are of fluvial origin and caused striking erosion unconformities in the exposures. There have been views that the sand layers intercalated into loess should be horizons of blown sand. Sand grains manifest fluvial roundedness by recent electron microscopic analyses (Z. Borsy et al. 1984).


CaCO3 %
30 20 10
m
Q mm %
0 20 40 60 80 100
0
5
10
15
20
25
30
Loess Subseries of Dunaújváros-Tápiósüly
Young Loess
Basaharc
Loess Subseries of Mende
MF1
MF
MF2
BD1
BD
BD2
BA
MB1
MB
MB2
h1
h2
l1
l2
l3
l4
l5
mm ø
A = 0.005
I = 0.005-0.02
L = 0.02-0.05
H = 0.05-1
A I L
H
1
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It is considered to be an oversimplification to identify each of the old loess horizons of a profile with a glacial period in the stratigraphy of loess. Similarly, it has not been proven either that each of the paleosols intercalated into loess represents a single interglacial and no evidence supports the identification of the interglacial, because of the erosion hiatuses. The chronological significance of the sand layers intercalated into old loess is also conceived variably. Some hold the view that if it is blown sand, it was presumably accumulated during a glacial stage. In contrast, those who regard them fluvial sand accumulations connect them with interglacials.

A further difficulty is represented by the fact that no uniform opinion has been formed on the number of repetitions and the durations of glacials and interglacials and their subcycles. Thus, the subdivision of

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Fig. 2. Typical locality of the young loess profile at Mende near Budapest (according to M. Pécsi and E. Szebényi; profiling done with the cooperation of Á. Juhász and M. di Gléria)

1 — recent chernozem, locally chernozem and brown forest soil (double profile); 2 — sandy loess, in the loess l_2 a complete young mammoth skeleton was found; 3 — weak humus horizon (with charcoal); 4 — stratified loessy sand, at the lower part reindeer bone remnants occur; 5 — stratified sandy slope loess; 6 — stratotype of Mende Upper (MF) soil complex, a double forest-steppe soil profile with a number of charcoal fragments in the upper part (MF_1 *Picea, Larix, Pinus cembra*, radiocarbon date: 29,800 ±600, Lab. No Mo 422; 27,200 ±1400, Lab. No I. 3130; 27,000 ±1589, Lab. No Hv 5422), the Cca horizon of MF_2 is rich in lime and carbonate concretions; 7 — typical loess, but in the lower part there is a little more sandy loess; 8 — "Basaharc Double" soil complex (chernozem-like paleosol) below the BD_2 there are *Elephas primigenius* remnants; 9 — "Basaharc Lower" paleosol (BA), locally the uppermost part is soil sediment; 10 — stratotoype of Mende Base (MB) soil complex, the upper part (MB_1) is a dark, chernozem-like paleosol, the lower part is well-developed brown forest soil; 11 — alluvial, proluvial sand at the Tápió brook (second terrace); Mende Base probably developed during the second half of the Riss-Würm interglacial, because the alluvial sand below is cca 125 ka old by TL data (Z. Borsy et al. 1980); h_1, h_2 — weak humus horizons; l_1—l_5 — number of young loess packets; l_1', l_1'', l_2' — subdivisions of main loess packets. Graphic signature legend to the Figs. 2—8: 1 — loessy sand; 2 — sandy loess; 3 — loess; 4 — old loess; 5 — infusion loess; 6 — slope sand; 7 — loessy slope sand; 8 — sandy slope loess; 9 — slope loess; 10 — semipedolite; 11 — fluvial-proluvial sand; 12 — silty sand; 13 — silt, gleyed silt; 14 — clay; 15 — sandy gravel; 16 — weak humus horizon; 17 — steppe-type soil, chernozem; 18 — forest soil altered by steppe vegetation; 19 — brown forest soil; 20 — grey-brown forest soil; 21 — red clay; 22 — hydromorphous soil; 23 — alluvial meadow soil; 24 — forest soil (on floodplain); 25 — calcium carbonate accumulation; 26 — loess doll; 27 — krotovina; 28 — charcoal; 29 — microfauna; 30 — discontinuity in profile; 31 — traces of non--linear erosion; 32 — traces of linear erosion; 33 — volcanic ash. Grain size distribution letter symbols to the Figs. 2 and 3: A — clay (<0.005); I — silt (0.006—0.02); L — loess (0.02—0.05); H — sand (0.05—1.00)

the old loess-paleosol and sand horizons on the Pleistocene time-scale is highly hypothetical and may result in an oversimplified conclusion for the correction of which the application of several other techniques is required.

Along with the evaluation of the biostratigraphical and lithostratigraphical situation, paleomagnetic investigations are helpful in the absolute dating of the particular loess horizons. For old loess, the results of TL analyses are received with doubt or great reserve by some researches and representatives of scientific schools.

It is not yet clear what role the "loess doll" horizons in thick old loess packets may play in the lithostratigraphical subdivision of loess. It is assumed that the "loess doll" horizons of old loess series had formed in the BC horizons of one-time soils, but the soil profile was subsequently eroded to the degree that it is only preserved in the $CaCO_3$ concretion layer. According to this view, the number of soil formations and erosions (of A and B horizons) in thick old loess series equals the number of $CaCO_3$ concretion horizons (for instance 3 or 4). Others say that a considerable part of the concretion horizons results from reworking, as the concretions in the preserved BC and CCa horizons of surviving paleosols are oriented vertically. Our experience suggests that examples can be found to support either of the hypotheses. At any rate, from the above it also can be concluded that during the formation of the thick old loess series not only the conventional loess and paleosol formation periods but also repeated minor cycles of soil development — soil erosion — loess doll reworking processes should be taken into account.

With regard to the above, of the absolute age of old loess and intercalated paleosols along the Danube in Hungary, it can only be claimed with high probability that the Brunhes-Matuyama boundary (0.73 Ma BP) lies in the lowermost third of old loess, below the "Paks Double" (PD) soil complex as it has been observed in several exposures and during repeated measurements. It was also found that the Jaramillo event (0.9 Ma BP) is not located in old loess, but in the upper part of the non-loessy, subaerial sediment sequence underlying the loess formation of the Carpathian Basin, which is called the "Dunaföldvár formation" (M. Pécsi 1982, 1984).

POSSIBLE SUBDIVISION OF THE OLD LOESS IN HUNGARY

While the above described sequence of young loess can be detected almost completely in several key sections, old loess of cca 25—30 m thickness usually presents unconformities (Fig. 3). It is studied in greatest detail along the Danubian loess bluff from Dunaujváros to Paks. Old loess was called the "Paks loess" after the profile of the Paks brickyard (M. Pécsi 1975, 1985). Lithostratigraphically it can be also subdivided into distinct parts (Fig. 3).

Upper part of the "Paks Loess" (125—210 ka). This part with great unconformities includes the loess horizon between the paleosols MB and PD. Below paleosol MB, in several sections, fluvial sand and an erosion unconformity are observed (Fig. 4). This sand layer is not found in some of the exposures.

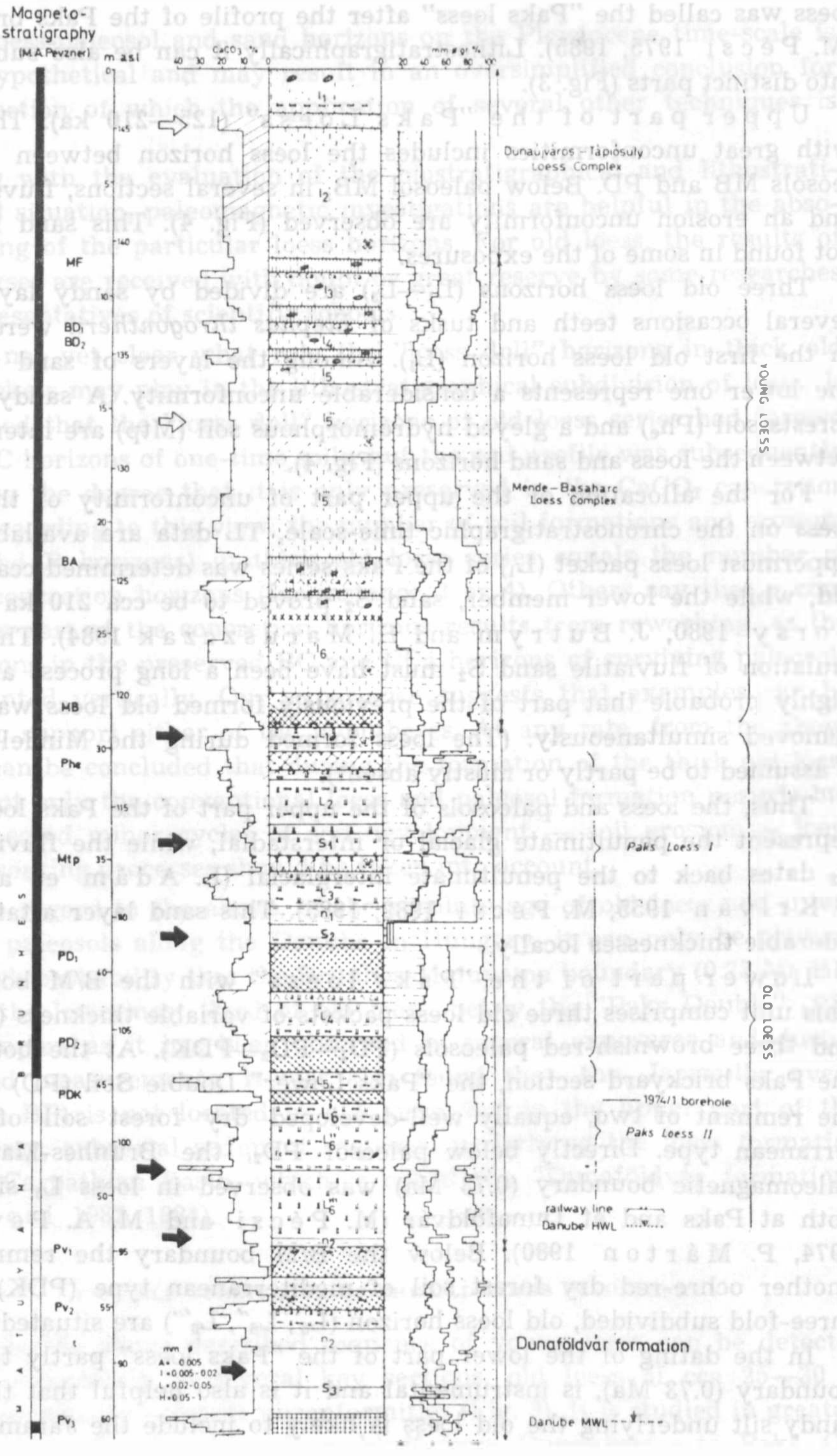
Three old loess horizons (L_1—L_3) are divided by sandy layers. On several occasions teeth and tusks of *Elephas throgontherii* were found in the first old loess horizon (L_1). Among the layers of sand (S_1—S_2) the lower one represents a considerable unconformity. A sandy brown forests soil (Ph_e) and a gleyed hydromorphous soil (Mtp) are intercalated between the loess and sand horizons (Fig. 4).

For the allocation of the upper part of unconformity of the Paks loess on the chronostratigraphic time-scale, TL data are available. The uppermost loess packet (L_1) of the Paks series was determined cca 125 ka old, while the lower member, sand S_2 proved to be cca 210 ka old (Z. Borsy 1980, J. Butrym and H. Maruszczak 1984). The accumulation of fluviatile sand S_2 must have been a long process and it is highly probable that part of the previously formed old loess was being removed simultaneously. (The loess formed during the Mindel glacial is assumed to be partly or mostly absent).

Thus, the loess and paleosols of the upper part of the Paks loess may represent the penultimate glacial or interstadial, while the fluvial sand S_2 dates back to the penultimate interglacial (L. Ádám et al. 1954, P. Kriván 1955, M. Pécsi 1982, 1985). This sand layer attains considerable thicknesses locally.

Lower part of the "Paks loess" with the B/M boundary. This unit comprises three old loess packets of variable thickness (L_4—L_6) and three brownish-red paleosols (PD_1—PD_2—PDK). At the bottom of the Paks brickyard section, the "Paks Lower" Double Soil (PD) may be the remnant of two, equally well-developed dry forest soil of mediterranean type. Directly below paleosol PD_2, the Brunhes-Matuyama paleomagnetic boundary (0.73 Ma) was observed in loess L_5 similarly both at Paks and at Dunaföldvár (M. Pécsi and M. A. Pevzner 1974, P. Márton 1980). Below the B/M boundary the remnant of another ochre-red dry forest soil of mediterranean type (PDK) and a three-fold subdivided, old loess horizon (L_6', L_6'', L_6''') are situated.

In the dating of the lower part of the "Paks loess" partly the B/M boundary (0.73 Ma), is instrumental and it is also helpful that the pink sandy silt underlying the old loess is likely to include the Jaramillo pa-


Magneto-
stratigraphy
(M.A.Pevzner)
m a.s.l
CaCO3 %
mm # gt %
Dunaújváros-Tápiósüly
Loess Complex
Mende-Basaharc
Loess Complex
Paks Loess I
1974/1 borehole
Paks Loess II
railway line
Danube HWL
Dunaföldvár formation
Danube MWL
YOUNG LOESS
OLD LOESS
MF
BD1
BD2
BA
MB
Phe
Mtp
PD1
PD2
PDK
Pv1
Pv2
Pv3
mm #
A< 0.005
I = 0.005-0.02
L = 0.02-0.05
H = 0.05-1

leomagnetic event (0.9 Ma). The lithological analyses of data from several exposures and boreholes suggest that the lowermost old loess packet in Hungary is the horizons L_6 of the "Paks loess".

It is assumed (M. Pécsi 1982) that paleosols PDK, PD_2 and PD_1 represent the various stages of the Cromer Interglacial of long warm and short cold spells, which separates probable the Günz from the Mindel glacial. This subdivision also assumes that Mindel glacial loess is mostly absent in the Paks series or loess had not formed (or was not subsequently preserved in the Paks sequence) prior to the Günz glacial in the Middle Danubian basin.

The loess-paleosol sequence, however, is not identical in each of the studied key sections of old loess (Fig. 5). Therefore, the particular loess horizons and paleosols of the Paks old loess cannot as yet be unambiguously related to determined glacials or interglacials. In this respect, we are now aware of the need for more caution than which was taken earlier by some researches in interpretation on the basis of the number and sequence of loess and paleosol horizons.

Fig. 3. Lithostratigraphical subdivision of the old and young loess formations at Paks. Lithological and pedological analysis made by M. Pécsi and E. Szebényi, paleomagnetic measurements by M. A. Pevzner (Institute of Geology Acad. of Scis. USSR, 1974)

l_1, l_2 — the typical youngest loess beds of the profile (between l_1, l_2 sandy slope loess deposited in a derasional valley (dell) the lower part of l_2 (x) fragments of reindeer bones occur as well as locally 1 to 2 humus horizons); MF — chernozem-like paleosol of "Mende Upper", only the MF_1 remained; l_3, l_4 and l_5 — young loess beds below paleosols (MF, BD_1 and BD_2) with numerous krotovinas in it; BD_1 and BD_2 — "Basaharc Double" paleosol complex chernozem-like locally hydromorphous meadows soil type; l_5'' — well-stratified sandy slope loess, the loessy sand filled up the derasional valley (with *Cervus* sp. and *Elephas primigenius* fauna remnants); l_5'' — sandy loess; BA — "Basaharc Lower" chernozem-like forest-steppe-like dark paleosol; l_6 — the lowermost young loess bed (with *E. primigenius* remnants) with a thin layer of volcanic tuffite on top; MB — "Mende Base" paleosol complex, the upper part is forest-steppe soil, but the lower one is a well-developed brown forest soil by TL data of Z. Borsy et al. 1980 about 105 ka old; L_1 — old loess, sandy loess, with large 'loess dolls' (molars, tusks of *Elephas trogontherii* were found on two occasions); Phe — weakly developed sandy brown forest soil; L_2, L_3 — old loess with 2—3 layers of 'loess dolls'; Mtp — hydromorphous paleosol (flood-plain, clayey soil) with *Allohippus* sp. teeth; S_1, S_2, n_1 — sand and silty clay of alluvial fan; PD_1, PD_2 — stratotype of "Paks Lower Double" paleosol complex with krotovinas, submediterranean xerophile forest soil or chestnut, usually reddish-brown soil (below the PD_2 paleosol the Brunhes-Matuyama boundary is observed); L_4, L_5 and L_6 — old loess horizons with 'loess doll' layers; L_6 — lowermost old loess horizon with rare 'loess dolls'; n_2, n_3 and S_3 — sandy, silty clay and sand of alluvial fan; Pv_1, Pv_2, Pv_3 — reddish, ochre-red paleosols below old loess (they belong to the "Dunaföldvár formation")

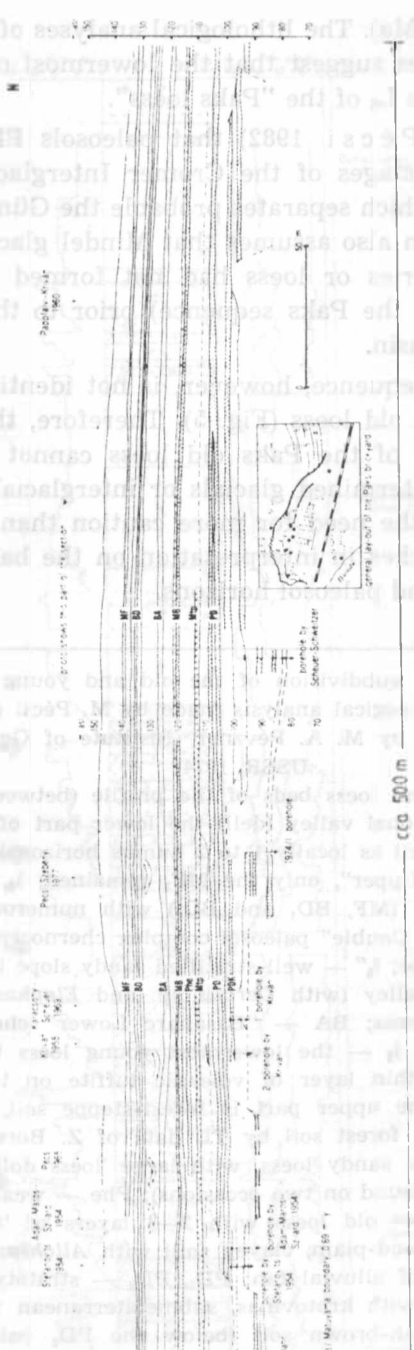


Fig. 4. Geological section of the Paks loess exposure (by M. Pécsi). Exposures and boreholes studied by other authors are also indicated

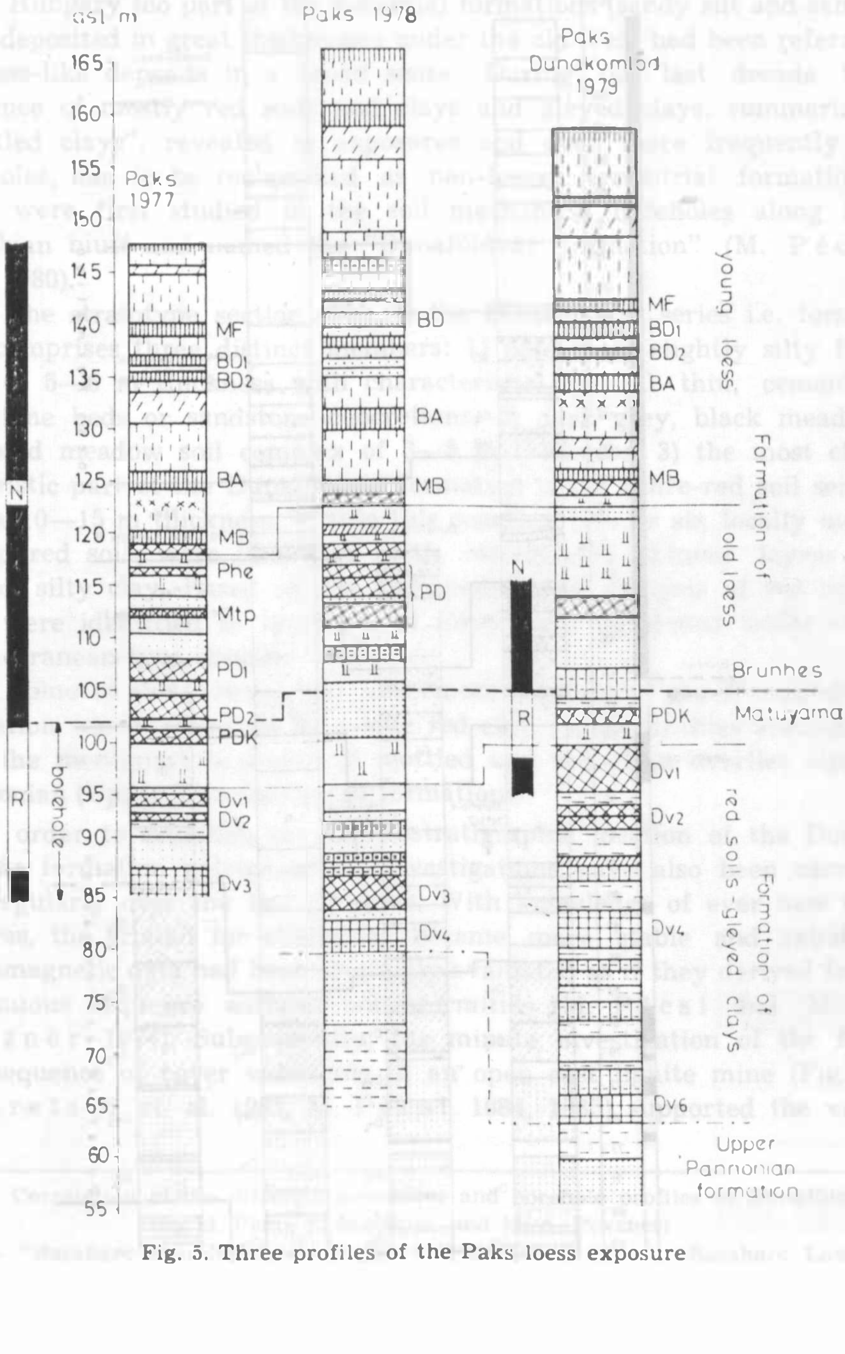
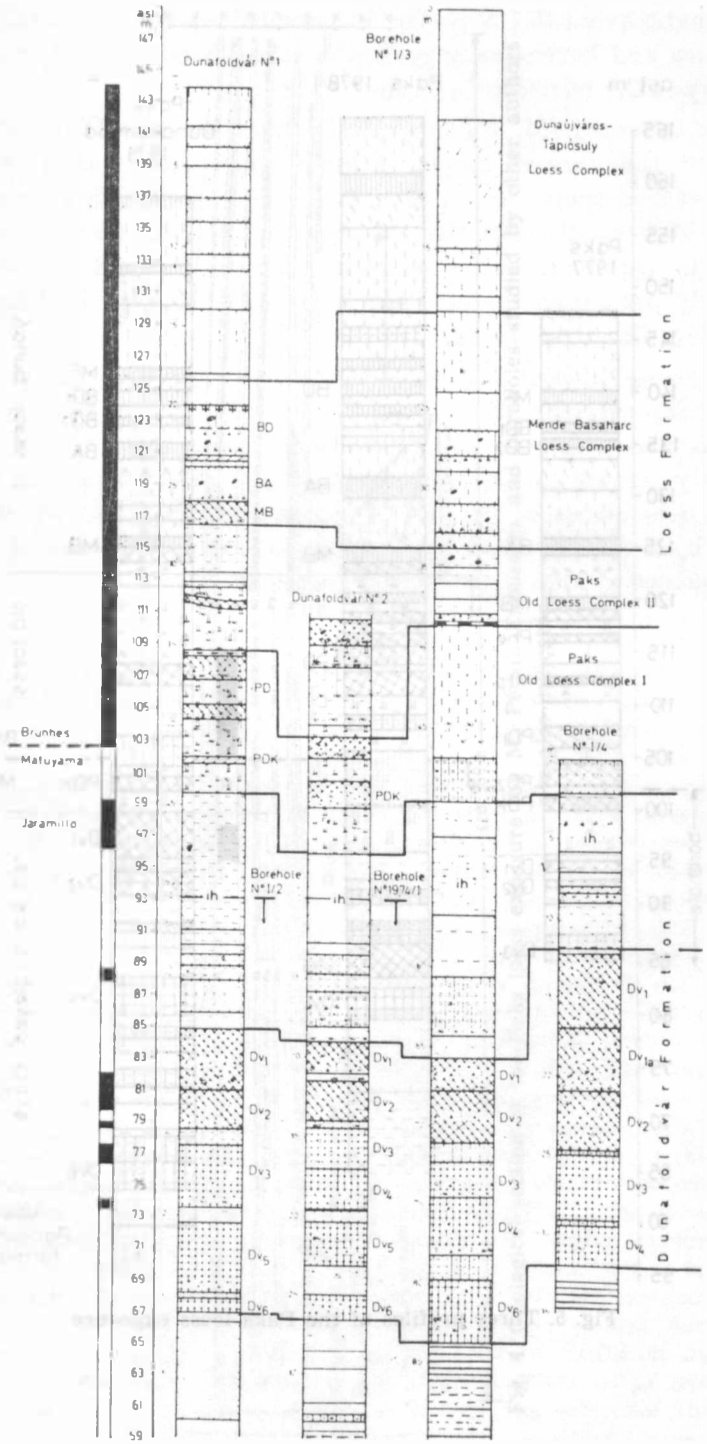


Fig. 5. Three profiles of the Paks loess exposure


asl m
Dunafoldvár N°1
Borehole N° 1/3
Dunaújváros-Tápiósuly Loess Complex
Mende Basaharc Loess Complex
Paks Old Loess Complex II
Paks Old Loess Complex I
Dunafoldvár N°2
Borehole N° 1/4
Brunhes
Matuyama
Jaramillo
BD
BA
MB
PD
PDK
ih
Borehole N°1/2
Borehole N°1974/1
Dv1
Dv1a
Dv2
Dv3
Dv4
Dv5
Dv6
Loess Formation
Dunaföldvár Formation

SUBAERIAL FORMATION BELOW LOESS

In Hungary too part of the subaerial formations (sandy silt and sandy clay) deposited in great thicknesses under the old loess had been referred to loess-like deposits in a broad sense. During the last decade the sequence of mostly red soils and clays and gleyed clays, summarized "mottled clays", revealed in exposures and even more frequently in boreholes, had to be reclassified as non-loessy terrestrial formations. They were first studied in the soil mechanical boreholes along the Danubian bluff and named the "Dunaföldvár formation" (M. Pécsi 1975, 1980).

In the stratotype section (Fig. 6) the Dunaföldvár series i.e. formation comprises three distinct members: 1) pale pink, slightly silty fine sand of 5—6 m thickness with characteristic cyclical thin, cemented sandstone beds or sandstone concretions; 2) dark grey, black meadow clay and meadow soil complex of 3—5 m thickness; 3) the most characteristic part of the Dunaföldvár formation is the ochre-red soil series of cca 10—15 m thickness. Within this complex five or six locally more buried red soils were identified with intercalated thinner layers of gleyed, silty clay. Based on the paleopedological analysis of red soils, they were identified as remnants of forest soils developed under submediterranean-type climate.

In some of the sections, the lowermost member of the Dunaföldvár formation was represented by a true red clay. In the profiles studied to date the mentioned sequence of mottled and red clays overlies Upper Pannonian (Upper Miocene) sandy formations.

In order to establish the chronostratigraphic location of the Dunaföldvár formation paleomagnetic investigations have also been carried out regularly over the last 10 years. With knowledge of ever new exposures, the ground for evaluation became more stable and reliable. Paleomagnetic data had been originally evaluated as if they derived from continuous sequence without unconformities (M. Pécsi and M. A. Pevzner 1974). Subsequently, the minute investigation of the foot hill sequence of cover sediments in an open cast lignite mine (Fig. 7; M. Kretzoi et al. 1982, M. Pécsi 1984, 1985) supported the view

Fig. 6. Correlation of the different exposures and borehole profiles at Dunaföldvár (by M. Pécsi, E. Szebényi, and M. A. Pevzner)

BD — "Basaharc Double" forest-steppe soil complex; BA — "Basaharc Lower" chernozem soil; MB — "Mende Base" soil complex (brown forest soil+forest-steppe soil); PD — "Paks Lower Double" soil complex (brownish-red mediterranean-type dry forest soil); PDK — Paks-Dunakömlőd brownish-red soil; Dv_1—Dv_6 — Dunaföldvár red soils; ih — silty sand

Fig. 7

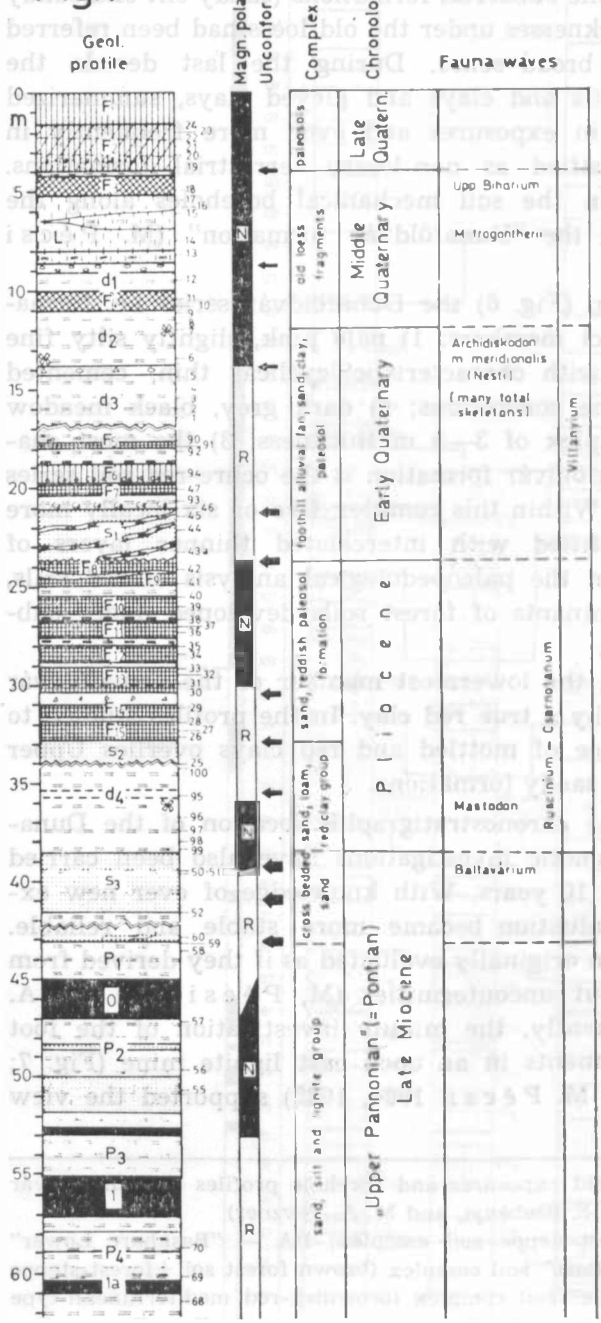
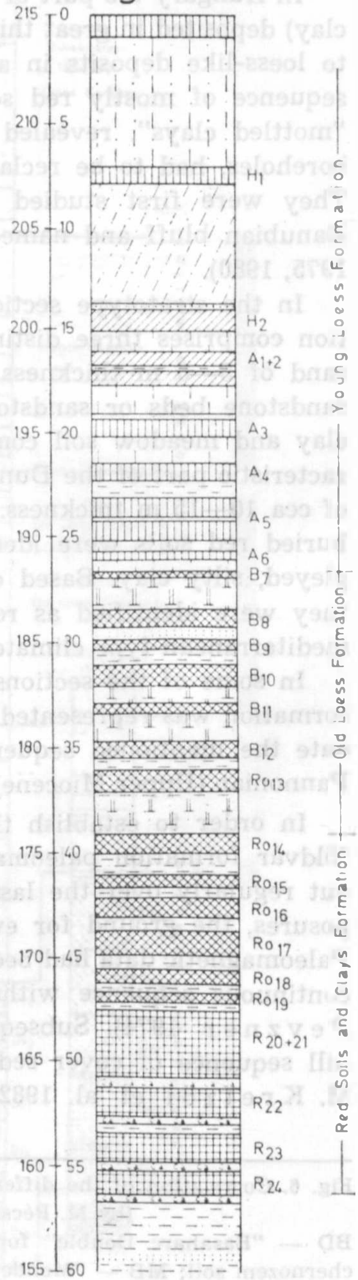

Geol. profile
Magnetpolarity
Unconformity
Complex
Chronology
Fauna waves
0
m
5
10
15
20
25
30
35
40
45
50
55
60
F1
F2
F3
L
d1
F4
d2
d3
F6
F7
S1
F8
F9
F10
F11
F13
F15
S2
d4
S3
P1
0
P2
P3
1
P4
1a
N
R
N
R
N
R
paleosols
old loess fragments
foothill alluvial fan, sand, clay, paleosol
sand, reddish paleosol formation
cross bedded sand, loam, sand, red clay group
sand, silt and lignite group
Late Quatern.
Middle Quaternary
Early Quaternary
P l i o c e n e
Upper Pannonian (=Pontian)
Late Miocene
Upp Biharium
M. trogontherii
Archidiskodon m. meridionalis (Nesti)
(many total skeletons)
Villanyium
Ruscinium - Csarnotanum
Mastodon
Baltavarium

Fig 8


asl m
215 0
210 5
205 10
200 15
195 20
190 25
185 30
180 35
175 40
170 45
165 50
160 55
155 60
H1
H2
A1+2
A3
A4
A5
A6
B7
B8
B9
B10
B11
B12
Ro13
Ro14
Ro15
Ro16
Ro17
Ro18
Ro19
R20+21
R22
R23
R24
Young Loess Formation
Old Loess Formation
Red Soils and Clays Formation

that the Dunaföldvár formation dates back to the Gilbert epoch. The Pliocene period (the Gauss and Gilbert epochs) can be considered as the climax of red clay formation (M. Pécsi 1985). In some of the boreholes the Dunaföldvár formation is constituted exclusively of consecutive red soils the lower ones of which are typical red clays (Fig. 8). The red clays usually overlie bentonite beds or even intercalate with them. The bedrock of bentonite is probably related to the main period of basaltic volcanism in Hungary. Most recently K/Ar investigations place the age of basaltic rocks into the time interval between 3 Ma and 5 Ma (K. Balogh et al. 1985).

The pink, sandy silt ("ih" layer of Fig. 6) in the upper part of Dunaföldvár formation according to the paleomagnetic measurements of M. A. Pevzner may have formed between the paleomagnetic events Jaramillo and Olduvai. Today it is difficult to form a final and unambiguous opinion, since the recognition of possible unconformities in the future may influence the evaluation of paleomagnetic data.

At any rate, it can be claimed that during the formation of reddish paleosols and red clays, climatic and, in general, ecological conditions were essentially different from those in the cold and arid or semiarid environments of loess formation. Presumably, in the Middle Danubian basin the development of red clays and subsequently of red soils and pink silts continued for a long period after the Upper Miocene. It was probably a simultaneous process not only at local scale, but at regional or continental scales too.

CONCLUSION

The experiences gathered to data during the investigations of loess profiles in Hungary suggest that even the continuous sequence of young loess (probably of last glacial age) can be reconstructed after the thorough analyses of several sections and the establishment of stratotypes and four typical forest-steppe pedocomplexes.

Fig. 7. Comprehensive profile of the Gyöngyösvisonta open cast Lignite mine (Thorez Mine), 1981. The profile was surveyed and identified by J. Balogh, P. Márton, F. Schweitzer and Gy. Szokolai under the guidance of M. Pécsi

F_1—F_{15}— paleosols; s_1—s_3 — sand; 0, 1, 1a — lignite layers

Fig. 8. Piedmont loess section in the S foreland of the Mecsek Mountains, borehole profile of Posta valley (by M. Pécsi and F. Schweitzer)

H_1—H_2 — humus loess; A_1—A_6 — forested steppe soils; B_7—B_{12} — brown forest soils; R_0 — (13—19) — ochre-red soils; R (20—24) — red clays. During the development of the red soils a subhumid warm climate of submediterranean character with cyclically more dry climatic spell dominated

The old loess sequences, however, contains five-six brown forest paleosols, two-three unconformities, and even the investigations of several boreholes and exposures do not enable us to reconstruct a more or less conformable sequences. Although previously the sediment sequence of the Paks brickyard was regarded continuous and it was applied for the history of the formation of loess in the whole of Central Europe as a key section.

Earlier and recent exposures and boreholes indicate 12—16 loess packets in the whole loess formation with 8—13 intercalated paleosols. It cannot exactly be defined how many unconformities are to be taken into account i.e. the combination of which paleosol and loess horizons results in a reconstructed sequence. This not being available, the methods based on paleomagnetic measurements as well as those calculating with the rate of loess and soil formation are liable to lead to erroneous consequences and speculation.

REFERENCES

Ádám L., Marosi S., Szilárd J. 1954, A paksi lőszfeltárás (Der Lössaufschluss von Paks). Főldr. Kőzl. 2 (78), 3, 239—254.

Balogh K., Árva-Soós E., Pécskay Z., Ravasz-Baranyai L. 1985, K/Ar dating of pst-Sarmatian alkali basaltic rocks in Hungary (in press).

Borsy Z., Félszerfalvy J., Lóki J. 1984, Electron microscopic investigation of the sand material from the loess exposure at Paks. [In:] Lithology and stratigraphy of loess and paleosols, Budapest, 71—86.

Borsy Z., Félszerfalvi J., Szabó P. P. 1980, Thermoluminescence dating of several layers of the loess sequences at Paks and Mende (Hungary). Acta Geol. Hung., XXII, 1—4, 451—459.

Butrym J., Maruszczak H. 1984, Thermoluminescence chronology of younger and older loesses. [In:] Lithology and stratigraphy of loess and paleosols, Budapest, 195—199.

Kretzoi M., Márton P., Pécsi M., Schweitzer F., Vőrős L. 1982, Pliocene-Pleistocene piedmont correlative sediments in Hungary (based on lithological, geomorphological, paleontological and paleomagnetic analyses of the exposures in the opencast mine at Gyöngyősvisonta). [In:] Quaternary studies in Hungary, Budapest, 43—73.

Kriván P. 1955, A kőzép-európai pleisztocén éghajlati tagolódása és a paksi alapszelvény (Distribution of the Central-European Pleistocene climate and the loess profile at Paks). MÁFI Évk. 43, 3, 365—400.

Márton P. 1980, Paleomagnetism of the Paks Brickyard exposures. Acta Geol. Hung., XXII, 1—4, 443—449.

Pécsi M. 1975, A magyarországi lőszszelvények litosztratigráfiai tagolása (Lithostratigraphical subdivision of the loess sequences in Hungary). Főldr. Kőzl., 23 (99), 3—4, 217—230.

Pécsi M. 1980, Lithostratigraphical subdivision of the loess profiles at Paks. Acta Geol. Hung., XXII, 1—4, 409—418.

P é c s i M. 1982, The most typical loess profiles in Hungary. [In:] Quaternary studies in Hungary, Budapest, 145—169.
P é c s i M. 1984, Is typical loess older than one million years? [In:] Lithology and stratigraphy of loess and paleosols, Budapest, 213—224.
P é c s i M. 1985, Chronostratigraphy of Hungarian loesses and the underlying subaerial formation. [In:] Loess and the Quaternary, Budapest, 33—49.
P é c s i M., P e v z n e r M. A. 1974, Paleomagnetic measurements in the loess sequences at Paks and Dunaföldvár, Hungary. Földr. Közl., 22, (98), 3, 215—224.

STRESZCZENIE

Węgry zajmują środkową część rozległej kotliny w łuku Karpat (Basen Panoński). Przeważającą część kraju pokrywają lessy i utwory lessopodobne. Wśród nich najbardziej rozpowszechniony jest less młody, nieco piaszczysty, akumulowany 13—26 ka BP. Te młode warstwy mają miąższość 8—10 m; stwierdzono wśród nich dwa poziomy humusowe (gleby embrionalne), liczące 16 ka i około 20 ka. Niżej położone warstwy lessu młodego mają większą miąższość (15—20 m). Dzielą się one na cztery poziomy lessowe rozdzielone trzema glebami leśno-stepowymi: MF (Mende-Felső=Mende Upper), BD (Basaharc-Dupla=Basaharc Double) i BA (Basaharc-Alsó=Basaharc Base). Wiek najmłodszej spośród tych gleb MF wynosi 27—30 ka.

Less młody oddzielony jest od starego kompleksem glebowym MB (Mende--Bázis=Mende Base), na który składa się gleba leśno-stepowa MB_1 i leśna gleba brunatna MB_2. Zgromadzone dotychczas dane świadczą, że ten kompleks glebowy powstał w ostatnim interglacjale (105—125 ka BP).

Less stary dzieli się także na dwie części. Wśród warstw górnych w profilu Paks występuje przerwa erozyjna, podkreślona poziomem piasków rzecznych (S_1). Następna miąższa warstwa piasków (S_2) najprawdopodobniej stanowi osad z przedostatniego interglacjału (min. 200 ka BP). Dolna część lessu starego rozdzielona jest przez trzy gleby kopalne: PD_1 i PD_2 (Paks-Dupla=Paks Double) oraz PDk (Paks--Dunakömlőd), charakteryzujące się czerwonawobrunatnym zabarwieniem. Wiek tych gleb określa granica paleomagnetycznych epok Brunhes-Matuyama (0,73 Ma), stwierdzona w różnych profilach węgierskich w dolnej części lessu starego bezpośrednio pod glebą PD_2.

Na podstawie badań paleomagnetycznych ustalono, że oznaki epizodu Jaramillo (0,9 Ma) występują pod lessem starym, a więc w utworach nie należących już do formacji lessowej. Najniższe warstwy lessu starego w profilach Paks i Dunaföldvár datowane są na 0,85 Ma BP.

РЕЗЮМЕ

Венгрия расположена в центре Карпатского бассейна, на низких абсолютных высотах. Преобладающая часть площади страны покрыта лёссом и лёссовидными отлежниями. Среди этих отлежений наиболее широко распростанен слегка песчаный молодой лёсс, формировавшийся 13—26 тыс. лес назад. Эти толщи имеют мощность 8—10 м и в них развиты только два гумусовых горизонта (эмбриональные почвы), возрастом 16 и ок. 20 тыс. лет соответственно. Низшая, более

мощная часть молодых лёссов имеет толщину 15—20 м и содержит четыре горизонта типичных лёссов, среди которых расположены три лесостепные почвы (MF, BD и BA). Среди них самая молодая MF (Менде верхняя) палеопочва имеет возраст 27—30 тыс. лет.

Молодой лёсс от древнего отделяется почвенным комплексом MB (Менде базисная), который состоит из лесостепной почвы (MB_1) и коричневой лесной почвы (MB_2). Накопленные данные указывают на возраст последнего межледниковья (105—125 тыс. лет).

Древний лёсс также подразделяется на две части. Верхняя толща в разрезе Пакш содержит эрозионный врез (в форме флювиального песка). Мощный слой песка (S_2) по всей вероятности является остатком предпоследнего межледниковья (мин. 200 тыс. лет. н.). Низшая часть древнего лёсса подразделена тремя характерными красно-коричневыми погребенными почвами (PD_1, PD_2, PDk). Они датируются лишь границей Брюнес-Матуяма (0,73 млн. лет), наблюдаемой в низшей трети древнего лёсса непосредственно под почвой Пакш двойная (PD_2), как это было установлено и измерено в различных разрезах по стране.

По результатам палеомагнитных датировок установлено, что событие Харамильо (0,9 млн. лет) располагается под древним лёссом, вне лёссовой формации. Самый нижний горизонт древнего лёсса датируется 0,85 млн. лет н. в разрезах Пакш и Дунафёльдвар.