ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN—POLONIA
VOL. XLI, 3, 55—65 SECTIO B 1986

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Loess Stratigraphy of North-East Bulgaria

Stratygrafia lessów północno-wschodniej Bulgarii

Стратиграфия лёсса Северовосточной Болгарии

ABSTRACT

A complex analysis based mainly on geomorphological, paleopedological, paleontological and paleomagnetic researches has been accomplished to work out the eolian loess stratigraphy in north-east Bulgaria. The results of this analysis have allowed us to accept the three upper loesses (L_1, L_2, L_3) Würm age, the following two (L_4 and L_5) Riss and the oldest (L_6 and L_7) Mindel age. The position of the Neogene-Quaternary boundary has been defined and it determines the Quaternary. A morphostratigraphic scheme of the Quaternary in the region has been elaborated which includes sediments of river, lake-river and eolian origin.

We can find the first information about loess stratigraphy in north Bulgaria in G. Gunchev's (1935) and I. Boykov's (1936) works, where three loesses and two fossil soils are described. G. Gunchev referred the two upper loesses to Würm and the third to Riss. I. Boykov for the first time made detailed descriptions of the fossil soils. Later on D. Yaranov (1956, 1961), K. Mishev (1959), L. Filipov and L. Mikova (1967, 1977), N. Popov and L. Filipov (1982) worked on different problems of the Quaternary and connected loess accumulation in north Bulgaria with Würm glacial. Only M. Minkov (1968) assumed the presence of loesses not only of Würm but also of Riss and

Mindel age. Minkov's stratigraphical scheme is confirmed by the researches of P. D o n c h e v et al. (1986); these authors propose morphostratigraphical scheme of the Quaternary in the region of Rousse on the basis of detailed geomorphological and lithostratigraphical analysis, paleomagnetic and scanty paleontological data. K. S t o i l o v (1984) assumes Günz age to be the seventh loess bed.

The full profile of the loess complex in north-east Bulgaria consists of seven loess beds and six fossil soils. Fossil soil (Fs) is developed on every loess bed and they jointly form one lithogenetic cycle (M. M i n k o v 1968). The thickness of this cycle varies from some metres in the most south regions and young loess terraces (T_1 and T_2) to 35—40 m on the Günz-Mindel terrace and the north part of the Eopleistocene planed surface. There are serious difficulties in determining the age of the loess complex or parts of it due to: the absence of biostratigraphical data in the lower part of the eolian complex (under L_3), the mollusca fauna is of a transitional type and it has no stratigraphical value (J. P e t e r b o k 1927) while at the same time the paleobotanical data are not enough for interpretation, and the absence of accurate geochronological data.

The complex method of approach, based on morphological, paleopedological, paleomagnetic and paleontological analyses used in the researches give a possibility to elaborate a similar stratigraphical scheme in spite of the difficulties. It contains both the loesses and the infraloess lake-and-river or river sediments from different morphological forms.

For the stratigraphical scheme of Quaternary in north-east Bulgaria of important value are those relief forms which are connected with the rhytmical fluctuations of the sea bottom and which correspond to the climate changes. Our researches determine t h r e e l e v e l s (planed surfaces) a n d s e v e n r i v e r t e r r a c e s f o r m e d d u r i n g t h e l a t e P l i o c e n e (Roman) a n d i n t h e Q u a t e r n a r y. Their genesis and the time of their formation predetermine the lithostratigraphy and the age of the respective loess suprastructure.

Y o u n g P l i o c e n e d e n u d a t i o n a l s u r f a c e (YPDS) is characteristic for the south of the Roman basin (Fig. 1). It is developed over lower karstified limestones at a relative height in relation to the Danube river 155—205 m. Kaolin deposits have been formed in many paleokarst forms older than the Quaternary. Terra rosa followed then which was formed mostly during the warm and humid climate of Sarmation and Pliocene. The young Pliocene surface is fossilized by the next postpliocene layer order: gravel from limestones of a small thickness, red clays similar to terra rosa and loess complex with full profile.

T h e o l d a b r a s i v e - a n d - a c c u m u l a t i v e l e v e l (OAAL) is cut into Aptian and Sarmation limestones at a relative height of 110—

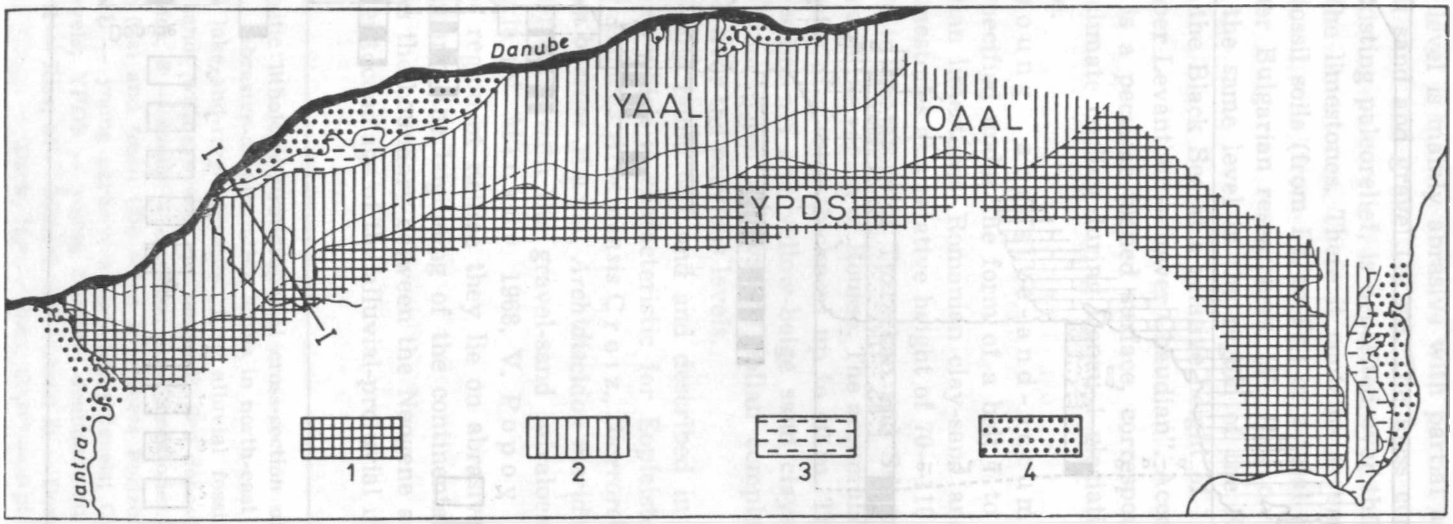
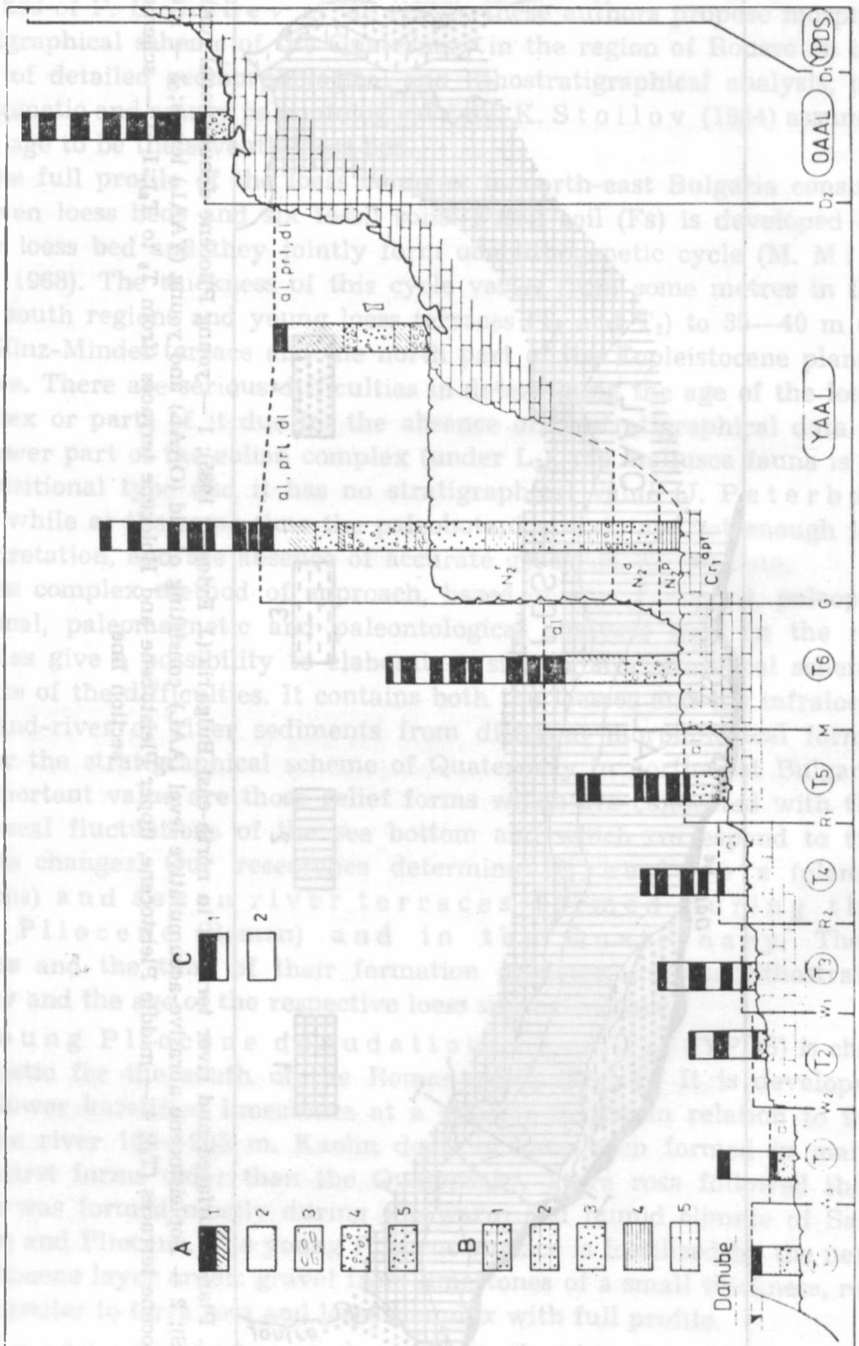


Fig. 1. Planed surfaced and river terraces in north-east Bulgaria (J. Evlogiev 1985); 1 — young Pliocene denudational surface (YPDS); 2 — Eopleistocene abrasive-accumulative level (AAL) consisting of old (OAAL) and young (YAAL) levels; 3 — lower Pleistocene terraces (T_6); 4 — middle Pleistocene, upper Pleistocene and Holocene terraces (from T_5 to T_0); I—I — schematic section line


A
B
C
Danube
T_1
T_2
T_3
T_4
T_5
T_6
W_2
W_1
R_2
R_1
M
G
D_2
D_1
YAAL
OAAL
YPDS
Cr_1
N_2
al, pl, dl
al, prl, dl

150 m. That level is mainly abrasive with partial accumulation of alluvial-proluvial sand and gravel (10 m). The loess complex which mantly covers the existing paleorelief, is deposited over this sand and gravel or directly on the limestones. There it contains seven loesses (from L_7 to L_1) and six fossil soils (from Fs_6 to Fs_1) of a total thickness up to 35 m (Fig. 2). Other Bulgarian researchers (V. Popov and K. Mishev 1974) found the same level in the region of the Kamchia river valley flowing into the Black Sea at a relative height of 110—150 m, and they called it "upper Levantian — lower Chaudian". According to its morhpology OAAL is a peculiar planed surface, corresponding most probably to the first climate cooling during Donau 1 glaciation which begins the Eopleistocene.

The young abrasive-and-accumulative level (YAAL) is specified under the form of a belt 7 to 25 km wide. It cuts into the Aptian limestones, Romanian clay-sand and limestone deposits, Sarmatian limestones at a relative height of 70—110 m. Similar to OAAL it is abrasive in the areas of Tutrackan and Silistra and abrasive-and--accumulative in the region of Rousse. The accumulative layers are river--and-lake facies of a total thickness up to 40 m. They are presented by gravel-sand sediments and yellow-beige sand clays with fossil soil developed on them. Then follows the eolian complex with full vertical profile as it is over the previous levels.

The following fauna is found and described in the sand pits of the Rousse region, which is characteristic for Eopleistocene (M. Halvadgiev 1966): *Anancus Arvernensis* Croiz., *Dicerorchinus mercii* Jager., *Zygolophonon borsoni* Hays., *Archidiscidon meridionalis* Nesti. These sediments correlate with the gravel-sand infraloess complex of north--west Bulgaria (M. Minkov 1968, V. Popov 1964, D. Yaranov 1961). In the region of Rousse they lie on abrasive surface of different age, which marks the beginning of the continental deposit, and in our case it marks the boundary between the Neogene and Quaternary.

The Eopleistocene age of the alluvial-proluvial infraloess sediments of

Fig. 2. Schematic lithologic-stratigraphical cross-section of the river terraces and abrasive-accumulative levels in north-east Bulgaria
A. River and lake-and-river deposits: 1 — alluvial fossil soils; 2 — clays; 3 — gravels; 4 — sands with gravels; 5 — sands. B. Sea deposits: 1 — sands and clays; 2 — sand stones; 3 — sands; 4 — clays; 5 — limestones. C. Eolian deposits: 1 — contemporary (Cs) and fossil (Fs) soils; 2 — loess horizons (L). T_0 ... T_6 — river terraces; YAAL — young abrasive-accumulative levels; OAAL — old abrasive-accumulative levels; YPDS — young Pliocene denudational surface. Other symbols: W — Würm; R — Riss; M — Mindel; G — Günz; D — Donau; N_2^r — Roman; N_2^d — Dack; N_2^p — Pont; Cr_1^{apt} — Apt

YAAL proves well-grounded that the loess complex is of Pleistocene age. The erosion, the result of which was the formation of that layers, corresponds to the pluvial phase of Donau 2 glaciation. The loess accumulation of that time was not specified because of the Donau cooling was weak. The deposition of the lake-and-river and alluvial-and-proluvial sediments began at the time of the glaciation (Donau 2), then it reached its maximum during the latest stage and finnaly abated in Donau-Günz Interglacial. Its climate brought favourable conditions for soil formation on these sediments (Fs al, prl, dl).

The lake-and-river facies of OAAL and YAAL prove that they correspond to the Getae basin phases of destruction, respectively to the Romanian basin (E. Liteanu 1959). J. Fink (1968) reported the presence of a similar lake in Hungary. Probably the old Danube has flowed into the Romanian lake. Probably Günz glaciation put an end to the existance of that basin in north-east Bulgaria. Then followed a new typically river period of the Danube valley development. It is characteristic for the formation of seven river terraces (T_6 to T_0; Figs. 2, 3), with which the loess accumulation is connected.

The bottom of terrace T_6, at a depth of 30—40 m lower than the bed of YAAL, is shaped by the pluvial phase of Günz glaciation. The overlying layers contain alluvial sediment with developed on it fossil soil and loess complex with full profile — seven loesses and six fossil soils. The alluvial sediment is related to the late Günz and the alluvial fossil soil with the Günz-Mindel Interglacial. The lithostratigraphy of the loess complex of T_6 is equal to that of YAAL and OAAL and YPDS, which means that there were no conditions for eolian accumulation during Günz.

The profile of terrace T_5 consists of alluvial sediment, in the upper part with soil, and loess complex with five loesses and four fossil soils. F. Wiegank (1977) fixed the Mindel-Riss age for the alluvium of T_5 that determined Riss age for L_5. That fact in connection with the bipartition of Mindel warrants acceptation of the idea that the unspecified in our country terrace level T_5^1 (between T_5 and T_6) with a small erosion cut corresponds to interstadial Mindel 1—Mindel 2. That level should be related to the foundation of fossil soil Fs_6 and the two stages with the deposit of loesses L_7 and L_6 on the older relief elements — T_6, YAAL, OAAL, YPDS. At that time the necessary initial material for the eolian deposit could come from the alluvia of T_5 and T_5^1, which were an object of blowing off. Fossil soil Fs_5 was formed in Mindel-Riss Interglacial and developed as a typical pedocomplex on L_6. It is the strongest and best expressed paleosol in the whole loess complex and can be synchronized with the Italian "ferreto".

As regards the next terraces, the mechanism of erosion cutting, alluvial accumulation and loess deposition remains one and the same. The loess sediment lies over the older layers. The profiles of the t e r r a c e s

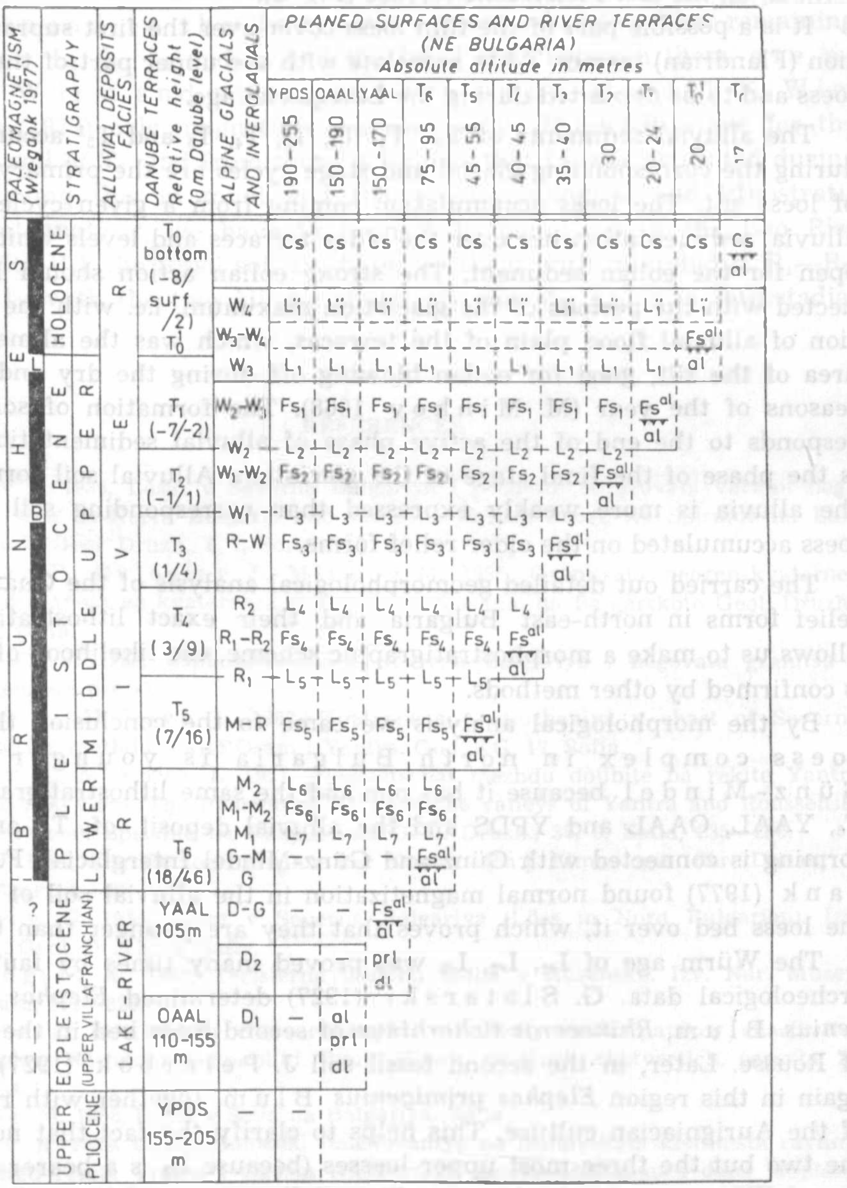


Fig. 3. Stratigraphical scheme of the loesses and paleosols in north-east Bulgaria

T_4, T_3, T_2, T_1 consist of alluvia with developed elluvial soils on them and eolian complex with 4, 3, 2 and 1 loess beds respectively. On all forms older than T_5 (Mindel-Riss) or the supposed level T_5^1 (Mindel 1—Mindel 2), the loess complex contains all beds and fossils soils. Over the younger forms the eolian suprastructure is reduced and completes T_1 with L_1 on the last Pleistocene terrace (Fig. 2).

It is a possible part of the thin loess cover over the first suprainundation (Flandrian) terrace T_0^1 to correlate with the upper part of the young loess and to be deposited during the Lateglacial age.

The alluvial sediments of T_0^1, T_1, T_2, T_3, T_4, T_5 and T_5^1 accumulated during the corresponding glacial and stage cycles are the primary source of loess silt. The loess accumulation coming from a given cycle of the alluvial sedimentation lies over the older terraces and levels which were open for the eolian sediment. The strong eolian action should be connected with the periods of the glaciation maximum, i.e. with the formation of alluvial flood plain of the terraces, which was the alimentation area of the silt, good for eolian blowing off during the dry and windy seasons of the year (M. Minkov 1968). The formation of soils corresponds to the end of the active phase of alluvial sedimentation, that is the phase of the final stage of the glaciation. Alluvial soil formed on the alluvia is more weakly expressed than corresponding soil on the loess accumulated on the older relief forms.

The carried out detailed geomorphological analysis of the Quaternary relief forms in north-east Bulgaria and their exact lithostratigraphy allows us to make a morphostratigraphic scheme, the likelihood of which is confirmed by other methods.

By the morphological analysis we came to the conclusion that the loess complex in north Bulgaria is younger than Günz-Mindel because it has one and the same lithostratigraphy on T_6, YAAL, OAAL and YPDS and the alluvial deposit of T_6 and soil forming is connected with Günz and Günz-Mindel Interglacial. F. Wiegank (1977) found normal magnetization in the alluvial soil of T_6 and the loess bed over it, which proves that they are younger than 690 ka.

The Würm age of L_1, L_2, L_3 was proved many times by fauna and archeological data. G. Slatarski (1927) determined *Elephas primigenius* Blum, *Rhinoceros tichorhinus* of second loess bed in the region of Rousse. Later, in the second fossil soil J. Peterbok (1927) found again in this region *Elephas primigenius* Blum together with remains of the Aurigniacian culture. This helps to clarify the fact that not only the two but the three most upper loesses (because L_3 is a bearer of Fs_2) are of Würm age. In the loess profiles of Rousse and Silistra, F. Wiegank (1977) found the paleomagnetic Blake event — 110 ka old in the third loess bed. With the help of the eolian accumulation rate he determined the following ages: Fs_3 — 120, Fs_2 — 95 up to 90, Fs_1 — 40 ka. Therefore, Fs_3 is connected with Riss-Würm, i.e. the last interglacial. The fossil soils over Fs_3 which are Fs_2, Fs_1 and the initial fossil soil (Fs_1'') found in the first loess bed are interstadial (W_1—W_2, W_2—W_3, W_3—W_4). The accumulation of L_3, L_2, L_1 and L_1'' loesses correspond to the four Würm stadials. The remaining loesses L_4, L_5, L_6 and L_7 and the fossil soils between them are of older Würm and younger than Günz-Mindel. F. Wiegank's (1977) paleomagnetic researches prove Mindel-Riss age for the alluvial soil of T_5, and from there it follows that L_5 was deposited during Riss. Having this in mind and the geomorphological and lithostratigraphical analysis, we have to connect L_4 and L_5 with the two Riss stages (R_2, R_1), the fossil soil Fs_4 between them with interstadial R_1—R_2, L_6 and L_7 with the two Mindel stages M_1 and M_2, Fs_5 with interstadial M_1—M_2.

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STRESZCZENIE

Pokrywa lessowa Bułgarii północno-wschodniej dzieli się na siedem poziomów lessowych, wśród których jest sześć gleb kopalnych. Miąższość ogólna pokrywy waha się od kilku metrów na peryferii południowej i młodych terasach „lessowych" (T_1, T_2) do 40 m na terasie staroplejstoceńskiej (T_6) i w północnej części eoplejstoceńskiego poziomu abrazyjno-akumulacyjnego (OAAL). Dla ustalenia stratygrafi pokrywy lessowej przeprowadzono kompleksową analizę wyników badań geomorfologicznych, paleontologicznych, paleopedologicznych i paleomagnetycznych. W rezultacie przyjęto, że pokrywa lessowa jest młodsza od granicy epok paleomagnetycznych Matuyama—Brunhes (0,75 Ma), a więc także i od interglacjału Günz-Mindel. Cztery górne poziomy lessowe (L_3, L_2, L_1, L_1'') odpowiadają stadiałom zlodowacenia Würm (W_1, W_2, W_3, W_4), a występujące między nimi gleby kopalne (Fs_2, Fs_1, Fs_1'') interstadiałom tego zlodowacenia. Wśród nich wielokrotnie stwierdzano występowanie szczątków *Elephas primigenius* Blum i *Rhinoceros tichorhinus*, razem z kamiennymi narzędziami kultury oryniackiej. W trzecim poziomie lessowym stwierdzono występowanie paleomagnetycznego epizodu Blake (0,11 Ma). Wynika z tego, że ostatniemu interglacjałowi, Riss—Würm (Eem) odpowiada trzecia gleba kopalna. Pozostałe poziomy lessowe (L_4, L_5, L_6, L_7) oraz gleby kopalne (Fs_4, Fs_5, Fs_6) są starsze od interglacjału Riss—Würm i młodsze od Günz—Mindel. Mając to na uwadze należy powiązać L_4 i L_5 ze stadiałami zlodowacenia Riss (R_2, R_1), a Fs_4 z interstadiałem R_1—R_2. Piąta gleba kopalna, rozwinięta na L_6, wyróżnia się dobrze zaznaczoną barwą czerwoną i dużą miąższością; tylko ona może więc odpowiadać wielkiemu interglacjałowi Mindel—Riss. Przypuszcza się, że najstarsze lessy (L_7, L_6) były akumulowane w kolejnych stadiałach zlodowacenia Mindel (M_1, M_2) a gleba Fs_6 rozwinęła się w interstadiale M_1—M_2.

РЕЗЮМЕ

Лёссовый комплекс Северновосточной Болгарии состоится из семи лёссовых горизонтов, на которых формированых шесть погребённых почв. Толщина этого комплекса варирует от нескольких метров в самых южных районах и молодых лёссовых террасах (T_1, T_2) до 40 м на нижнеплейстоценской террасе (T_6) и в северной части эоплейстоценского абразионно-аккмулятинвного уровня (OAAL). Для изяснения стратитрафии лёссового комплекса совершен комплексный анализ основанный главним образом на геоморфологических, палеонтологических, палеопедологических и палеомагнитних исследованиях. Результаты этого анализа дают основания принять, что лёссовый комплекс моложе палеомагнитной границы Матуяма—Брюнес (0,75 млн. лет), как и интергляциала гюнц-миндель. Верхние четыре лёссовые горизонта (L_3, L_2, L_1, L_1'') соответствуют вюрмским стадиалам (W_1, W_2, W_3, W_4), а погребённые почвы между ними (Fs_2, Fs_1, Fs_1'') вюрмским интерстадиалам. В них многократно открыты остатки *Elephas primigenius* Blum, *Rhinoceros tichorhinus* вместе с каменными орудиями ориньяковской культуры. В третьим лёссовом горизонте установленный палеомагнитный эпизод Блейк (0,11 млн. лет). Следовательно с последним интергляциалом рисс-вюрм (ээм) коррелируеться третья погребённая почва. Остальные лёссовые горизонты (L_4, L_5, L_6, L_7) как и погребённые почвы (Fs_4, Fs_5, Fs_6) старше рисс-вюрма и моложе гюнц-минделья. Имея в виду все это, необходимо связать L_4 и L_5 со стадиалами рисса (R_2, R_1), а Fs_4 с интерстадиалом R_1—R_2. Пятая погребённая почва, формираная на L_6, отличаеться хорошо выраженым красным цветом и мощным разрезом; она единствена в комплексе могла бы соответствывать большому интерглациалу миндель-рисс. Предполагается что самые древние лёссовые горизонты (L_7, L_8) аккумулированы во время стадиалов минделья (M_1, M_2), а формирование Fs_6 во время интерстадиала M_1—M_2.