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Thermoluminescence Stratigraphy of Danubian Loesses in Beograd Environs

Chronostratygrafia termoluminescencyjna lessów naddunajskich w okolicy Belgradu

ABSTRACT

Forty six samples from the sections: Mošorin-Surduk Dukatar, St. Slankamen-Čot and Batajnica-Kapela were dated by TL method. The results confirm the correlation done by J. Markowić-Marianović (1969) of the "Neštin" pedocomplex (two soils of degraded chernozem type) with R/W interglacial, and "Slankamen" pedocomplex (three rubified brown earths) with the M/R interglacial. At the same time our results revealed that the correlation of the paleosol F5 with the last interglacial done by A. Bronger (1975) on the basis of paleopedological criteria is unjust. Between the "Neštin" and "Slankamen" pedocomplex there can be distinguished another pedocomplex, developed similarly as the older one; we propose to determine it as "Batajnica" pedocomlex. It results from datings that thus distinguished pedocomplexes correspond to the following oxygen-isotope stages of deep-sea sediments: "Neštin" — 5; "Batajnica" — 7; "Slankamen" — 9. The oldest two of the soils dated by us — occurring below the "Slankamen" pedocomplex — are connected with the interval 520-570 ka BP.

The results of geological-stratigraphical investigations of serbian loesses near Beograd were compiled in the 60's by J. Marković-Marjanović (1964, 1969). She related two soils distinguished as "Neštin pedocomplex" with the last interglacial (Riss-Würm = R/W), and three soils forming the "Slankamen pedocomplex" with the last but one (Mindel-Riss = M/R). Thus established scheme of loess stratigraphy she also correlated with adequate studies related to the area of Austria and Bohemia. J. Butrym (1974) referred to this scheme in his detailed studies of the lithological features of loesses of the Stari Slankamen-Čot section — probably the best known in this region. One year later A. Bronger (1975) published a paper, in which he presented — on the basis of paleopedological criteria — an attempt to correlate the stratigraphical schemes of Danubian loesses in Austria, Bohemia, Hungary and Yugoslavia. For paleosols occurring in loess sections near Beograd he gave denotations from F2 to F11, finding that the younger Pleistocene was represented by soils F2, F3, F4 and F5. Soil F5, developed as Braunerde and occurring below the Neštin pedocomplex, was unequivocally related with the R/W interglacial by A. Bronger.

In a recently published paper, A.K. Singhvi has presented the results of datings by thermoluminescence (TL) method for several samples of loesses of the St. Slankamen and Mošorin sections (A.K. Singhvi et al. 1988). These results induced A. Bronger to correlate soil F5 in Serbian loess section with oxygen-isotope stage 9 or even 11, i.e. with the Holsteinian interglacial (A. Bronger and Th. Heinkele 1989).

We want to join this heated discussion about the stratigraphy of Serbian loesses by publishing the results of the datings by TL method carried out by J. Butrym for 46 samples from three sections: Mošorin-Surduk Dukatar, St. Slankamen-Čot and Batajnica-Kapela. These samples were collected in October 1988 by H. Maruszczak during the investigations conducted together with M. Zeremski.

SECTIONS EXAMINED

The Surduk Dukatar section is situated near Mošorin, in the area of north-eastern edge of the loessy Titel Plateau on the border of the Tisa valley (Fig. 1). A verified description of the Mošorin section was published by J. Marković-Marjanović (1967). She found that in this section the oldest paleosol occurring at a depth of about 35 m was developed on subaquatic deposits (sands and boggy loess) with remnants of *Corbicula fluminalis*, which were correlated with the M/R interglacial. In the section we have investigated, the sequence of paleosols corresponds entirely to that described by J. Marković-Marjanović (Fig. 2). We can only stress that the oldest of these soils, the one developed on the boggy loess (i.e. the pedocomplex from the M/R interglacial) could be divided into two parts. A distinct bipartity of this soil (F8 ? and F7 ?) was also found

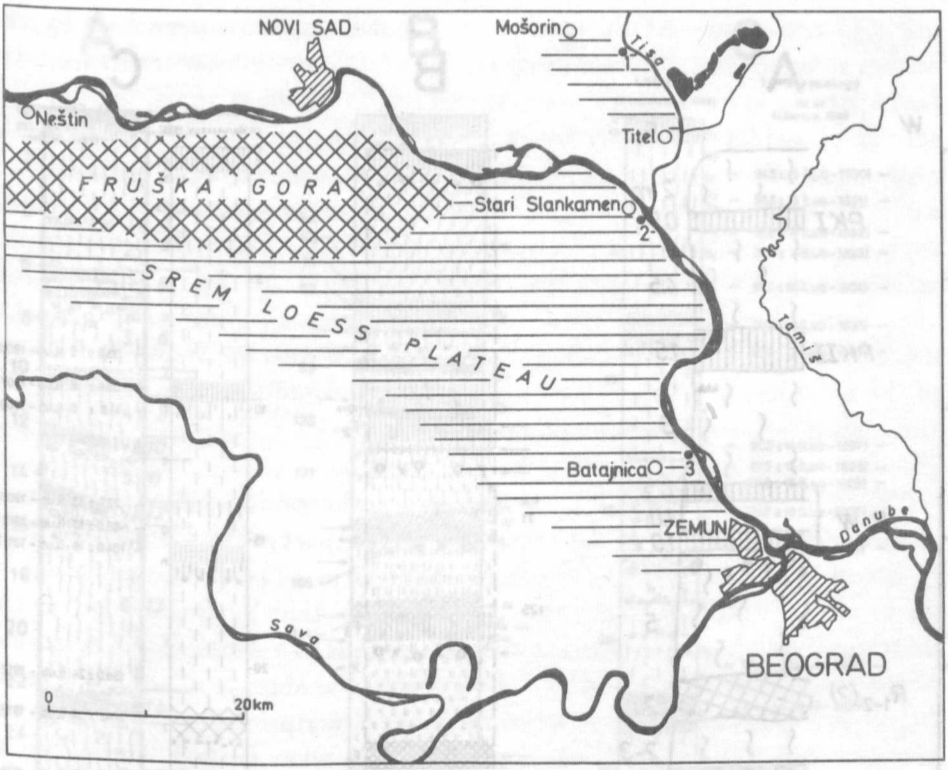

Fig. 1. Situation of the examined loess sections near Beograd:
1 — Mošorin-Surduk Dukatar; 2 — Stari Slankamen-Čot; 3 — Batajnica-Kapela

by A. Bronger (1975). However, in the section described by him, the sequence of younger soils differs from our version, probably due to a more generalized presentation (Fig. 2).

The St. Slankamen-Čot section is situated on the loessy Srem Plateau, on the steep, right border of the Danube valley, opposite the Tisa mouth (Fig. 1). It was described many times, but the particular descriptions are sometimes distinctly different. This exposure is connected with the steep scarp undercut by the Danube; landslide processes are developing in the lower part of the river bluff due to the occurrence of Pliocene loams under the loesses (M. Zeremski 1961).

After J. Marković-Marjanović (1969), in the Slankamen section, 11 paleosols occur, five of which she arranged in two pedocomplexes. All soils distinguished by her appear in the description of the exposure examined by J. Butrym (1974). However, in the section investigated by A. Bronger (1975), the youngest of these soils, and probably the oldest

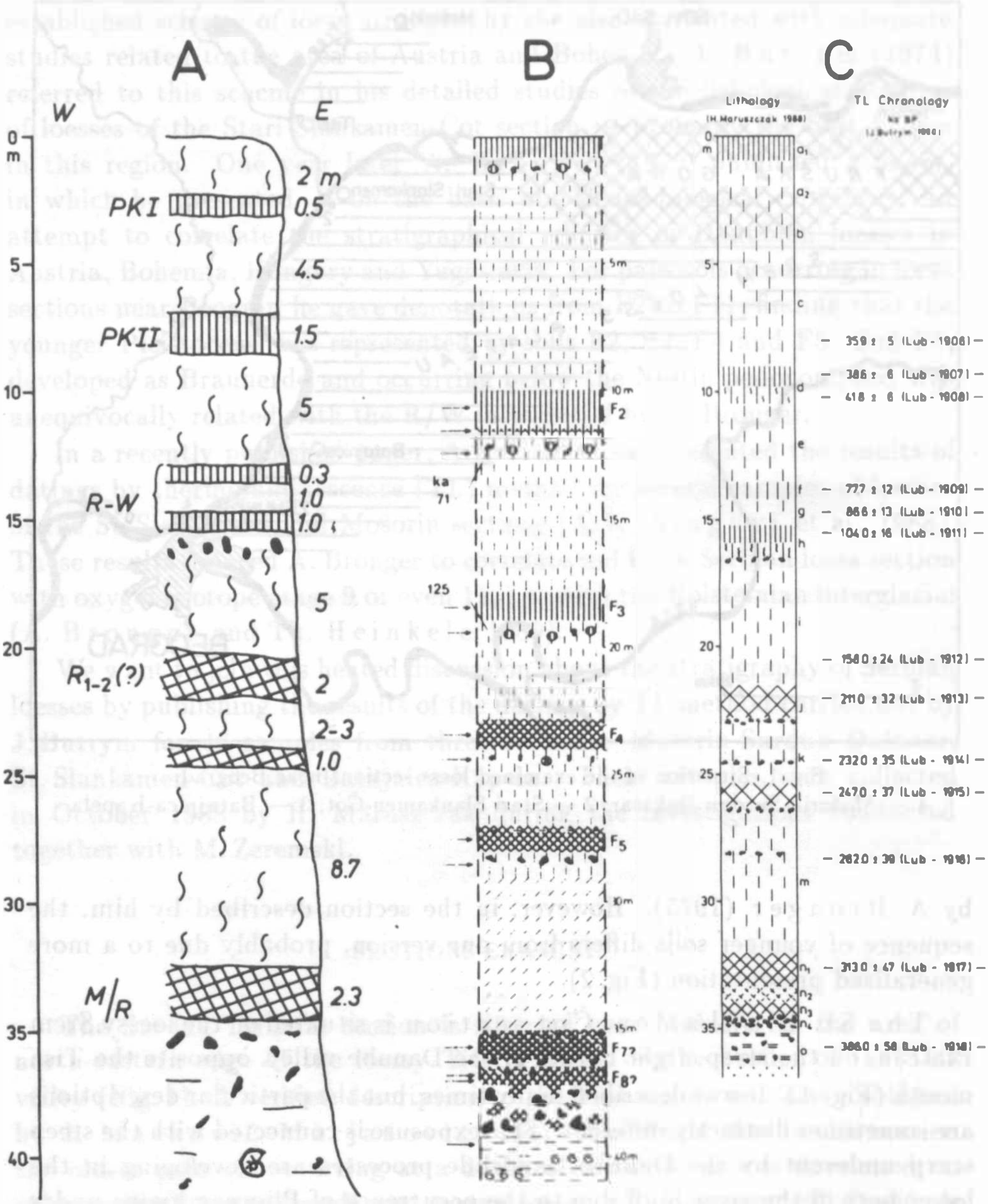

Fig. 2. Loess section in Mošorin-Surduk Dukatar

A — after J. Marković-Marjanović (1967); B — after A. Bronger (1975), datings by TL method after A.K. Singhvi (vide A.K. Singhvi et al. 1988); C — according to our studies (explanations see Fig. 4)

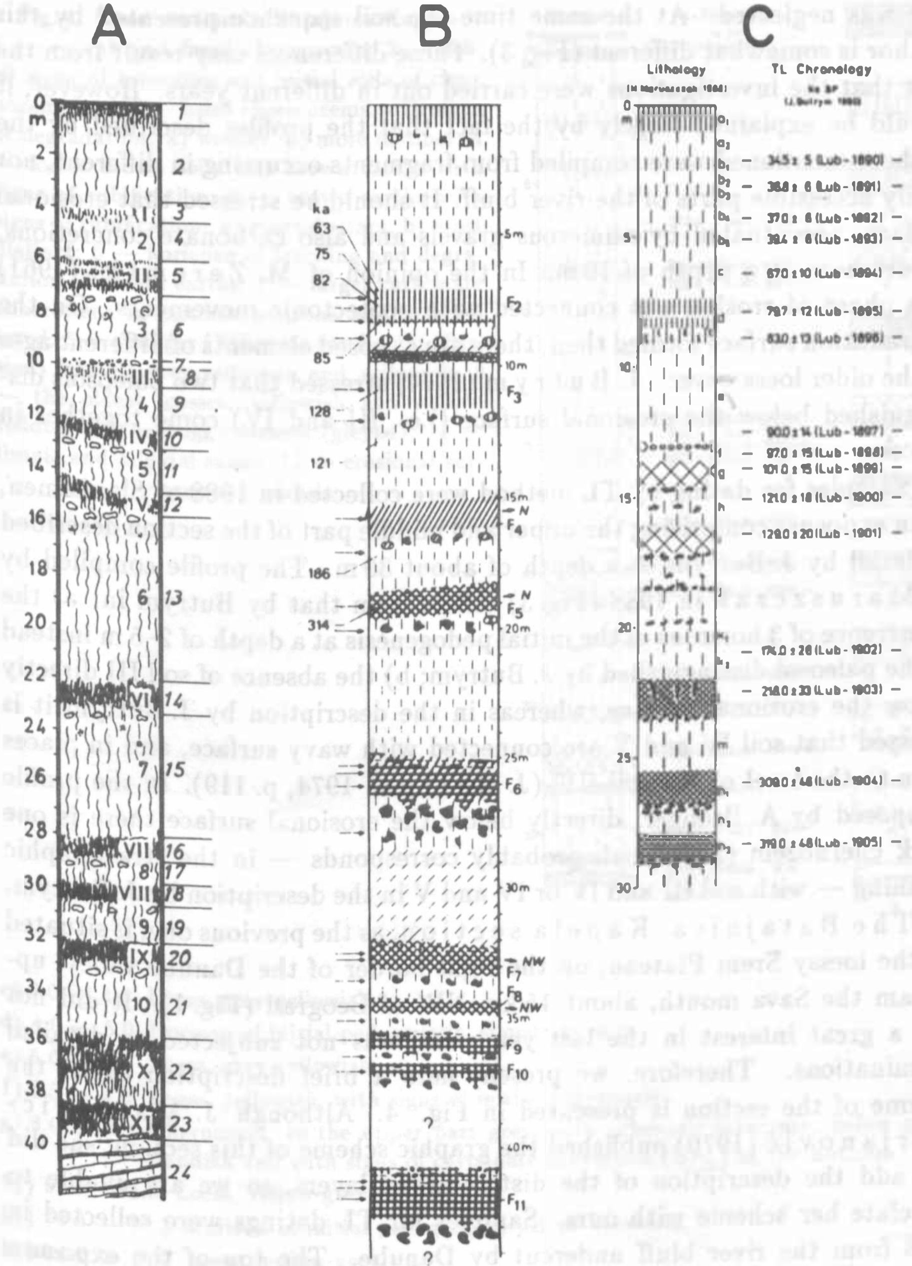

Fig. 3. Loess section in Stari Slankamen-Čot
A — after J. Butrym (1974); B — after A. Bronger (1975), datings by TL method after A.K. Singhvi (vide A.K. Singhvi et al. 1988); C — according to our studies (explanations see Fig 4)

one was neglected. At the same time the soil sequence presented by this author is somewhat different (Fig. 3). These differences may result from the fact that the investigations were carried out in different years. However, it should be explained largely by the fact that the profiles described by the authors mentioned were compiled from fragments occurring in different, not easily accessible parts of the river bluff. It should be stressed that erosional surface, accentuated by numerous gravels and also carbonate concretions, occurs here at a depth of 10 m. In the opinion of M. Zeremski (1961) this phase of erosion was connected with neotectonic movements. On the degradation surface formed then, there are exposed elements of different ages of the older loess cover. J. Butrym (1974) stressed that two paleosols distinguished below the erosional surface (i.e. III and IV) come together in places.

Samples for dating by TL method were collected in 1988 at Slankamen, in an exposure comprising the upper and middle part of the section described in detail by J. Butrym to a depth of about 30 m. The profile compiled by H. Maruszczak in 1988 (Fig. 3) differs from that by Butrym in: a) the occurrence of 3 horizons of the initial pedogenesis at a depth of 2–5 m instead of the paleosol distinguished by J. Butrym; b) the absence of soil III directly below the erosional surface, whereas in the description by J. Butrym it is stressed that soil IV and V are connected with wavy surface, and in places "rise to the level of the soil III" (J. Butrym 1974, p. 119). In the profile composed by A. Bronger, directly below the erosional surface there is one thick chernozem (F3) which probably corresponds — in the stratigraphic meaning — with soil III and IV or IV and V in the description by J. Butrym.

The Batajnica-Kapela section, as the previous one, is situated on the loessy Srem Plateau, on the right border of the Danube valley, upstream the Sava mouth, about 15 km NW of Beograd (Fig. 1). It did not rise a great interest in the last years and was not subjected to detailed examinations. Therefore, we present here a brief description of it; the scheme of the section is presented in Fig. 4. Although J. Marković-Marjanović (1970) published the graphic scheme of this section, she did not add the description of the distinguished layers, so we are unable to correlate her scheme with ours. Samples for TL datings were collected in 1988 from the river bluff undercut by Danube. The top of the exposure described by H. Maruszczak rose then about 114 m a.s.l.; the mean level of the Danube waters was about 71 m a.s.l.

a_1) 0.0 — 0.3 Turf (recent initial soil).

a_2) 0.3 — 2.3 Loess, grey-yellowish.

b) 2.3 — 3.0 Horizon of initial pedogenesis, yellowish and yellow-brownish coloured.

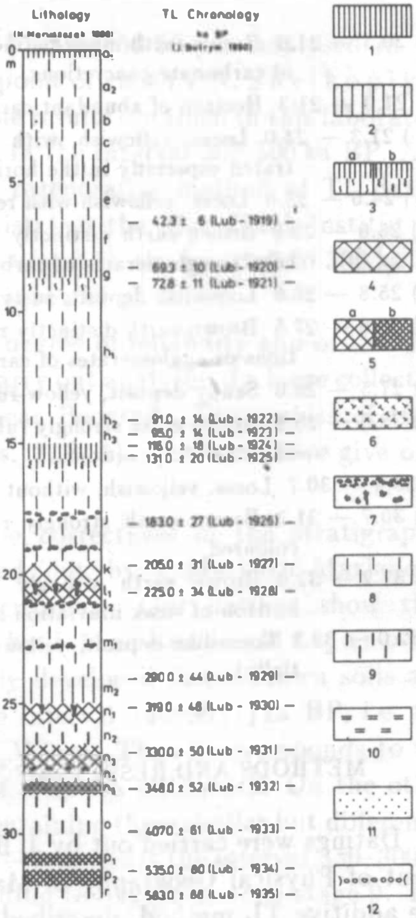

Fig. 4. Loess section in Batajnica-Kapela
1 — recent and fossil chernozems; 2 — fossil signs of browning and initial soils of chernozem type; 3 — fossil chermozems with signs of degradation: a) weaker, b) more distinct; 4 — forest brown soils and brown earths with signs of rubification; 5 — brown earths with signs of rubification: a) more distinct, b) most distinct; 6 — horizons of leaching and degradation of brown earths; 7 — larger carbonate concretions in distinct horizons and/or scattered; 8 — younger (Würmian) and older (Rissian) loesses, grey-yellowish and yellowish; 9 — the oldest loesses, yellowish and yellow-reddish; 10 — boggy loesses (gleyed); 11 — limnic and alluvial sands; 12 — erosional surface with gravels

c) 3.0 — 4.0 Loess, grey-yellowish.

d) 4.0 — 5.0 Horizon of initial pedogenesis, similar as in b.

e) 5.0 — 6.5 Loess, grey-yellowish.

f) 6.5 — 8.0 Loess, yellowish, with signs of initial pedogenesis.

g) 8.0 — 9.2 Chernozem; in the upper part grey, with prismatic structure, below grey-dunnish and with signs of carbonate illuviation (B_{Ca}) at the bottom.

h_1) 9.2 — 14.0 Loess, yellow-greyish.

h_2) 14.0 — 14.3 Horizon of initial pedogenesis, yellow-brownish.

h_3) 14.3 — 15.0 Loess, yellow-grey.

i) 15.0 — 16.0 Brown soil; in the middle part darker, grey-brown coloured, and in the lowest part weak signs of carbonate illuviation.

j) 16.0 — 19.5 Loess, yellowish and grey-yellowish; at a depth of about 17.2 m and 19.0 m horizons with numerous big carbonate concretions.

k) 19.5 — 20.3 Brown earth with signs of rubification; downwards coloured lighter; not very numerous, small carbonate concretions occur.

l_1) 20.3 — 21.0 Brown earth more distinctly rubified, with numerous fissure agglomerates of carbonate concretions.

l_2) 21.0 — 21.3 Horizon of abundant carbonate illuviation with numerous concretions.

m_1) 21.3 — 24.0 Loess, yellowish, with rather numerous carbonate concretions concentrated especially in the horizon 22.7–22.9 m.

m_2) 24.0 — 25.0 Loess, yellowish with reddish tint.

n_1) 25.0 — 25.8 Brown earth distinctly rubified; not very numerous fissure (and rhisocole?) agglomerates of carbonates.

n_2) 25.8 — 26.6 Loess-like deposit, rusty coloured.

n_3) 26.6 — 27.5 Brown earth distinctly rubified, sandy, with not numerous small concretions or agglomerates of carbonates.

n_4) 27.5 — 28.0 Sandy deposit, yellow-rusty.

n_5) 28.0 — 28.4 Brown earth strongly rubified, with rather numerous but small, bean-like carbonate concretions.

o) 28.4 — 30.7 Loess, yellowish, without distinct agglomerates of carbonates.

p_1) 30.7 — 31.2 Brown earth strongly rubified, thin, turning into subsoil (?) lighter coloured.

p_2) 31.2 — 32.0 Brown earth strongly rubified, highly-coloured with vertical leaks; horizon of weak illuviation and carbonate cementation at the bottom.

r) 32.0 — 32.5 Loess-like deposit, yellowish and yellowish-brownish (exposed only partially).

METHODS AND RESULTS OF THERMOLUMINESCENCE DATINGS

Datings were carried out by J. Butrym, in the laboratory of the Department of Physical Geography of Maria Curie-Skłodowska University, using the additive TL method, described and presented during the international symposium of the INQUA Commission on Loess in 1985 (J. Butrym 1985). This method was then critisized by physicists, who preferred the regenerative technique of TL dating (A.G. Wintle 1987). However, the results obtained for Polish loesses appeared to be reliable from the geological point of view. At the same time, they were fully comparable with the results obtained by means of a similar, additive technique of dating in the laboratory of the Institute of Geological Sciences of the Ukrainian Academy of Sciences in Kiev. It was proved in both laboratories by experimental datings of 20 samples of loesses collected in the Volhynia Upland (V.N. Shelkoplyas et al. 1985).

It should be stressed that even extreme opponents of the TL method of dating agree that it is most reliable for eolian deposits, especially loesses. At the same time, numerous results obtained for loesses are reliable in the time interval considerably exceeding 100 ka which is accepted by physicists as credible. They find this interval suitable for analyses carried out on quartz grains; this mineral dominates in the fraction 50-56 μm analysed in the Lublin laboratory. From the geological point of view (V.N. Shelkoplyas et al. 1985, J. Butrym et al. 1988), the results obtained in this laboratory and in that in Kiev seem to be reliable in the interval 300-500 ka BP. Also the results obtained for loesses by the regenerative method of TL dating (more reliable in the opinion of physicists) in the Max-Plank-Institut für Kernphysik in Heidelberg are credible at least in the interval to 300 ka BP from the geological point of view (L. Zöller et al. 1988).

The presented determination of the degree of reliability and of the time interval of TL datings stimulated us to carry out analyses of a large collection of samples taken from loess sections near Beograd. The results of these analyses are presented graphically (Figs. 2, 3, 4). In the text we give only a short interpretation.

Our datings confirm in general the correctness of the stratigraphic scheme of Yugoslavian loesses, worked out by J. Marković-Marjanović on the basis of different geological criteria. Our datings show that the Neštin pedocomplex distinguished by J. Marković-Marjanović (1964, 1969) — containing two similarly developed forest brown soils and degraded chernozems — represents the interval 130–90 (?) ka BP, i.e. the last interglacial (R/W) and the earliest Würm. Thus it corresponds to the older parts of oxygen-isotope stage 5 of deep-sea sediments. On the other hand, the Slankamen pedocomplex — containing three similar but differently developed soils (rubified brown earths) — represents the interval 350–300 ka BP, i.e. the M/R interglacial corresponding to oxygen-isotope stage 9. The oldest two of the described soils (from Batajnica-Kapela section) — dated for about 520 and about 570 ka BP — probably represent G/M interglacial and correspond to oxygen-isotope stage 13 or 15.

From the paleopedological point of view, other two soils (pedocomplex?), typologically similar to those of the Slankamen pedocomplex, can be recognized as units of interglacial rank. These brown earth with more weakly marked signs of rubification represent the interval 250–205 ka BP, i.e. correspond to oxygen-isotope stage 7. J. Marković-Marjanović distinguished this unit as interstadial during Riss glaciation and denoted it as R_{1-2}.

In younger loesses (Würmian) there occur well developed chermozems of interstadial rank, about 80–70 ka old, and more weakly developed initial chernozems or brown earths (?) 42–34 ka old. According to J. Marković-Marjanović they would correspond to pedostratigraphic units PK II and PK I of the Czechoslovakian authors. Signs of pedogenesis of interstadial rank also occur in older (Rissian) loesses. In the sections presented these are horizons of weak or initial brunification (about 170 ka old in the Slankamen section and about 290 ka old in the Batajnica-Kapela section).

The stratigraphic scheme worked out by A. Bronger (1975) on the basis of paleopedological criteria did not stand the test of dating of the mentioned loesses. It was already found by the author of this scheme himself after analysis of the results of TL datings carried out by A.K. Singhvi (A. Bronger and Th. Heinkele 1989). The results of these datings carried out for Mošorin and Slankamen sections in Physical Research Laboratory in Ahmedabad (India), are presented graphically (Fig. 2 and 3). It can be stressed that they seem to be fully consistent with our results.

FINAL REMARKS

1. The results of our datings of 46 samples from three sections of Danubian loesses appear to be fully consistent with the results obtained by A.K. Singhvi for 10 samples coming from these sections. Therefore, it can be stated that the results of datings by TL method from the Lublin laboratory correspond not only with the results obtained in the Kiev laboratory, but also with those in Ahmedabad. From the geological point of view, they are comparable with the datings carried out for loesses in the Heidelberg laboratory using different analytical techniques. It can be also stressed that our results confirm the opinion of reliability of TL datings of loesses in the interval to 500 ka at least.

2. A large collection of our samples allows us to state that the stratigraphic scheme of Yugoslavian loesses worked out by J. Marković-Marjanović in the 60's had a good geological basis. The distinction of two pedocomplexes corresponding to R/W (Neštin pedocomplex) and M/R (Slankamen pedocomplex) interglacials was fully justified. Among the layers occurring between them there could be distinguished another pedocomplex of interglacial rank, visible in Mošorin and Batajnica sections; it could be determined as "Batajnica pedocomplex". These pedocomplexes corespond to the following oxygen-isotope stages of deep-sea sediments: "Neštin" — 5; "Batajnica" — 7; "Slankamen" — 9.

3. Soils of interglacial rank (R/W) occurring in neo-Pleistocene layers are developed as forest brown or as degraded chernozems. Well developed chernozems of interstadial rank from early Würm are distinguishable equally distinctly. Therefore, the paleopedologic criterium cannot be used for unequivocal distinction between soils of interglacial and interstadial rank in loesses near Beograd as successfully as for example in the north part of

East Europe. A. Bronger would probably agree with such an opinion, as he evidently overestimated the role of paleopedologic criteria in determination of the stratigraphy of Danubian loesses.

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STRESZCZENIE

Zbadano trzy profile lessów: 1) Mošorin-Surduk Dukatar, 2) Stari Slankamen-Čot, 3) Batajnica-Kapela (ryc. 1). Dla 46 pobranych próbek wykonano datowania metodą termoluminescencyjną w laboratorium Zakładu Geografii Fizycznej UMCS w Lublinie. Wyniki datowań podano na rycinach, na których uwzględniono także schematy stratygraficzne dwu profili wcześniej opracowanych przez innych autorów (ryc. 2 i 3). Tylko profil Batajnica (ryc. 4) nie był ostatnio badany; dlatego w tekście podano jego opis.

Wyniki datowań potwierdziły poprawność schematu stratygrafii lessów jugosłowiańskich, który opracowała J. Marković-Marjanović (1964, 1967) na podstawie różnych kryteriów geologicznych. Niezgodny z tymi datowaniami okazał się schemat opracowany przez A. Brongera (1975) na podstawie kryteriów paleopedologicznych. Skorelowana z ostatnim interglacjałem (R/W) gleba F_5, wyróżniona przez tego drugiego autora, jest znacznie starsza. Stwierdził to on już sam, na podstawie datowań metodą TL kilku próbek z profili Slankamen i Mošorin opracowanych przez A.K. Singhviego w laboratorium w Ahmedabad (A.K. Singhvi et al. 1988). Wyniki datowań z tego laboratorium są w pełni zbieżne z wykonanymi przez nas w laboratorium lubelskim (ryc. 2B, C i 3B, C).

Do wyróżnionych przez J. Marković-Marjanović interglacjalnych pedokompleksów Neštin (R/W) oraz Slankamen (M/R) proponujemy dodać pedokompleks Batajnica, gdyż z paleopedologicznego punktu widzenia ma on podobną rangę. Te trzy pedokompleksy pod względem chronologicznym odpowiadają następującym stadiom izotopowo-tlenowym osadów głębokomorskich: "Neštin" (130-90 ka BP) — 5; "Batajnica" (250-205 ka BP) — 7; "Slankamen" (350-300 ka BP) — 9.