STUDIA GEOMORPHOLOGICA CARPATHO-BALCANICA
VOL. XXIV KRAKÓW 1990 PL ISSN 0081-6434

NADEŽDA KRSTIĆ (BEOGRAD)

THE HOLOCENE IN THE VOJVODINA SECTION OF THE DANUBE AND TISA RIVER VALLEYS (YUGOSLAVIA)

INTRODUCTION

During the upper Würm large quantities of water draining the mountain chains that surrounded the Pannonian Basin ran toward the plain. In Vojvodina which occupies the south-eastern part of the Pannonian Basin rivers flowed from the north, west and less from the north-east. In these directions the rivers Danube, Sava and Tisa, together with its left tributaries eroded the wide Würmian loess surfaces extending along the rivers (Fig. 1). The erosion of loess changed the subsidence rate of some tectonic blocks. As a result, they even were affected by slow movements of uplift. These in turn activited other tectonic blocks occurring in the southeastern part of the Pannonian Plain and on its southern rim. Consequently, the courses of the Danube, Tisa and Sava follow some reactivated old faults.

In Vojvodina, with exception of the Fruška Gora mountain, three main facies of Holocene deposits have been distinguished. The first one which includes eluvia and deluvia developed on the Würmian loess plateaux corresponding to the third river terrace. Alluvia of the overbank facies are developed on the second („varos") terrace and on the first terrace. The third type includes channel deposits preserved in palaeochannels and along recent river courses. At present such sediments are being laid down along the non regulated river reaches.

THE HOLOCENE ON LOESS PLATEAUX

The loess plateaux correspond to the third river terrace in the sense used by K o c h (1867). Pedogenic processes affecting either swampy or dry terrace loesses led to the formation of the pedocomplex — different types of chernozem developed as eluvium. It varies in thickness due

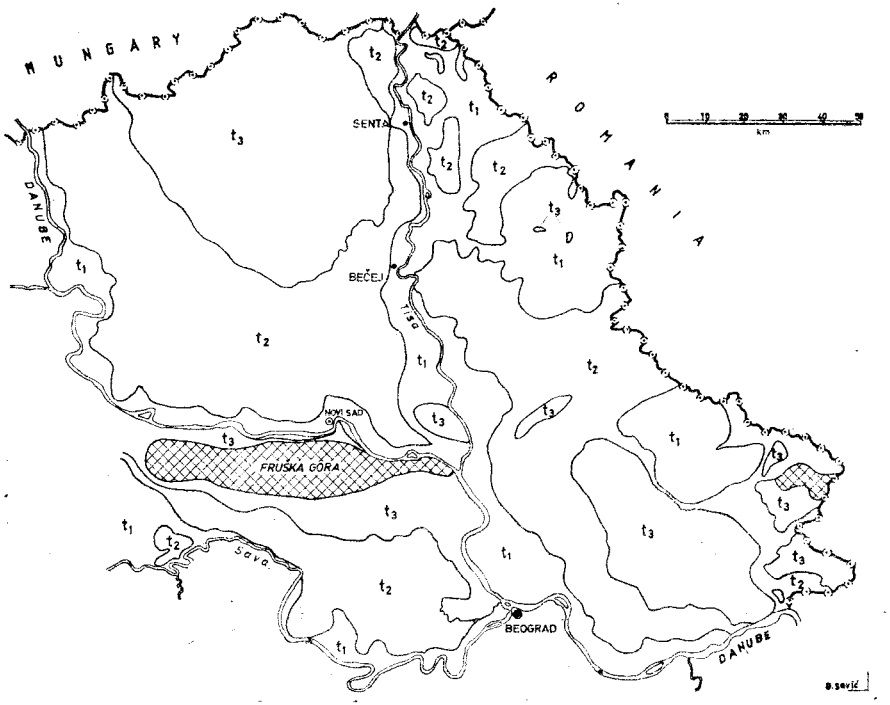

Fig. 1. Geomorphological picture of Vojvodina. t_1 — first river terrace (flood-plain), t_2 — second („varos") river terrace, t_3 — third river terrace (Würmian loess plateaux), chequers — pre-Quaternary bedrock

Ryc. 1. Geomorfologiczna mapa Wojwodiny. t_1 — pierwsza terasa rzeczna (równina zalewowa), t_2 — druga terasa („varos"), t_3 — trzecia terasa (würmskie plato lessowe), szachownica — skały podłoża przedczwartorzędowego

to the varied primary plateaux relief (Fig. 2). On the small knolls the thickness of the chernozem became reduced by the processes of erosion. Similar conditions prevail in places, where the original aeolian loess is exposed. For that reason only some *Helicigona banatica* and similar thermophilous species have been found in the chernozem.

Deluvia constitute the second type of Holocene deposits occurring on the loess plateaux (third terrace). The pedolite that has been eroded from the knolls became displaced toward the small depressions. This short-distance transport was of the order of a few metres or a few dozens of metres. The fills of the rather circular depressions consist of deluvial sediments. Depression widths depend upon the height of the eroded knolls (Fig. 3). The deluvia contain frequently shells of the xerophilous species *Cepaea vindobonensis*. Comparison with some proto-Neolithic localities (e.g., Lepenski Vir, B e n a c *et al.* 1979), where *Cepaea vindobonensis* was found revealed that deluvial processes lasted at least 8000 years.

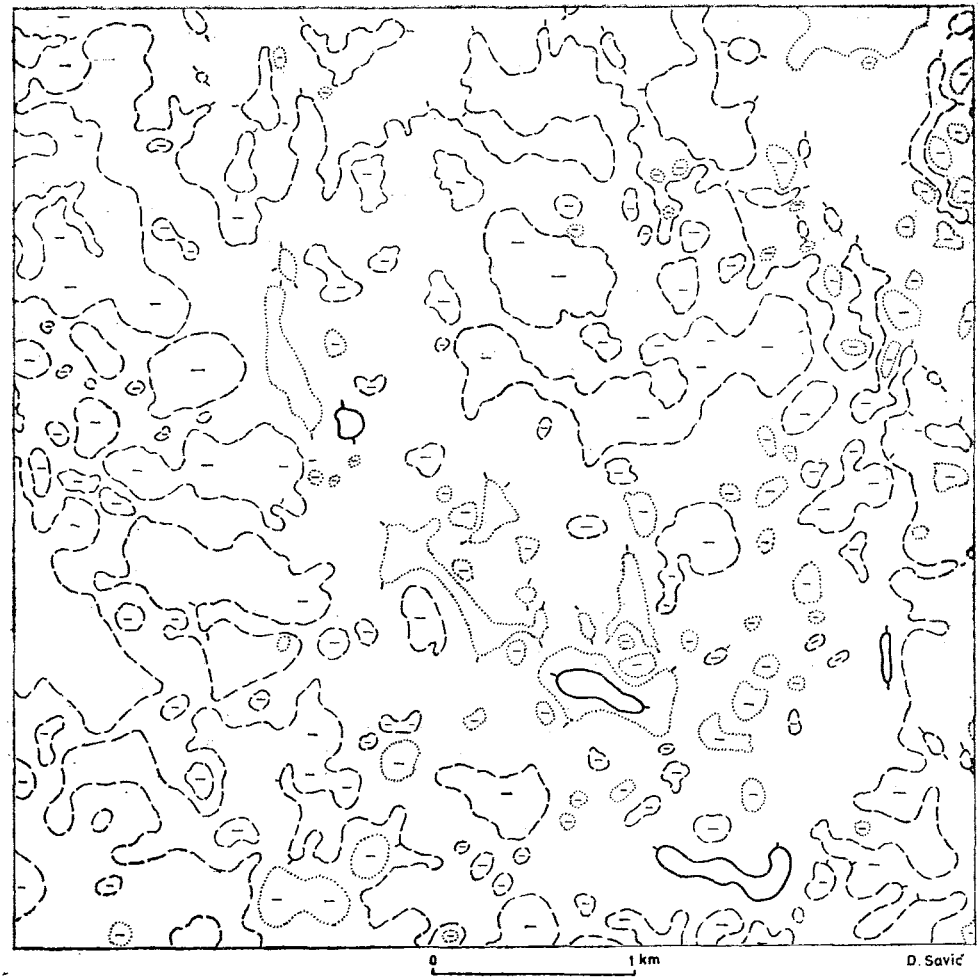

Fig. 2. The varied surface of the loess plateau (third, Würmian terrace) in north-eastern Bačka. The W_3 relief is well preserved. It includes depressions containing a swampy loess and the dividing heights consisting of a dry loess (cf. Krstić *et al.* 1983, Fig. 3)

Ryc. 2. Zróżnicowana powierzchnia równiny lessowej (trzecia, würmska terasa) w północno-wschodniej Bačce. Rzeźba W_3 jest dobrze zachowana. Zawiera ona depresje z bagnistym lessem i rozdzielające je wzniesienia zbudowane z suchego lessu (Krstić *i in.* 1983, Ryc. 3)

THE HOLOCENE OF THE SECOND AND FIRST RIVER TERRACES

On both terraces a blackish silt has been disclosed in many sections such as melioration ditches, sand pits, brickyards etc. Its lower boundary is sharp provided that it is not disturbed by roots.

The thickness of the Holocene silt occurring on both terraces is ne-

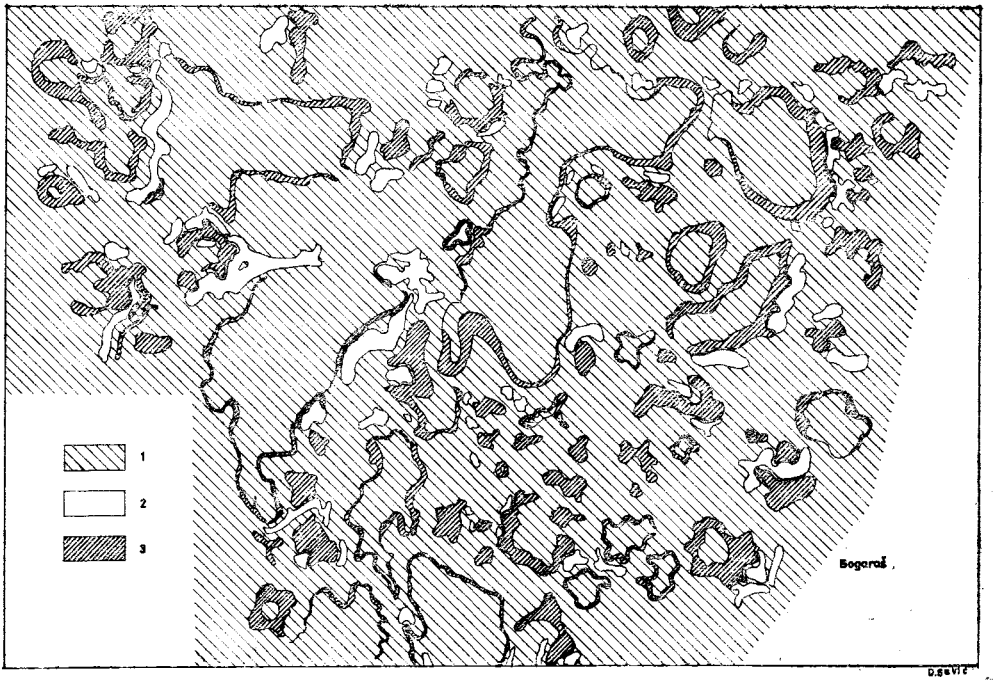

Fig. 3. Eluvium and deluvium. 1 — eluvial sheet, 2 — erosional spots, 3 — deluvial irregular circles

Ryc. 3. Osady eluwialne i dyluwialne. 1 — pokrywa eluwialna, 2 — miejsca erozji, 3 — dyluwialne nieregularne kręgi

arly the same, i.e. about 1 m. Even within the late bogs (Fig. 4) its thickness is the same. This indicates that sinking took place only a short time before present (BP) or that sedimentation rates in the bogs were very low. The blackish Holocene silt attains greater thicknesses only in the palaeochannels the widths of which tend to vary from between 0.5 and a few metres.

In Banat and Bačka the blackish Holocene silt rests on a yellow silt of Middle Pleistocene age (Mindel-Riss interglacial). This is indicated by pre-Riss species including *Virgatocypris elongata, Candona permanenta, Scottia tumida, Pisidium rudosim* and *P. neumayeri.* In the sunken tectonic blocks (at Kikinda) a Würmian silt with remains of *Mammuthus primigenius* is buried beneath the Holocene series.

Fauna identified from the Holocene blackish silt includes most often *Cepaea vindobonensis* and *Mastus bielzi.* For the most part, the samples investigated did not contain any pollen because swamps dried periodically. Locally the blackish silt may contain abundant *Fungi* spores. „On the basis of known data, in the connection to the water level, *Fungi* spores are present in a greater number in the zone of „swampy peat", where the water was relatively high, from between 1.5 and 4 m" (P a n-

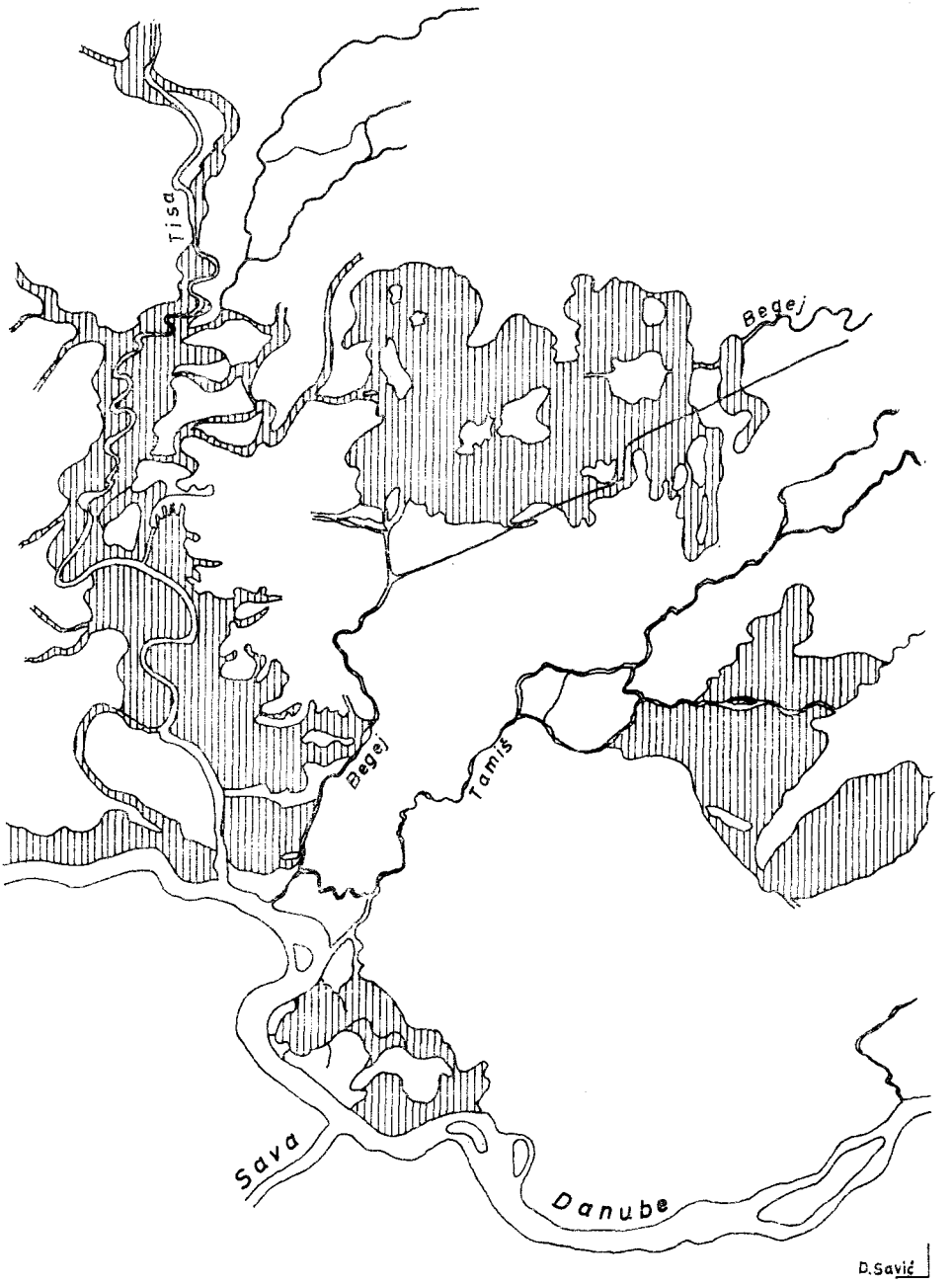

Fig. 4. The eastern part of Vojvodina (Banat) in 1765 when correction was undertaken on the rivers, together with the drainage of bogs

Ryc. 4. Wschodnia część Wojwodiny (Banat) w roku 1765, gdy wykonano regulację biegu rzeki i melioracją torfowisk

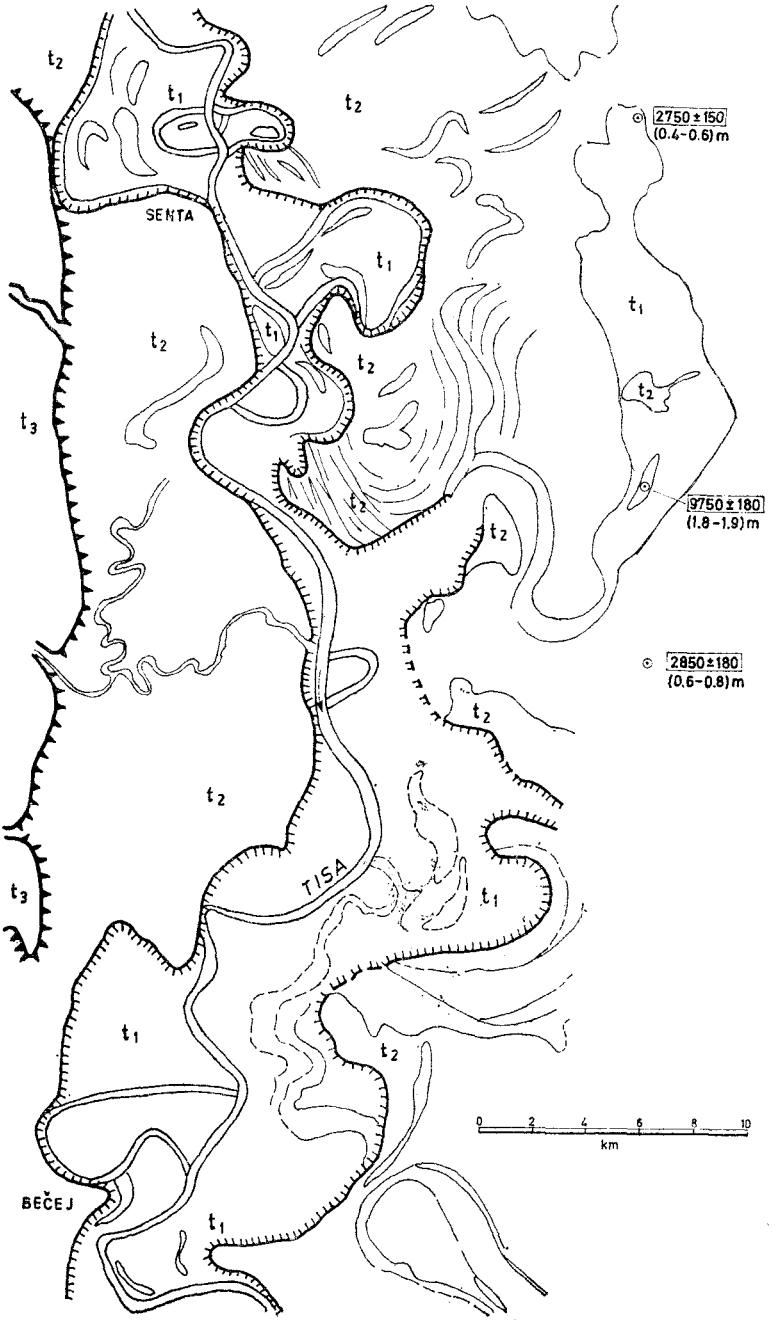

Fig. 5. Morphology of the Tisa valley between Senta and Bečej (by K o p r i v i c a). t_1—t_3 — for explanations see Fig. 1, circles indicate radiocarbon datings, in brackets — depths of samples

Ryc. 5. Morfologia doliny Cisy między Senta i Bečej (wg K o p r i v i c a). t_1—t_3 — objaśnienia jak na rycinie 1, kółka oznaczają datowanie C-14, w nawiasach głębokości próbek

tić — Report). This means that the name „swampy soil" used on the soil map of Vojvodina (*Pedological map...* 1972) is fully justified.

The Holocene deposits have been radiocarbon dated at the Institute „R. Bošković" in Zagreb at 9750±180 (Koprivica 1986) and at 2850±180 years BP. The older sample has been taken from the ancient river bed on the second terrace, where the Holocene silt is 3.5 m thick. The other one was obtained from a sand pit being only 0.6—0.8 m deep. It is probable that the sample was contaminated with younger roots.

FLOOD-PLAIN DEPOSITS

These include sandy sediments with pebbles. There also are the fills of small river branches containing a blackish silt, where sand is reduced to thin layers and pebbles are represented by redeposited calcium carbonate concretions. Silty fills overlying the sandy alluvium were studied at Gložanjska Čarda (Fig. 6).

The sandy Danube sediments here are more than 25 m thick. The Holocene deposits are overlying the Lower Pliocene silt. They are represented by a full sedimentation cycle including two subcycles.

In the lower part of the column instead of pebbles there are big rounded Pliocene silt balls being either clayey or limy. These balls have been derived from the lower part of the upper *Paludinian* beds and transported from the upper valley reach. The Danube at Gložanjska Čarda eroded the lower *Paludinian* and lower parts of the middle *Paludinian* beds (Pliocene). The size of the silty balls varies from between a few centimetres and 1 m. In the higher part of the column pebbles consisting of Mesozoic and older rocks are a few centimetres in diameter. These pebbles contain a fauna of the reophilous type (*Lithoglyptus naticoides, Fagotia, Unio* etc.). A piece of wood found in the pebbles was radiocarbon dated at 8300±1000 years BP. Two other datings of 27 000±1200 and 37 000 or more years BP can be explained in two ways: either a part of the section is of Würmian age (comp. Fig. 6) or some pieces of redeposited wood became incorporated with the Holocene alluvia. The latter case is more likely.

No remains of a microfauna were found in the silt lense in the later half of the lower part of the Holocene series at Gložanjska Čarda. Among the pollen two grains of *Secale* type together with a very pure association were determined by Šercelj (1963). These may indicate the Boreal phase. Sands both underlying and overlying the silt show traces of soil processes. From one of the humus layers developed on the silt Šercelj determined 3 *Secale* grains, 2 other cereal grains as well as *Pinus* (60), *Picea* (30) and *Alnus* (14 pollen grains). This spectrum has been related to the Subboreal phase.

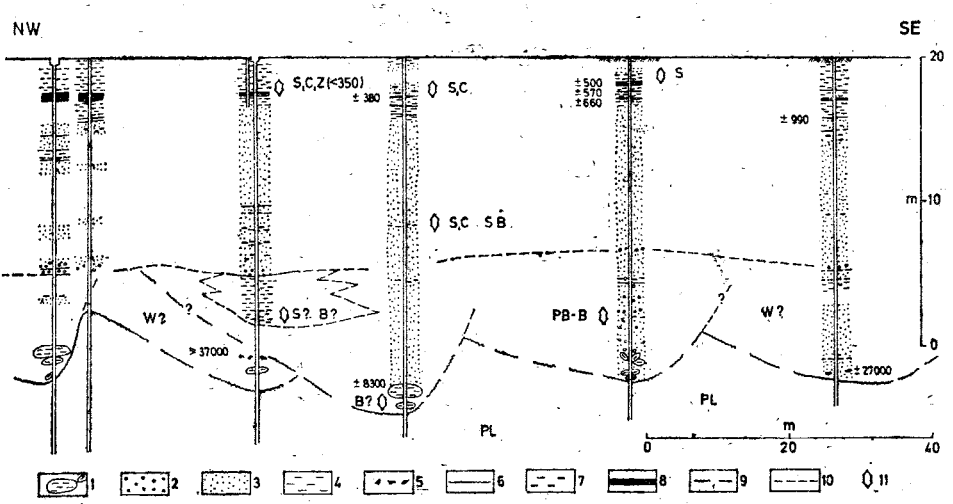

Fig. 6. Structure of the Danube alluvia at Gložanjska Čarda. 1 — large Pliocene silt balls in natural position, 2 — gravel, 3 — sand, 4 — silt, 5 — pieces of wood blackened with fire, 6 — pedolite, 7 — coaly silt, 8 — peat, 9 — erosional boundary, 10 — assumed boundary dividing two Holocene subcycles or Holocene and Würmian(?) strata, 11 — pollen analyses, W? — probably Würm, PB — Preboreal, B — Boreal, SB — Subboreal, S — rye (*Secale*) pollen, C — other cereal pollen, Z — maize (*Zea*) pollen, numbers indicate radiocarbon ages

Ryc. 6. Budowa aluwiów Dunaju w Gložanjska Čarda. 1 — duże toczeńce plejstoceńskich iłów w naturalnym położeniu, 2 — żwir, 3 — piasek, 4 — mułek, 5 — zwęglone kawałki drewna, 6 — gleba kopalna, 7 — mułek węglowy, 8 — torf, 9 — granica erozyjna, 10 — przypuszczalna granica rozdzielająca dwa holoceńskie subcykle albo warstwy holoceńskie i würmskie (?), 11 — analizy pyłkowe, W? — prawdopodobnie würm, PB — preboreał, B — boreał, SB — subboreał, S — pyłki żyta (*Secale*), C — pyłki innych zbóż, Z — pyłki kukurydzy (*Zea*), cyfry oznaczają wiek bezwzględny określony metodą C-14

In the uppermost part of the Danube flood-plain there are deposits belonging to the palaeochannel fills and backswamps. They consist of silts with thin sandy intercalations. Fossil *Ostracodes* are abundant (*Linocythere inopinata inopinata, Ilyocypris salebrosa carinata, Fysocypria kreapelini).* Findings of *Charophytae algae (Tolypella prolifera, T. cf. glomerata)* show that the water was less than 1 m deep. In the pollen spectrum Šercelj has found maize (*Zea*). This is in accordance with C-14 datings on the underlying peat. Obelić of the Institute „R. Bošković" in Zagreb obtained a succession of radiocarbon datings of 990 ± 110 to 380 ± 100 years BP. The horizon with maize on top of the peat was dated at less than 350 years BP. The end of the peat accumulation and the beginning of the sandy sedimentation, together with the reophilous *Fagotia acicularis* and *Dreissena polymorpha* can be referred to as the Little Ice Age in the 16th—18th centuries (cf. Starkel 1982, 1987).

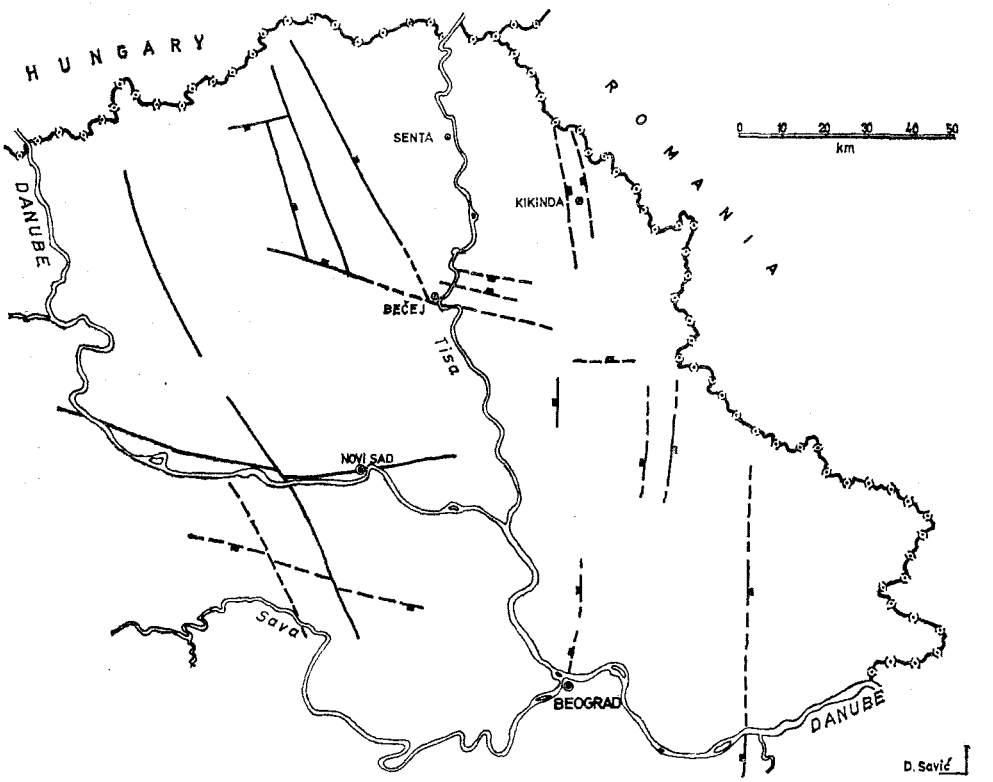

Fig. 7. Quaternary faults in Vojvodina. Faults occurring in the northeastern part of the area were tested in the field (acc. to Bilibajkić 1970; Prelogović and Cvijanović 1983; Krstić 1985; Krstić *et al.* 1983, in print)
Ryc. 7. Czwartorzędowe uskoki w Wojwodinie. Uskoki występujące w północno-wschodniej części obszaru zostały stwierdzone w terenie (wg Bilibajkić 1970; Prelogović, Cvijanović 1983; Krstić 1985; Krstić *et al.* 1983, in print)

NEOTECTONICS

There are many records of tectonic movements during the youngest Quaternary (e.g. Moldovay 1965; Prelogović and Cvijanović 1983; Krstić 1985; Krstić *et al.* 1983, in print).

In northern Vojvodina faults turned out to have been active at the Late Glacial/Holocene transition. Evidence of activity of the remaining faults is lacking.

In northern Bačka (i.e. on the Danube — Tisa interfluve) faults disturbed the Würmian loess sequence. It is very easy to disclose them by analysing the heights of the different parts of the loess plateau. Some stream courses on the Bačka loess plateau follow fault lines (Krstić 1985; Krstić and Dimitrijević 1988).

In northern Banat (at Kikinda) the whole Würmian sequence has sunken along the faults (K r s t i ć *et al.* in print). To the west the Würmian loess came into contact with the Mindel-Riss sand, so that the boundary could be traced there. To the east the Würmian silt came into contact with the Mindel-Riss loess and the boundary could be determined on the basis of geophysical profiles of the deep Neogene strata. Both faults are not visible on the surface because a continuous sheet of overbank deposits covers the second river terrace and the flood-plain.

The fault that can be traced west of the town of Kikinda is probably the cause of the straight course of the Tisa channel. It also is possible that between the Hungarian border and Novi Sad the course of the Danube is controlled by the same fault. To the west loess Würmian in age is forming the steep right side of the Danube valley.

Data presented above indicate that the second („varos") terrace has been finally formed during the early Holocene, whereas the flood-plain is a younger feature. Tectonic lines were active at the Würm/Holocene transition, but the Danube used its present-day valley course much earlier — before the Holocene.

Geoinstitut
Beograd 11050
P.O.B. 42

REFERENCES

B e n a c A., G a r a š a n i n M., S r e j o v i ć D. 1979. *Introduction: Neolithic time, Praehistory of Yugoslav lands,* Sarajevo.

B i l i b a j k i ć P. 1970. *Analytical transformation of the Bouger map of Banat and possibilities for gravimetric approach in problem of the Mesozoic.* Vesnik, 10—11, Beograd.

K o c h A. 1867. *Beocsin környekenek földtani leirasa.* A mag. Földt. tars. munkalatai, III, Budapest.

K o p r i v i c a D. 1986. *Discussion* [in:] N. K r s t i ć, *On the Holocene in Vojvodina.* Zapisnici Srpskog geol. društ., Beograd.

K r s t i ć N. 1985. *On the genesis and tectonics of Bačka plateau.* Zapisnici Srpskog geol. društ., Beograd.

K r s t i ć N., D i m i t r i j e v i ć V. 1988. *Swampy loess fauna of Bačka Topola.* Zapisnici Srpskog geol. društ., Beograd.

K r s t i ć N., J o v a n o v i ć R., I s a i l o v i ć S. 1983. *Geology of the Bačka plateau between Senćanski Trešnjevac and Čantavir.* Zapisnici Srpskog geol. društ., Beograd.

K r s t i ć N., N o v o v i ć M., K o p r i v i c a D., J o v a n o v i ć R. in print.

The column of Mammontheus locality in Kikinda. Zapisnici Srpskog geol. društ., Beograd.

Moldovay L. 1965. *The manifestation of Quaternary tectogenesis in the mountains of Hungary.* Acta geol. 9, 1—2, Budapest.

Pedological map of Vojvodina. 1972. Institute for Agricult. Investig. in Novi Sad. Beograd.

Prelogović E., Cvijanović D. 1983. *Prikaz neotektonske aktivnosti dijela Slavonije, Baranje i Bačke.* Geol. vjesnik, 36, Zagreb.

Šercelj A. 1963. *Paleobotanical examination and the development of Ljubljana moor.* Geol. Transact. Reports, 8, Ljubljana.

Starkel L. (ed.). 1982. *Evolution of the Vistula river valley during the last 15 000 years.* Part I, Geographical Studies, 1, Warszawa.

Starkel L. (ed.). 1987. *Evolution of the Vistula river valley during the last 15 000 years.* Part II, Geological Studies, 4, Warszawa.

STRESZCZENIE

N. Krstić

Holocen w odcinku wojwodinskim dolin Dunaju i Cisy (Jugosławia)

Na obszarze Wojwodiny druga terasa („varos") Dunaju i Cisy została ostatecznie ukształtowana we wczesnym holocenie, natomiast równina zalewowa jest młodszym elementem. Na przełomie Würmu i holocenu były czynne liczne linie tektoniczne. Obecny bieg doliny Dunaju nawiązuje do formy istniejącej przed holocenem.

РЕЗЮМЕ

Н. Крстич

ГОЛОЦЕН НА ВОЙВОДИНСКОМ УЧАСТКЕ ДОЛИН РЕК ДУНАЙ И ТИССА (ЮГОСЛАВИЯ)

На территории Войводины вторая терраса („варос") Дуная и Тиссы окончательно сформировалась в раннем голоцене, низменная же равнина, заливаемая паводковыми водами, более молодой элемент. На рубуже Вюрма и голоцена были активны многочисленные тектонические линии. Нынешнее направление долины Дуная связано с формой существовавшей до голоцена.