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LOWER AND MIDDLE PLEISTOCENE SEDIMENTS OF EASTERN SREM (NORTHERN SERBIA) - PALEOGEOGRAPHICAL RECONSTRUCTION

DRAŽENKO NENADIĆ, KATARINA BOGIĆEVIĆ,
ZORICA LAZAREVIĆ, JELENA MILIVOJEVIĆ

Institute for Regional Geology and Paleontology, Faculty of Mining and Geology, University of Belgrade, Kamenička 6, 11000 Belgrade, Serbia,
e-mail: geolozi@nadlanu.com

In the territory of eastern Srem, Pleistocene deposits have a wide distribution. Under the deposits of loess of the Late Pleistocene age, which are situated on the surface of the terrain, Lower and Middle Pleistocene sediments (so called "pre--loess" deposits) are found. Among them, four successive units with different lithostratigraphical and palaeogeographical characteristics are distinguished: 1. bog-lake-terrestrial sediments (Pliocene - Pleistocene), 2. polycyclic-fluvial deposits (Lower Pleistocene), 3. proluvial-deluvial deposits – "Srem series" (Lower Pleistocene - Middle Pleistocene) and 4. fluvial-palustrine sediments (Middle Pleistocene). Their lithological and palaeontological contents are described and palaeogeographical reconstruction of the area during the formation of these deposits has been performed. The main goal of this paper is to present a palaeogeographical reconstruction of the studied area, while the stratigraphical account has been given in short form.

Key words: Lower and Middle Pleistocene, Pannonian basin, eastern Srem, Serbia, paleogeography.

INTRODUCTION

In the territory of eastern Srem (northern Serbia), Pleistocene sediments have a wide distribution and a significant thickness. Generally, two units can be distinguished: pre-loess deposits, mostly built of fluvial sediments deposited in the alluvial plains of the Danube and Sava, and "polygenetic covers" of proluvial-deluvial origin, connected with the slopes of Fruška Gora Mountain. The second unit comprises loess deposits and their lateral equivalents (Fig. 1).

Loess deposits have been investigated by many geologists and geographers (Gorjanović-Kramberger 1921, Laskarev 1938, Marković-Marjanović 1972, Stevanović 1977, Rakić *et al.* 1990, Kuzmić *et al.* 1999, Nenadić 2003, Marković *et al.* 2006 etc), so their stratigraphical and palaeogeographical characteristics are quite well-known and clear. On the other hand, pre-loess deposits, which are not exposed on the surface, have been much less explored (Rakić 1973, 1990, Knežević *et al.* 1998, Nenadić 2003) and their relation to the older (Neogene) and the younger (loess) strata is yet unclear. This paper is an attempt to perform, by means of lithostratigraphical and palaeontological analysis of the data obtained from several boreholes, a palaeogeographical reconstruction of this area during the Early and Middle Pleistocene.

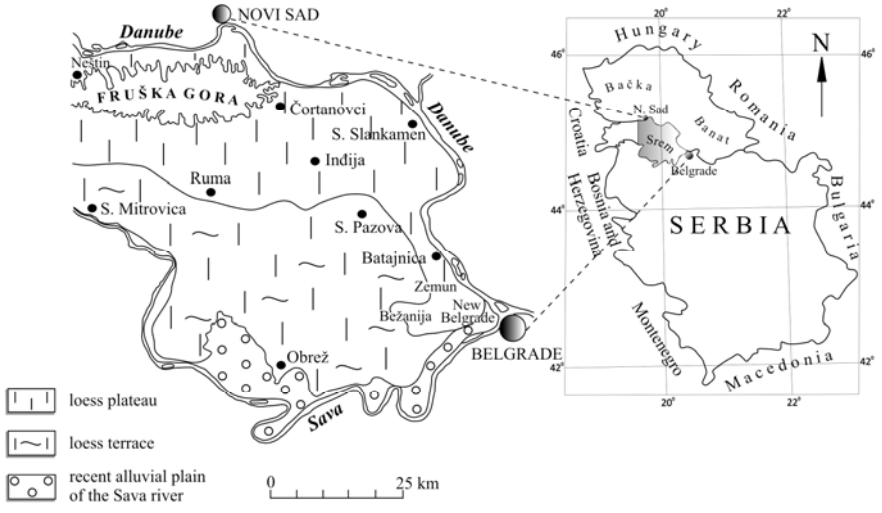

Fig. 1. - The geographical position of the investigated area.

The boreholes are mainly relatively shallow; however, we believe that the data collected in this way can provide us with a better understanding of stratigraphical and palaeogeographical characteristics of this area. In this

paper several characteristic holes are mentioned and described, but a complete stratigraphical account and palaeogeographical reconstruction have been based on all the known data about the investigated area.

MATERIAL AND METHODS

Samples of cores from several boreholes in the investigated area were collected. The petrological composition of these samples has undergone preliminary analysis, and grain-size analyses and XRD studies have been performed. Remains of molluscs and ostracodes have been picked out under a binocular microscope and, when possible, determined to the level of species. When no fossils were available, the age of deposits was estimated by the so-called superposition principle.

The terms "Quaternary" and "Pleistocene" are used according to the latest (2009) recommendations of the International Union for Geological Sciences (IUGS) and the International Commission on Stratigraphy (ICS): the Pleistocene includes the Gelasian Stage/Age, and begins about 2.6 million years ago.

A BRIEF STRATIGRAPHICAL DESCRIPTION OF THE "PRE-LOESS DEPOSITS"

On the basis of the genesis, superposition and age of the territory of eastern Srem the following palaeogeographical units can be distinguished:

1. **bog-lake-terrestrial** sediments of the Pliocene-Pleistocene;
2. **polycyclic-fluvial** deposits of the Lower Pleistocene;
3. **proluvial-deluvial** sediments ("Srem series") of the Lower Pleistocene-Middle Pleistocene;
4. **fluvial-palustrine** deposits of the Middle Pleistocene.

1. The oldest Quaternary deposits in the studied area are presented by bog-lake-terrestrial sediments. They are found in the boreholes drilled in the south-eastern part of the area (in the Sava valley and in the area of the Srem loess plateau between Novi Beograd and Zemun) and in the north--eastern part (in the territory of the village of Čortanovci) (Knežević *et al.* 1998; Nenadić 2003). In the Sava valley these deposits lie discordantly over Miocene sediments of the Paratethys (mostly marls of Pannonian age**,** the Late Miocene) or over lacustrine Pliocene deposits. Their thickness

increases from 18 meters in the Sava valley to 100 meters and more on the Srem loess plateau.

These deposits are varied and include clays, sandy clays and silts, clayey sands, and pebbly clays (Fig. 2). The occurrence of oolites and lenses of manganese and iron oxides is common. Only exceptionally are some remains of freshwater (pond) gastropods found (*Limneus, Planorbis*). These characteristics are best seen in the Zemun area (Fig. 2) in the borehole ZK-14 that reaches the depth of 162 metres.

Since their age could not be determined using biostratigraphical--palaeontological methods, on the basis of the superposition of sediments (they are covered with the Lower Pleistocene deposits and underlain by sediments of the Pliocene age) it could be assumed that they were deposited during the Late Pliocene and/or the lower part of the Early Pleistocene.

In other parts of the Pannonian basin (Slavonia, southern Banat, Bačka) formations of similar age and origin are "beds with molluscs *Viviparus vukotinovici*" (the youngest horizon of "Paludina beds") and "beds with *Viviparus boeckhi*" (Nenadić 2003). Fluvial-pond-lake deposits are rather widespread in neighbouring areas and they are mostly considered to be of the Late Pliocene age, as, for example, are those on the Vukovar plateau in Croatia (Bačani *et al.* 1999) or in the southern parts of the Moldavian plateau (Ghenea 1970). Fluvial deposits were also common during the Pliocene-Pleistocene: in Slovenia (Krško basin) non-carbonate sands and gravels on the oldest (fourth) terrace of the Sava River (Verbić *et al.* 2000); in Romania (Dacian basin) (Upper Romanian (Late Pliocene)-Early Pleistocene) deposits with mammal remains: *Zygolophodon borsoni* Hays, *Anancus arvernensis* (Croizet & Jobert), *Mammuthus meriodionalis* (Nesti) (Enciu & Balteanu 2002).

2. Polycyclic fluvial deposits are associated with the valleys of the rivers that meandered through eastern Srem. In earlier papers (Laskarev 1938, Stevanović 1977) they were called "Makiš beds" or "beds with molluscs *Corbicula fluminalis*". On the left bank of the Sava River they are underlain with unconformity by the thick Pliocene-Pleistocene deposits, and near the junction of the Sava and the Danube Rivers, by the Late Miocene (Pannonian) marls (Knežević *et al.* 1998, Jevremović *et al.* 1999, Nenadić 2001, 2003).

These deposits are widely distributed in the territory of the Pannonian basin *s.s.*, and in the studied area they are connected to the coastal parts of the Danube and Sava (Makiško polje, Ada Ciganlija, Novi Beograd, Zemun, Batajnica etc.).

This unit is composed mostly of sands, pebbly and silty sands, with intercalations of silt and clay. Typical coarse riverbed deposits often cyclically alternate with floodplain sediments.

The thickness of these deposits is very variable, from several meters up to several tens of meters (sometimes even more than 100 meters).

Index fossil molluscs for determining the age of these deposits are *Viviparus boeckhi* (Halavats) in the lower layers and *Corbicula fluminalis*

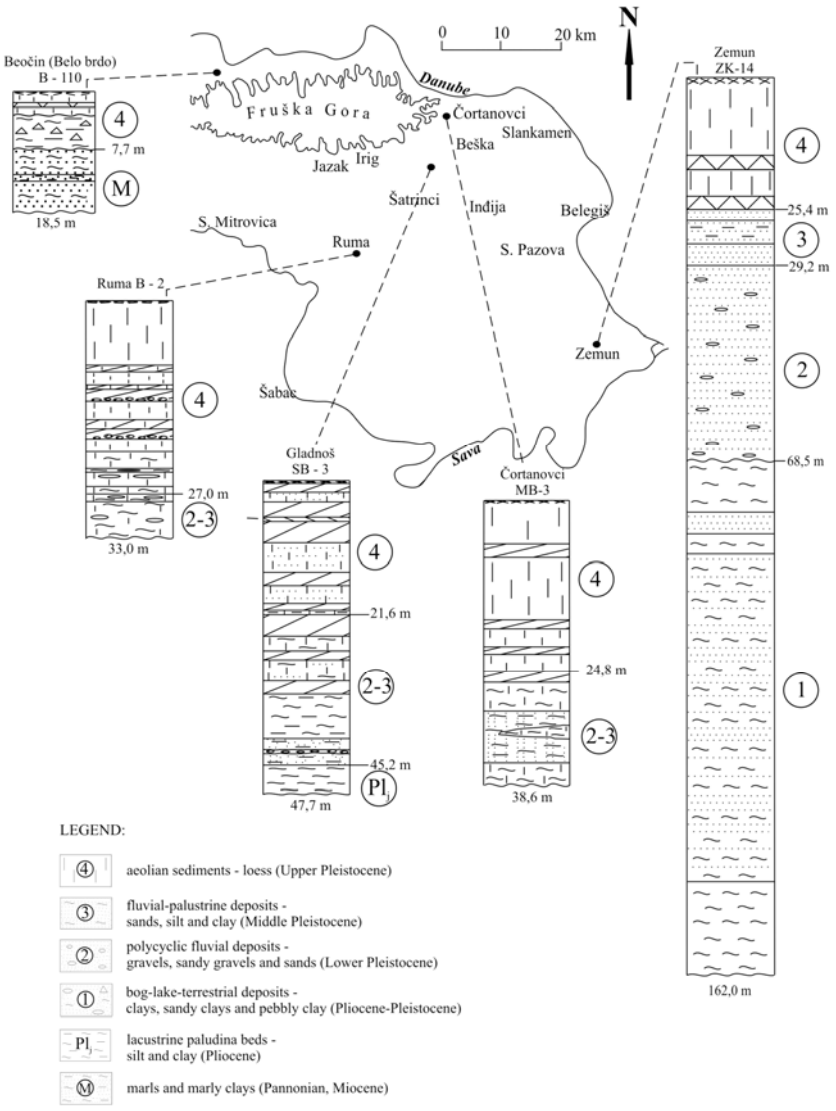

Fig. 2. - Geological columns of some borehole cores from the investigated area.

apscheronica (Andrusov) in the upper. On the Srem loess plateau *Planorbis planorbis* (Linnaeus) and *Scottia browniana* (Jones) have also been found.

Fluvial deposits of similar lithology, gravels and sands with occasional occurrences of silt and clay (Rakić 1985) occur in southern Banat (northern Vojvodina, Serbia) and overlie deposits of the Pontian age or "the Paludina beds" (lower part of the Late Pliocene). On the Belgrade Cape (to the south of the investigated area) lateral equivalents of this series are polygenetic terrestrial and pond sediments (Nenadić 2003). In eastern Slavonia (Croatia) fluvial sediments of the Early Pleistocene age are somewhat finer-grained than those in eastern Srem (Bačani *et al.* 1999). The oldest (fourth) terrace of the Drava River in Croatia and the seventh terrace of the Danube in the Dacian basin (relative height 110-120 *m*) are also composed of fluvial sediments of the Early and Middle Pleistocene age (Peh *et al.* 1998, Enciu & Balteanu 2002).

3. In the northern part of the area, on the southern slopes of Fruška Gora, deposits of proluvial - deluvial origin were formed (Rakić 1973, Nenadić 2003).

The lower parts of this heterogeneous series are composed of coarse-grained sediments (pebbly sands, sands and silts), while the upper ones are made of fine-grained material and are very similar to the so-called "pond loess". These deposits are intensely red and therefore readily discernible. The following fauna (gastropods) were found: *Parafossarulus crasitesta* (Brömme), *Anisus leucostomus* (Millet), *Aegopis klemmi* Schlickum & Ložek, *Pupilla muscorum* (Linne), *Gyraulus albus* (Müller) etc. (Rakić 1973).

The examination of the composition of clayey fraction of several samples from the territory of Ruma (Nenadić *et al.* 2001) has shown the clear difference between these deposits and overlying loess sediments. In these deposits montmorillonite is the main clay mineral, while there is a little illite and chlorite. In the loess deposits, on the other hand, the latter minerals are the most abundant, and montmorillonite is found in very small quantities or in traces. Also, the granulometric analysis confirmed that "pre-loess deposits" have more sandy and clayey components than the overlying loess (Nenadić *et al.* 2001).

The proluvial-deluvial sediments lie immediately below the loess, while their lower horizons cover lake and deluvial-proluvial deposits of the Early Pleistocene age (in the area of the village of Čortanovci). According to their faunistic composition and the superposition, an Early to Middle Pleistocene age for these deposits is proposed.

Sediments of similar composition and faunal content, but with much greater thickness, were found during drilling works in the wide area of Banat and Bačka (Vojvodina) over the polycyclic-fluvial sediments with *Viviparus böckhi*, and beneath the deposits of "Varoš terrace" and "loess terrace" (Nenadić 2003). These sediments are similar to the deposits of the Early Pleistocene age ("red beds") that were formed by ephemeral streams in the western Carpathians (Sliva *et al.* 2002). They are usually called "Srem series" in Serbian literature (Rakić 1973), while their lateral equivalents are called "Kličevac series" in the vicinity of Požarevac and "Zagajica series" in southern Banat (Rakić 1985).

4. Fluvial-palustrine deposits are present in the area of the Srem loess plateau. There they lie directly over the polycyclic fluvial deposits, and under the sands of the so-called "loess terrace". Their thickness varies from 2 to 10 meters (Knežević *et al.* 1998, Jevremović *et al.* 1999, Nenadić 2001, 2003).

These deposits in the investigated area are connected to the river valleys of the Danube and Sava, while their presence under the "pre-loess deposits" in the southern slope of Fruška Gora has not been confirmed yet.

The sediments are finer-grained than those beneath them; silts and clays (floodplain deposits) with occasional occurrences of sands (deposits of riverbed). The most common fossils (molluscs) are: *Armiger cristata* (Linne), *Bithynia leachi* (Sheppard), *B. tentaculata* (Linne), *Planorbis carinatus* (Müller), *P. planorbis* (Linne), *Succinea oblonga* Draparnaud, *Pisidium casertanum globulare* (Clessin) etc. This fauna is typical of the Tiraspol faunal complex of the Middle Pleistocene age (Rakić *et al.* 2002).

Most of these species have no stratigraphical importance, but *Scottia tumida* (Jones) has been found in the Middle Pleistocene sediments on the territory of Croatia (Velić *et al.* 1991), so the same age can be attributed to this package of sediments. In eastern Slavonia (Croatia) clayey-sandy deposits of the Middle Pleistocene age were formed in the remaining marshes and lakes (Bačani *et al.* 1999) and are very similar to the mentioned ones. Such deposits are found in the valley of the Sava River near the village of Jakuševac (Velić *et al.* 1999), and to the west of Krapina (Velić *et al.* 1991) where they are somewhat coarser-grained than those in eastern Srem. The Middle Pleistocene deposits in Croatia are also found in the higher levels of the fourth terrace of the Drava River (Peh *et al.* 1998), and in Slovenia (Krško basin) on the third terrace of the Sava (Verbić *et al.* 2000) where they are composed of mixed silicate-carbonate sand and gravel. In the western Carpathians deposits of the Middle Pleistocene age are represented by alluvial fans with horizons of palaeosols (Sliva *et al.* 2002), which are covered by the younger loess formations.

PALEOGEOGRAPHY

Variable climatic conditions that existed in the area of the Pannonian basin *s.s.*, together with occasional tectonic movements particularly pronounced during the Early Pleistocene, brought to the formation very varied categories of terrestrial deposits. Although there are no typical "Ice age" formations such as moraines, facies variability of sediments clearly testifies to climatic oscillations between cold and warm episodes of the Quaternary.

Pliocene - Pleistocene Bog-Lake-Terrestrial Sediments

The oldest Quaternary sediments in the area of eastern Srem were formed in bogs, lakes and terrestrial environments. Lithological characteristics of these deposits and the absence of faunal remains point to prolonged conditions of intensive increment of sediment material by slope processes, due to the progressive differentiation of relief caused by radial tectonic movements (Nenadić 2003).

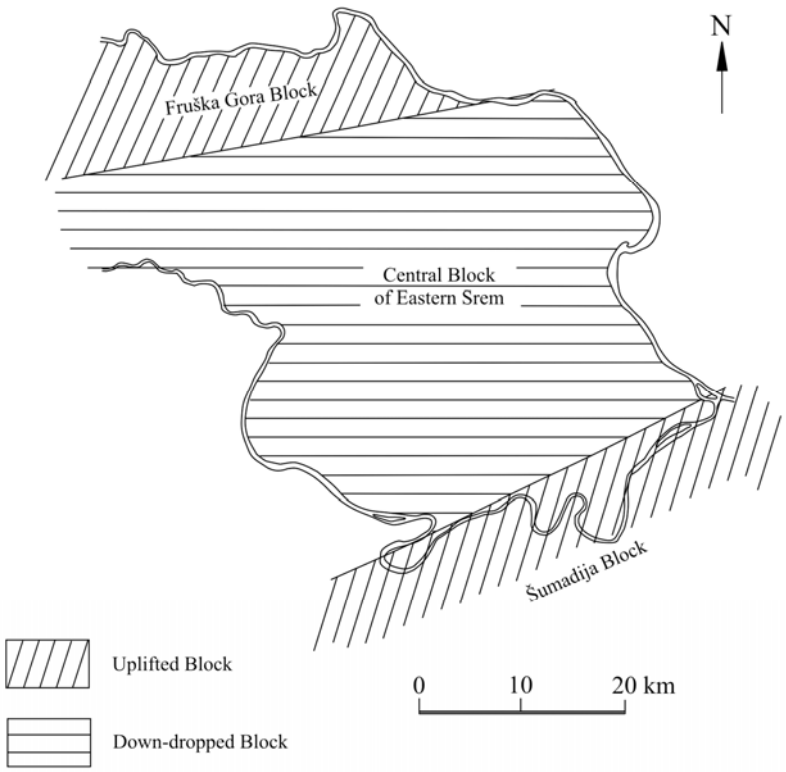

Fig. 3. - Tectonic sketch of the investigated area in the Pliocene-Pleistocene.

Strong epeirogenic movements during this epoch brought erosion and intense accumulation of eroded material to the recession of the Late Pliocene lakes, The early phase of these movements had already started at the end of the Miocene and reached its maximum during the Early Pleistocene, when vast basins, remains of "the Paludina lake" on the territory of Pannonian lowland, were rapidly filled up with sediment and elevated (Cloetingh *et al.* 2002, Rakić *et al.* 2002).

Large quantities of terrigenous material were eroded from local horst structures, such as Fruška Gora in the north, and prominent parts of the Belgrade Cape in the south (Fig. 3) and deposited in lower parts between these two areas.

The material eroded from the hilly slopes of the Belgrade Cape mainly originates from loose Neogene deposits of the Pannonian and Pontian age. It is deposited to the north of the mentioned area, particularly in the territory of present-day New Belgrade, Zemun and Bežanija, where these sediments in some places have great thickness (Knežević *et al.* 1998, Nenadić 2003). A similar type of sediments can also be found on the slopes of Fruška Gora in the area of the village of Čortanovci, which stresses a common origin of the deposits in the northern and southern part of the investigated area.

Lower Pleistocene Polycyclic Fluvial Deposits

During the upper part of the Early Pleistocene in the territory of the Pannonian basin *s.s.* major palaeogeographic and climatic changes occurred, together with enhanced subsidence in sedimentation areas.

On the basis of lithofacies features and the dynamics of sedimentation processes it can be inferred that an extremely wide alluvial plain, formed by the action of meandering rivers, existed in this part of the Pannonian basin (Fig. 4). These "pre-valleys" were much wider than the recent ones, which leads to the idea of the existence of the "lacustrine phase" during the Pleistocene (Laskarev 1938, Stevanović 1977). Nevertheless, characteristics of the sediments clearly indicate that they were formed by running waters in complex inter-mountainous alluvial plains (according to Alen 1965).

The most important dynamic factor in this phase was certainly the multi-phased epeirogenic movements which brought the sinking of the Pannonian basin floor and relative uplift of riverbeds. Depending on the length of the process and the number and intensity of the pulsation, specific alluvial deposits that in some places reach more than 100 meters of thickness (Rakić *et al.* 2002) were formed.

During the Early Pleistocene the tectonic trench of the Sava River was constantly sinking which influenced the increase in the thickness of deposits. Taking into account the gentle slope of the longitudinal river profile, the great width of the river valley, and the presence of almost all types of fluvial sediments, it can be inferred that the valley of the Sava River in this period was in the constrative dynamic phase of alluvium formation (according to Shantser 1951).

The lithological features of these deposits indicate deposition in a braided river environment. These rivers flowed into the vanishing Paludina lakes. With the constant diminishing of the surface of lakes which were left after the recession of the Pannonian aquatorium, erosional and transport power of the rivers was increasing, and fluvial-lacustrine currents dispersed material across the whole basin. At that time the southern part of the Srem depression was filled with alternating gravels and sands.

Great quantities of sand and gravel unambiguously indicate the existence of a humid climate and abundant precipitation, while cross-bedding of the mentioned deposits points to an unstable and running water environment.

Multiple and alternating epeirogenic movements caused the formation of distinctive and repetitive series of strata that are arranged vertically in complete or reduced cycles.

It could be inferred on the basis of the mode of sedimentation of these deposits that occasional shallowing and formation of ox-bows took place in the area of the alluvial plain, while in the higher parts of the river valley grassy parts of the plain were inundated (finds of grassland fauna). In that way, simultaneously with the deposition of sandy deposits in some parts of the depression, fine-grained deposits were laid down in the shallow waters and marshes.

The overall climate in this period can be described as rather humid and warm with short dry intervals, which affected the formation of coarse--grained deposits in humid periods and fine-grained floodplain deposits in dry ones (Nenadić 2003).

Lower Pleistocene-Middle Pleistocene Proluvial-deluvial deposits ("Srem series")

At the same time as the formation of polycyclic fluvial deposits in the peripheral parts of the basin in the northern part of the terrain, polygenetic covers of proluvial-deluvial type were formed (Fig. 4). This complex, known as "the Srem series", represents subareal deltas or complicated debris cones genetically connected to torrential flows and closer to slopes and

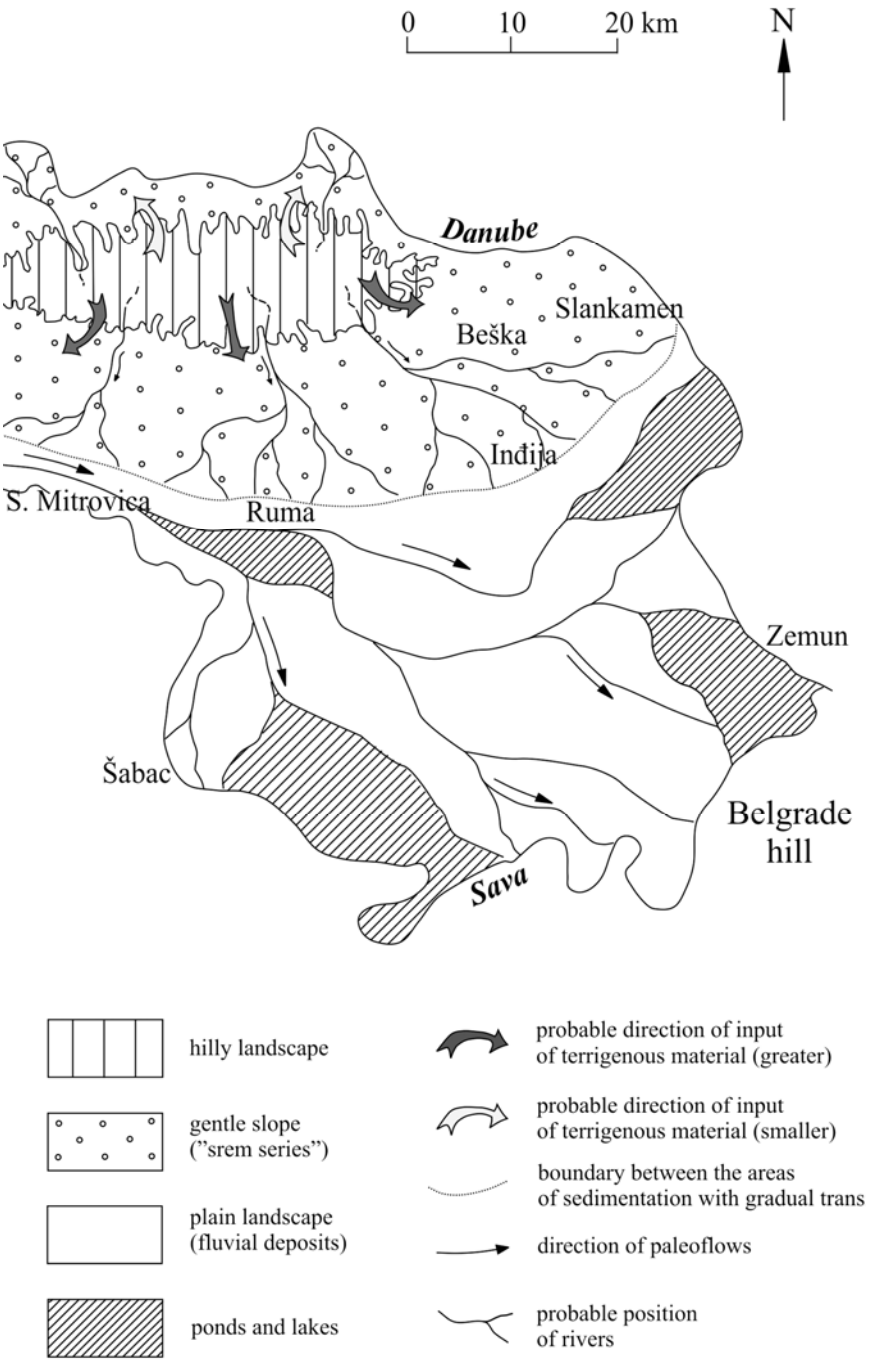

Fig. 4. - Paleogeographic sketch of eastern Srem in the Lower Pleistocene.

deluvial deposits which are found on the gentle slopes of the watershed in peripheral parts of alluvial fans (Rakić 1973, Nenadić 2003).

The uplift of the Fruška Gora massif reaches its maximum at the Pliocene-Quaternary boundary (Fig. 3). Intense torrent flows created a vast subareal delta beneath the mountain system, and under the conditions of a humid and warm climate, processes of hydrochemical decomposition and intense laterization took place, the latter being a phenomenon characteristic of sediments of debris cones.

The decomposition was triggered by watercourses arriving on the foothill lowland which rapidly lost their transmitted energy, deposited coarse-grained material near the margin of the mountains, and then uncoordinatedly effused into a series of effluents on an approximately plain surface, so finer-grained material deposited farther from the margin. The peripheral parts represent the areas to which watercourses reached only temporarily.

Simultaneously with burial by proluvial material, intensive deluvial processes took place. Under the conditions of a drier and colder climate the quantity of water was greatly diminished and processes of disintegration intensified, which resulted in the abundance of colluvial material at first transported gravitationally into the river valleys and then by torrent flows to the foothills of the mountain.

Since the rivers had no permanent channels and they reached their greatest discharge in short spring cycles, the complex cone was rather small, of steep slope, and made mainly of pebbly material. During wet and warm intervals rivers were much stronger so they reached the areas farther to the south and to the north of Fruška Gora, widening and flattening the cone while vast deluvial slopes were created with a gradually enlarged surface. At the ends of these cones, and also between their walls, shallow marshes were formed.

The increased content of magnetite in these sediments points to the process of redeposition, because this mineral is usually syngenetically formed in muds of coastal parts with a deficit of oxygen or in depressions of old peneplane surfaces made of altered serpentinites (Nenadić 2003).

Rare finds of ostracodes - *Iliocypris bradyi* Sars, *Candona neglecta* Sars, *Scottia tumida* (Jones) and opercula of *Bithynia tentaculata* (Linne) - support a fluvial or partly fluvial origin of these deposits, while gastropod fauna - *Helicopsis striata hungarica* (Soos & Wagner), *Clausilia dubia* Draparnaud, *Trichia striolata* (Pfeiffer) - indicate wet steppe biotopes of the Early Pleistocene.

In the Middle Pleistocene, the subareal delta on the slopes of Fruška Gora was transformed into a gentle deluvial delta, and the watercourses from this mountain began to tend towards the already well-defined valleys of the Sava and Danube Rivers.

The upper part of the polygenetic proluvial-deluvial cover got a somewhat different shape. Deposits are represented by loessoid silts in alternation with lenses of brownish fossil soils and, rarely, silty sands. The deposits are of uniform composition, unlayered, and the fauna found in them indicates an aeolian origin, especially in younger horizons (Fig. 5). However, it could be inferred that those sediments are of deluvial origin on the basis of the common facies changes and of the fact that the lithological complex follows the slope of the underlying layers towards the north, and towards the complex river basin. These deposits were formed under the conditions of steppe climate with cold intervals at the time of gradual cessation of tectonic activities.

In these deposits only several species of gastropods have been found: *Pupilla muscorum* (Linne), *Chondrula tridens* (Müller), *Clausilia dubia* Draparnaud, *Vallonia costata* (Müller) etc. This fauna indicates that during the formation of the upper parts of these deposits the climate was more arid and a little colder.

Middle Pleistocene Fluvial-Palustrine Sediments

As a result of significant climatic changes, at the end of the Early Pleistocene the Middle Danubian plain was transformed into a semiarid steppe with seasonal rivers of very variable flow, gentle slopes and without regular riverbed. Colder and drier conditions that prevailed in this period prove that the mountainous regions probably experienced periglacial conditions or the presence of permafrost.

Fluvial-pond deposits were formed in the widened river valleys during the “perstrative river phase” (according to Shantser 1951). Deposition took place mainly after the melting of snow in mountains. Wide and mostly shallow basins that were formed by the flooding of these rivers were either very rapidly transformed into a series of ponds or completely dried out (Fig. 5) during and after summer droughts. The so-formed sediments sometimes look like loess, but have no typical structural and textural characteristics of real loess.

By intensive melting of snow muddy flows were formed, with a lot of dragged and suspended material. On the longitudinal river profile gravels were first deposited, while suspended particles were carried away much further downstream and deposited as floodplain deposits.

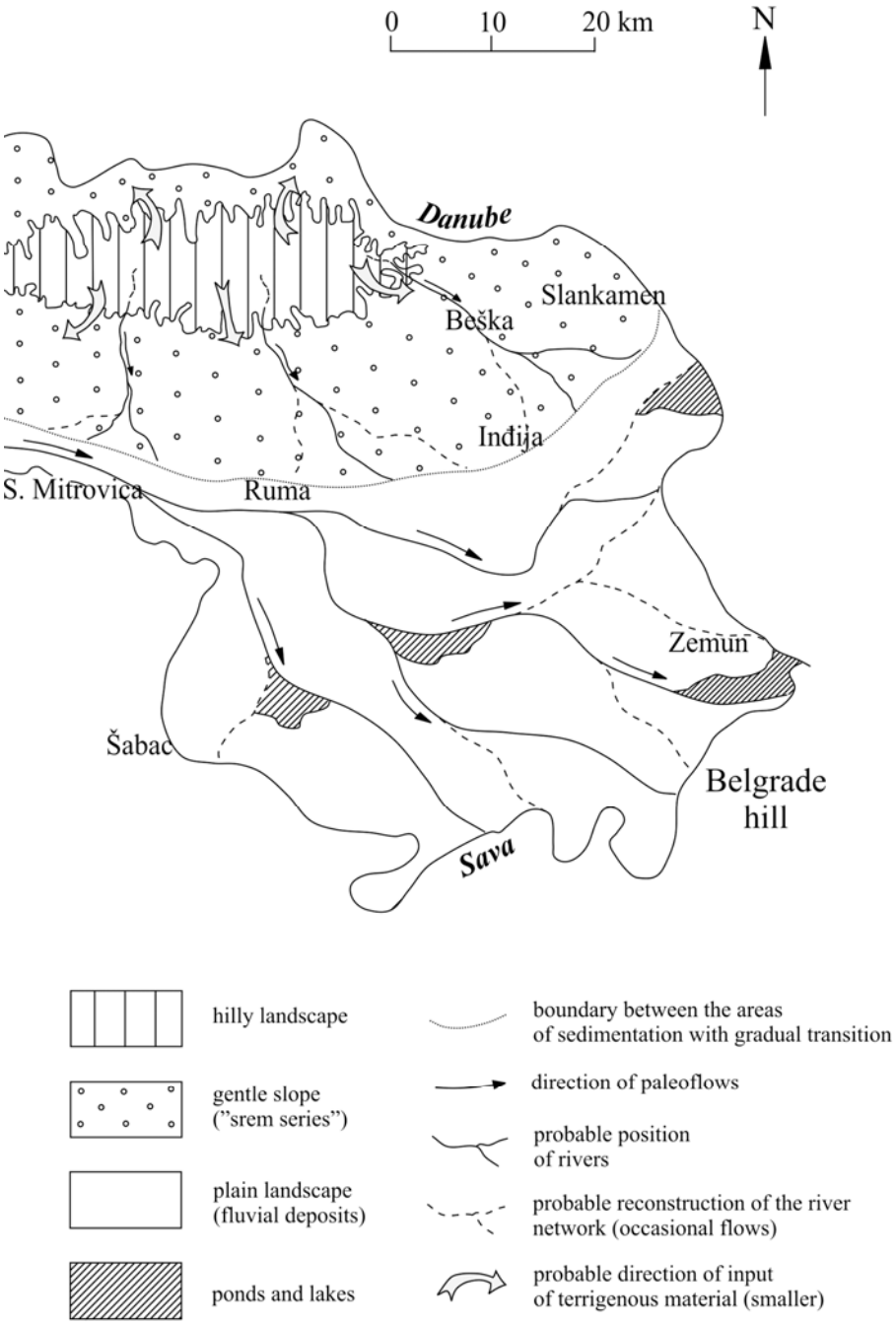

Fig. 5. - Paleogeographic sketch of eastern Srem in the Middle Pleistocene.

Lithological characteristics of these sediments (a high percentage of fine-grained material), point to a braided river system with a relatively small quantity of water and low depositional energy. Deposition took place in vast ponds, oxbows, etc.

The alternation of aquatic and terrestrial conditions could be proved by alternating occurrences of aquatic and terrestrial gastropods in the vertical profile of the deposits. This led to the previous conclusion (Laskarev 1938) that the sediments were formed by the blowing of aeolian dust into the water environment ("pond loess"). Palaeoecological characteristics of the fauna indicate weakly mobile, stagnant and shallow water environments that were surrounded by open steppe and wood-steppe areas with high groundwater levels. The climate was moderately cold and dry, with occasional wet periods. In conditions of alternating wet and arid conditions and of diminishing water surfaces, rubified soils, very enriched in oxides and hydroxides of iron, were formed. Red palaeosols indicate the interruption in sedimentation and partial or complete drying out of the river bed.

CONCLUSION

At the beginning of the Quaternary, the Danube started to cut its gorge through Đerdap, and significant drainage and the recession of the remaining "Paludina" lakes from the territory of the Pannonian Plain took place. At the same time, by intensified subsidence of these areas (especially prominent during the Early Pleistocene, but also during the Middle and Upper Pleistocene and Holocene), inflow of material from neighbouring areas was enhanced. The systems of lakes and ponds which were formed by filling the basins were connected to each other by permanent or intermittent streams. Climatic conditions were characterized by alternations of cold and warm phases. The water level oscillated constantly, and since the inflow of material was abundant, sediments of relatively great thickness were deposited.

The territory of the Pannonian Plain *s.s.* was downthrown, while the Belgrade Cape in the south and the Fruška Gora massif in the north were uplifted. Meanwhile, very heterogeneous material was deposited, especially at the foothill of the mentioned structures, in pond-lake and terrestrial environments.

In the upper part of the Early Pleistocene these sediments were covered by sandy-gravel deposits of fluvial-lacustrine origin. An extremely wide alluvial plain was created by the system of meandering rivers. It was

characterized by cyclic alteration of deposits as a result of variable climatic and tectonic conditions.

At the end of the Early and the beginning of the Middle Pleistocene this region was a semiarid steppe with seasonal rivers of gentle slope and unstable riverbed, where deposition of sediments took place mainly after the melting of snow in the mountains. In dry periods, these watercourses were transformed into a series of ponds or completely dried out. The deposits formed in these environments were loessoids and red palaeosols.

Synchronously with the formation of fluvial and fluvial - palustrine sediments in the river valleys, polygenetic covers of proluvial-deluvial type known in Serbian literature as "Srem series" were created on the slopes of Fruška Gora. These deposits were formed as a result of significant tectonic movements, uplift of the basic massif and subsidence of its northern and southern foothills.

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REFERENCES

Allen, J. R. L. (1965): A review of the origin and characteristics of recent alluvial sediments. Sedimentology **5**(2): 89-191.

Bačani, A., Šparica, M., Velić, J. (1999): Quaternary Deposits as the Hydrogeological System of Eastern Slavonia. Geologica Croatica **52**(2): 141-152.

Cloething, S. A. P. L., Horvath, F., Bada, G., Lankreijer, A. C. (2002): Neotectonics and surface processes: the Pannonian Basin and Alpine / Carpathian System. European Geosciences Union, Special Publication Series **3**: 1-7.

Enciu, P., Balteanu, D. (2002): Pliocene-Quaternary paleogeographical evolution of the Dacian Basin (Western Part). In: Michalík, J., Šimon, L., Vozár, J. (*eds*): Proceedings of the 17th Congress of Carpathian-Balkan Geological Association, Bratislava, Slovakia, September 1st-4th 2002. Geologica Carpathica **53**(special issue), 4 pp (on-line form). – Bratislava. [http://www.geologicacarpathica.sk/special/E/Enciu_Balteanu.pdf]

Ghenea, C. (1970): Stratigraphy of Upper Pliocene-Lower Pleistocene interval in the Dacian Basin (Romania). Palaeogeography, Palaeoclimatology, Palaeocology **8**: 165-174.

Gorjanović-Kramberger, D. (1921): Morfološke i hidrografske prilike srijemskog lesa. Glasnik geografskog društva **5**: 17-53.

Jevremović, M., Kuzmić, V. (1999): Zakonitost u taloženju aluvijalno jezerskih i aluvijalno barskih naslaga od leve obale Save prema Batajnici. In: Zbornik

referata 12. Jugoslovenski Simpozijum o hidrogeologiji i inženjerskoj geologiji, Novi Sad 2: 115-123. – Novi Sad.

Knežević, S., Nenadić, D., Stejić, P. (1998): Prelesni kvartarni i pliocenski sedimenti Zemuna i Novog Beograda. Geološki anali Balkanskoga poluostrva **62**: 57-73.

Kuzmić, V., Jevremović, M., Todorović, S. (1999): Zakonitost u taloženju eolskih naslaga na zemunskom platou. In: 12. Jugoslovenski Simpozijum o hidrogeologiji i inženjerskoj geologiji, Novi Sad. Zbornik referata 2: 201-207. – Novi Sad.

Laskarev, V. (1938): Treća beleška o kvartarnim naslagama u okolini Beograda. Geološki anali Balkanskoga poluostrva **15**: 1-35 [with French summary].

Marković, S. B., Oches, E., Sumegi, P., Jovanović, M., Gaudenyi, T. (2006): An introduction to the Upper and Middle Pleistocene loess-paleosol sequences of Ruma section (Vojvodina, Serbia). Geologica Carpathica **56**(6): 545-552.

Marković-Marjanović, J. (1972): Rasprostranjenje i stratigrafija lesa u Jugoslaviji. Bulletin du Museum d'Historie Naturelle, Beograd, A **27**: 93-109 (French summary).

Nenadić, D. (2001): Paleogeografske karakteristike prelesnih kvartarnih naslaga Beograda i bliže okoline. Vesnik, Beograd **51**: 1-12.

Nenadić, D., Simić, V., Knežević, S. (2001): Stratigrafsko-litološke karakteristike prelesnih pleistocenskih naslaga na prostoru istočnog Srema. Geološki anali Balkanskoga poluostrva **64**: 53-62.

Nenadić, D. (2003): Pleistocenske naslage istočnog Srema. Doktorska disertacija, Rudarsko-geološki fakultet, Beograd, 224 pp. (PhD Thesis, manuscr.) [with English abstract]

Peh, Z., Novosel-Škorić, S., Kruk, Lj. (1998): Discriminant Analysis as a Tool for Distinction of Quaternary sediments in the Region of Đurdevac. Geologica Croatica **51**(1): 47-58.

Rakić, M. (1973): Prilog poznavanju pleistocena na južnim padinama Fruške gore. Zapisnici SGD za 1972. godinu, Beograd: 27-33.

Rakić, M. (1977): Pleistocen Srema i Banata. In: Petković, K. (*ed.*): Geologija Srbije (Stratigrafija, Kenozoik) 2(3): 399-405. - Zavod za Regionalnu geologiju i paleontologiju Rudarsko-geološkog fakulteta Univerziteta u Beogradu, Beograd.

Rakić, M. (1985): Kvartarni sedimenti južnog Banata, regionalni pregled. Vesnik, Beograd, A **43**: 5-17.

Rakić, M. (1990): Regionalni pregled kvartarnih naslaga kotlina i dela Panonskog basena u Srbiji. Geološki anali Balkanskoga poluostrva **53**(1): 315-327 [English summary].

Rakić, M., Simonović, S., Hadži-Vuković, M. (1990): Nekoliko lesnih profila na desnoj obali Dunava i mogućnost njihove korelacije. Geološki anali Balkanskoga poluostrva **53**(1): 337-347 [English summary].

Rakić, M., Simonović, S., Stejić, P. (1998): Sedimentacioni ciklusi u pliocenu i kvartaru JI delova Panonskog basena sa osvrtom na problem donje granice

pleistocena. In: XIII Kongres geologa Jugoslavije, Regionalna geologija, stratigrafija i paleontologija 2: 415-427. - Herceg Novi.

Rakić, M., Stejić, P., Simonović, S. (2002): Paleogeography of Southeastern part of Pannonian basin during Pliocene and Quaternary. In: Michalík, J., Šimon, L., Vozár, J. (*eds*): Proceedings of the 17th Congress of Carpathian-Balkan Geological Association, Bratislava, Slovakia, September 1st-4th 2002. Geologica Carpathica **53**(special issue), 6 pp (on-line form). – Bratislava. [http://www.geologicacarpathica.sk/special/R/Rakic_etal.pdf]

Sliva, L., Vojtko, R., Joniak, P., Kovač, M., Barath, I. (2002): Sedimentology and Tectonics of the Plio-Quaternary sedimentary sequences of Southern part of the Považsky Inovec MTS. In: Michalík, J., Šimon, L., Vozár, J. (*eds*): Proceedings of the 17th Congress of Carpathian-Balkan Geological Association, Bratislava, Slovakia, September 1st-4th 2002. Geologica Carpathica **53**(special issue), 7 pp (on-line form). – Bratislava. [http://www.geologicacarpathica.sk/special/S/Sliva_etal.pdf]

Stevanović, P. (1977): Kvartar (Antropogen). Opšti pregled facija i njihovo rasprostranjene s posebnim osvrtom na prelesne, lesne i antropogene naslage severne Srbije. In: Petković, K. (*ed.*): Geologija Srbije (Stratigrafija, Kenozoik) 2(3): 357-417. - Zavod za Regionalnu geologiju i paleontologiju Rudarsko-geološkog fakulteta Univerziteta u Beogradu, Beograd.

Shantser, V., 1951: Alivuii ravninnykh rek umerenogo poiasa i ego znachenie dlia poznania zakonomernostei stroenia i formirovania alliuvianykh svit. Trudy Geologičeskogo instituta AN SSSR **135**(55): 1-274.

Velić, J., Saftić, B. (1991): Subsurface spreading and facies characteristics of Middle Pleistocene deposits between Zaprešić and Samobor. Geološki Vjesnik **44**: 69-82.

Velić, J., Malvić, T. (1999): Lithologic Composition and Stratigraphy of Quaternary Sediments in the area of the "Jakuševac" Waste Depository (Zagreb, Northern Croatia). Geologica Croatica **52**(2): 119-130.

Verbić, T., Rižnar, I., Poljak, M., Demšar, M., Toman, M. (2000): Quaternary sediments of the Krško Basin. 2. In: Hrvatski geološki kongres, Cavtat--Dubrovnik: 451-457. - Zagreb.

СЕДИМЕНТИ ДОЊЕГ И СРЕДЊЕГ ПЛЕИСТОЦЕНА ИСТОЧНОГ СРЕМА (СЕВЕРНА СРБИЈА) - ПАЛЕОГЕОГРАФСКА РЕКОНСТРУКЦИЈА

ДРАЖЕНКО НЕНАДИЋ, КАТАРИНА БОГИЋЕВИЋ, ЗОРИЦА ЛАЗАРЕВИЋ, ЈЕЛЕНА МИЛИВОЈЕВИЋ

Р Е З И М Е

Почетком квартара, просецањем данашње Ђердапске клисуре, смањена је количина вода у „палудинским језерима“ на подручју Панонске низије. Језера и баре, настале попуњавањем бивших басенских простора, биле су међусобно повезане сталним или повременим речним токовима. Клима се одликовала сменом сувих, аридних и топлих, плувијалних фаза.

На основу морфолошких и литолошких карактеристика седимената, дат је приказ депозиционих средина у доњем и средњем плеистоцену. Током доњег плеистоцена, као резултат интензивне тектонске активности, спуштен је део терена коме припада појас Панонске низије у ужем смислу а издигнут део београдског рта на југу и масив Фрушке горе на северу. На подручју источног Срема, у доњем плеистоцену депоновани су полициклични речно-језерски седименти (циклична смена шљункова, пескова, алеврита и глина). Крајем доњег и почетком средњег плеистоцена, формирани су седименти поводња (семиаридна клима са повременим, сезонским речним токовима) као и лесоидне наслаге и „црвене погребене“ земље (аридна клима). Крајем доњег и почетком средњег плеистоцена, на падинама Фрушке горе, формирани су пролувијално-делувијални седименти, познати у домаћој литератури под називом „сремска серија“.