Palaeoclimate record in the Late Pleistocene loess-paleosol sequence at Miseluk (Vojvodina, Serbia) [Le cycle climatique du Pléistocène supérieur dans la séquence loessique de Miseluk (Vojvodina, Serbie).]

Slobodan B. Markovic, Eric A. Oches, Tivadar Gaudenyi, Mladjen Jovanovic, Ulrich Hambach, Ludwig Zöller, Pal Sümegi

Résumé

Trois unités loessiques entrecoupées par deux complexes de sols sont décrites dans une coupe de loess d'environ 8 m localisée a Miseluk (Vojvodine, Serbie). Les données géochronologiques issues des mesures de racémisation des acides aminés des coquilles de mollusques permettent de proposer des corrélations entre les unités loessiques LI et L2 de Miseluk et les loess des deux derniers cycles glaciaires (B et C) des autres séquences d'Europe centrale. Les résultats des analyses sédimentologiques et des mesures de susceptibilité magnétique débouchent sur la mise en évidence de plusieurs épisodes froids et secs alternant avec des périodes plus chaudes et plus humides au cours des derniers 150 000 ans. L'étude malacologique montre par ailleurs des similitudes importantes entre les faunes de Miseluk et celles du sud de la Transdanubie en Hongrie ("Paleopreilynan fauna"), suggérant que la région de Miseluk constituait une zone refuge au cours des périodes de sédimentation loessique.

Abstract

Three loess units and two palaeopedological layers are preserved m the nearly 8 meter thick Miseluk exposure, Vojvodina, Serbia. Amino acid geochronology provides stratigraphie correlations between loess units LI and L2 at Miseluk with loess of glacial cycles B, and C, from other central European localities. Magnetic susceptibility and sedimentological evidence indicate several episodes of cold-dry and warm-wet palaeochmatic conditions during the last ca 150 ka. Malacofauna investigations at Miseluk demonstrate significant similarities to the Paleopreilynan fauna of the south Transdanubia region in Hungary, which suggests a réfugial character during periods of loess accumulation.

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PALAEOCLIMATE RECORD IN THE LATE PLEISTOCENE LOESS-PALEOSOL SEQUENCE AT MISELUK (Vojvodina, Serbia)

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ABSTRACT

Three loess units and two palaeopedological layers are preserved in the nearly 8 meter thick Miseluk exposure, Vojvodina, Serbia. Amino acid geochronology provides stratigraphic correlations between loess units L1 and L2 at Miseluk with loess of glacial cycles B, and C, from other central European localities. Magnetic susceptibility and sedimentological evidence indicate several episodes of cold-dry and warm-wet palaeoclimatic conditions during the last ca. 150 ka. Malacofauna investigations at Miseluk demonstrate significant similarities to the Paleopreilyrian fauna of the south Transdanubia region in Hungary, which suggests a refugial character during periods of loess accumulation.

Key-words : Loess, Serbia, aminostratigraphy, grain size, magnetic susceptibility, malacology.

RÉSUMÉ

LE CYCLE CLIMATIQUE DU PLÉISTOCÈNE SUPÉRIEUR DANS LA SÉQUENCE LOESSIQUE DE MISELUK (VOJVODINA, SERBIE)

Trois unités loessiques entrecoupées par deux complexes de sols sont décrites dans une coupe de loess d'environ 8 m localisée à Miseluk (Vojvodine, Serbie). Les données géochronologiques issues des mesures de racémisation des acides aminés des coquilles de mollusques permettent de proposer des corrélations entre les unités loessiques L1 et L2 de Miseluk et les loess des deux derniers cycles glaciaires (B et C) des autres séquences d'Europe centrale. Les résultats des analyses sédimentologiques et des mesures de susceptibilité magnétique débouchent sur la mise en évidence de plusieurs épisodes froids et secs alternant avec des périodes plus chaudes et plus humides au cours des derniers 150 000 ans. L'étude malacologique montre par ailleurs des similitudes importantes entre les faunes de Miseluk et celles du sud de la Transdanubie en Hongrie ("Paleopreilyrian fauna"), suggérant que la région de Miseluk constituait une zone refuge au cours des périodes de sédimentation loessique.

Mots-clés : Loess, Serbie, racémisation des acides aminés, granulométrie, susceptibilité magnétique, malacologie.

INTRODUCTION

Serbian loess-palaeosols successions are among the oldest and most complete loess sequences in Europe (Markovic´ *et al.*, 2003). Although loess-palaeosol sequences in Serbia could have great importance as long palaeoclimate records, they have been relatively few investigations up today. The region occupies an original position between well-studied western-central and eastern European loess areas and between "classical" loess-covered regions to the north and Mediterranean loess to the south.

The Miseluk section is located between Petrovaradin and Sremska Kamenica on the right bank of the Danube River, opposite the city of Novi Sad. In this part of the northern slope of Fruska Gora Mountain, loess covers a fossil landslide and mantles the Danube alluvial plain. Geographical coordinates of the Miseluk site are 45°16`N and 19°52`E (fig. 1). Approximately 8 m thick, the Miseluk profile includes two fossil soils separated by three

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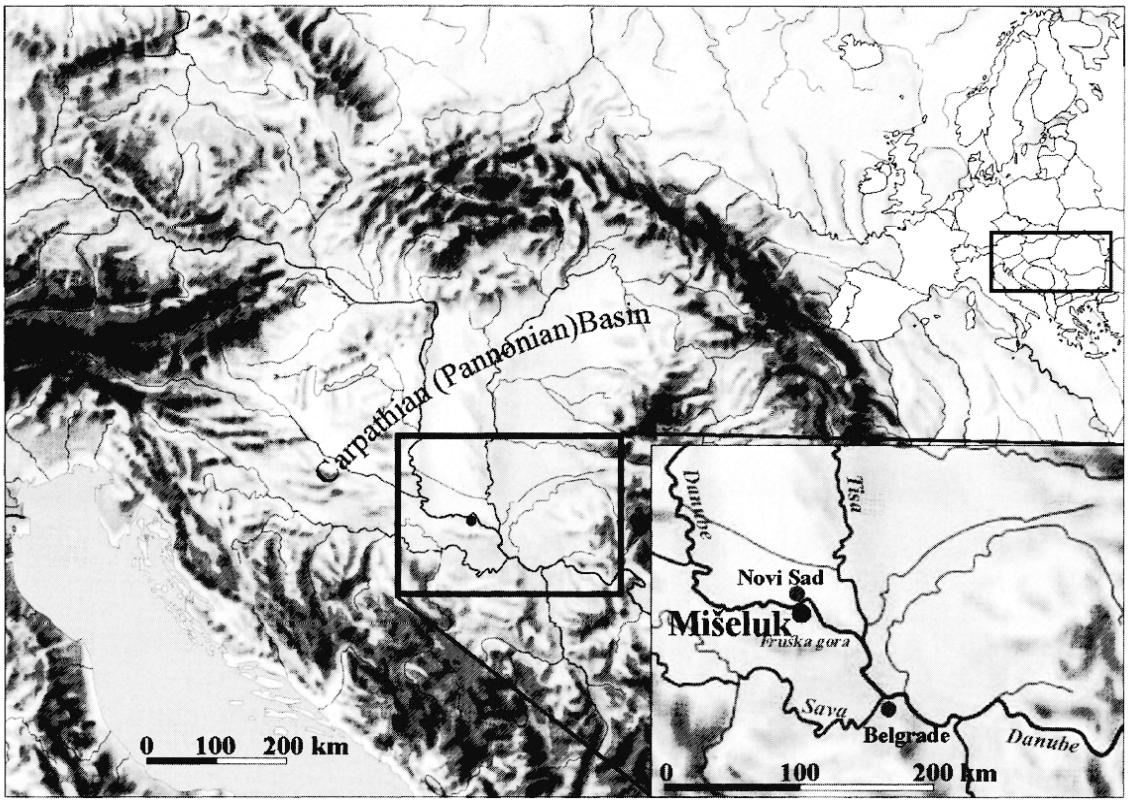

Fig. 1 : Location of Miseluk in the southeastern part of the Carpathian (Pannonian) basin.
Fig. 1 : Localisation du site de Miseluk dans la partie sud-est du bassin des Carpathes.

loess layers, all of which having been formed during the last climatic cycle (ca. 145 ka). The initial stratigraphic, palaeoclimatic and palaeoenvironmental data from Miseluk loess site were presented by Markovic´ *et al.*, (2000b, 2004).

During the Late Pleistocene the southeastern part of the Carpathian Basin was a periglacial environment, generally characterised by dry and temperate climatic conditions (Markovic´, 2000). The chronostratigraphy of the last glacial loess-palaeosols sequences of the Vojvodina region is based on amino-acid racemization (AAR), luminescence and radiocarbon geochronology ; geochronological results have been presented in several recent studies (Markovic´ *et al.*, 2000a, 2000b, in press). According to the current chronostratigraphic model (Markovic´ *et al.*, in press), the Last Interglacial-Early Glacial soil complex S1 correlates with Marine isotope stage (MIS) 5. This palaeosol is overlain by composite loess unit L1, correlated with MIS 4-2. The structure of the last glacial loess L1 varies in different loess localities across the Vojvodina region. The lower sub horizon of the upper loess, L1L2, accumulated above palaeosol S1. The Middle Pleniglacial is represented in the area by a weakly developed soil complex L1S1, which appears either as a complete pedological horizon (Ruma and Nestin sites), or as a double (Irig, Petrovaradin, Batajnica) or a triple pedocomplex (Stari Slankamen). In several exposures (Mosorin and Titel), however, palaeosol L1S1 is not well exposed. The youngest loess layer L1L1 accumulated during the Upper Pleniglacial period.

SAMPLING AND METHODS

Investigations of the loess-palaeosol sequences of the Miscluk exposure began in 1999. After a careful cleaning of the section, samples were collected at 5 cm intervals for sedimentological analysis, and at 25 cm intervals for malacological studies. Samples were collected for amino acid racemization (AAR) measurements from several intervals within two levels : 2.25-2.50 m and 7.00-7.25 m below the top of the profile. Loess and palaeosol units are designated following the Chinese loess stratigraphic system already adopted by Kukla (1987). Specific analyses include the following :

· Sedimentology : 4 grain size fractions (<2 µm, 2-20 µm, 20-200 µm, >200 µm) were measured by sieving and pipeting.

· Sediment colour : dry and moist colours were recorded using Munsell Soil Colour Charts.

· Malacology : 10 kg bulk sediment samples were sieved through 0.7 mm mesh. After fossil gastropod shells were identified, an ecological classification was compiled based on the study of Lozek (1964), but also extended with some local variants defined by Krolopp and Sümegi (1995) and Sümegi and Krolopp (2002).

· Magnetic susceptibility (MS) was measured in the field by using a portable Bartington MS2 susceptibilitymeter. Measurements were recorded every 10 cm. At each level, 10 independent readings were measured and averaged.

· Amino Acid Racemization geochronology : Gastropod shells were collected from the upper and lower

loess units for amino acid racemization analysis in order to independently correlate the stratigraphy at Vojvodina with loess-palaeosol units elsewhere in Europe. Details of the sample preparation and analytical methodology are presented in Oches and McCoy (2001).

RESULTS

LITHO- AND PEDO-STRATIGRAPHY

Figure 2 shows a detailed sketch of Miseluk loess profile. The oldest pale yellow (10YR 7/4-5/4) loess, L2, is 95 cm thick ; the base of this unit is not exposed. The lower part of this loess unit is covered with deluvial material. Many carbonate concretions (1-4 cm diameter) and humus infiltrations are developed at the contact of S1 soil complex and the underlying L2 loess.

The total thickness of the overlying soil complex S1 is 205 cm. The basal sub-unit is a 20 cm thick BC horizon with thin carbonate accumulations around pores and spherical carbonate concretions. The reddish-brown (10YR 4/3-3/3) B horizon with platy microstructure is 80 cm thick. This cambisol horizon is characterised by decalcification as well as an increase of clay content. The thickness of the overlying brown (10 YR 5/6-4/6) Ah horizon with many carbonate pseudomycelia is 60 cm. This pedological horizon is developed as a typical chernozem soil.

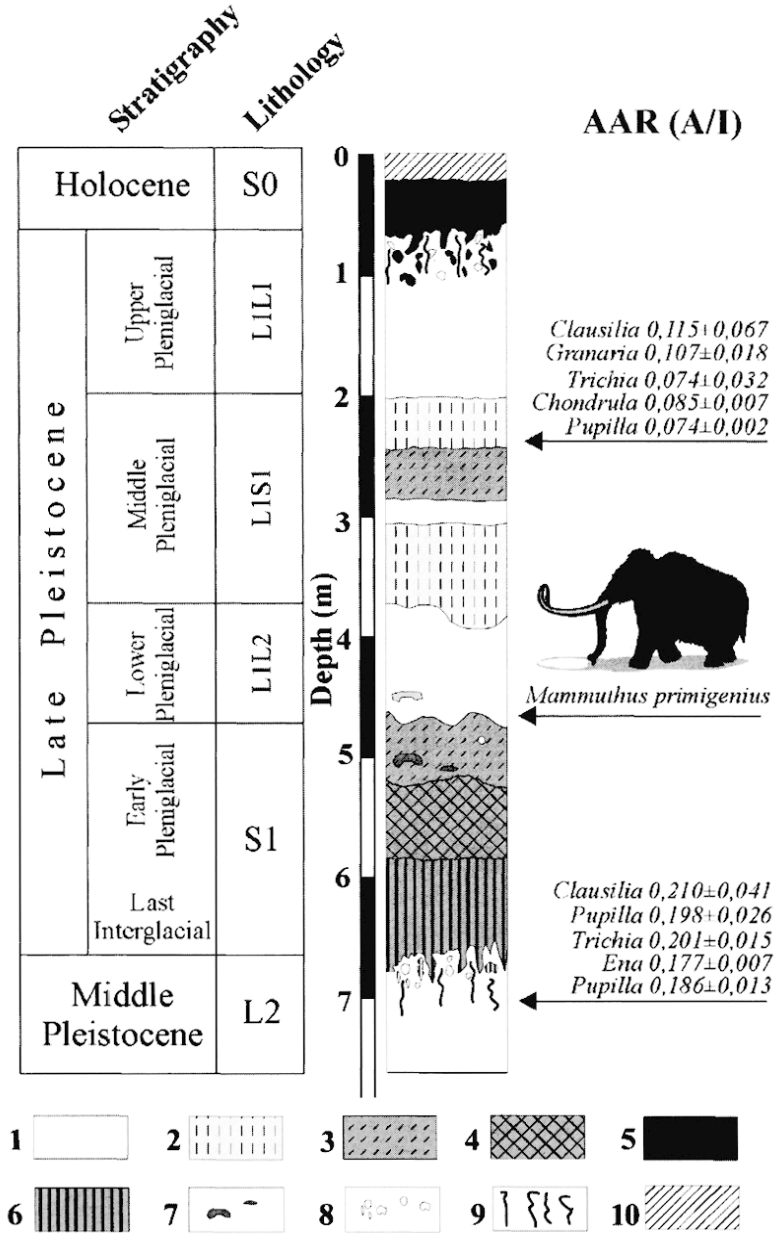

Fig. 2 : Stratigraphy of the Miseluk exposure. Positions of samples for amino acid analysis and *Mammuthus primigenius* skeletal remains are indicated by the arrows. HYD A/I values are shown for selected gastropod genera.
1. Loess ; 2. Embryonic pedogenetic (incipient soil horizon) layer ; 3. A horizon ; 4. Ah horizon ; 5. Transitional AB horizon ; 6. B-horizon ; 7. Krotovinas ; 8. Carbonate concretions ; 9. Humus infiltrations ; 10. Surface horizon disturbed by human activity.
Fig. 2 : Stratigraphie de la coupe de Miseluk. La localisation des échantillons prélevés pour la racémisation des acides aminés et du squelette de Mammuthus primigenius est indiquée par des flèches. Les valeurs de HYD A/I sont indiquées pour les genres de gastropodes sélectionnés.
1. Loess ; 2. Sol embryonnaire ; 3. Horizon A ; 4. Horizon Ah ; 5. Horizon de transition AB ; 6. Horizon B ; 7. Krotovines ; 8. Concrétions calcaires ; 9. Infiltrations d'humus ; 10. Horizon de surface remanié par les activités humaines.

The topmost part of S1 soil complex is 55 cm thick and characterised by brighter colour (10YR 5/3-4/3) and many crotovinas. This moderate cambisol-chernozem palaeosol is characteristic of transitional forest-steppe palaeo-environmental conditions.

A light yellow (10YR 7/4-5/3) 75 cm thick loess sub unit L1-L2 is accumulated above the S1 palaeosol. This loess layer is porous, loosely cemented and in some parts has weak humus infiltration and small carbonate dots. Lower part of loess L1-L2 is finely laminated with fine sand beds.

Weakly developed pedocomplex L1-S1 is 190 cm thick and represented by four sub-units. The lower one L1-S1-S3 is a weak, initial, 75 cm thick, dark yellow horizon (10YR 7/3-5/3). The inter-loess layer L1-S1-L1 is 20 cm thick, light coloured, calcareous fine silt with no indications of pedogenesis. The brownish (10 YR 4/3-3/3) porous palaeosol unit L1-S1-S2 is 40 cm thick. The uppermost layer L1-S1-S1 is 35 cm thick characterised by little brighter colour and has similar characteristics as the lower weakly developed embryonic pedogenetic horizon.

The uppermost loess stratum, L1-L1, is 145 cm thick. The unit is a porous and calcareous light yellowish-brown silt (10YR 7/4-5/3) with numerous carbonate coatings. Many spherical, relatively soft carbonate nodules and humus infiltrations in old root channels are observed at the contact zone with the modern soil S0.

The top-soil developed in the loess plateau surface of the surrounding area is classified as eroded and degraded chernozem and chenozem-cambisol (Miljkovic', 2001). The modern soil at this locality is a moderate cambisol-chernozem. Lower Ck horizon contains many carbonate nodules of 1-3 cm in diameter. A transitional reddish-brown (7.5YR 4/2-4/4) Ah/B horizon is 40 cm thick silt loam with fine blocky structure. The upper part of this soil is disturbed by human activity.

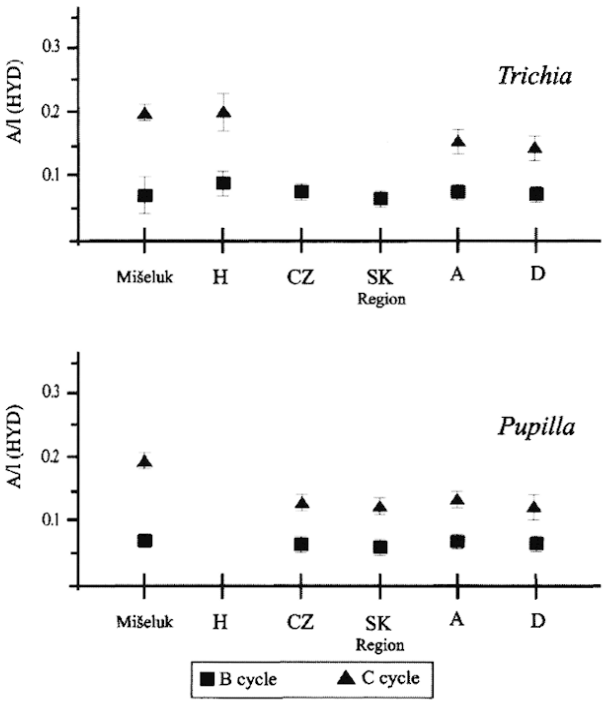

Fig. 3 : Aminostratigraphy of the Miseluk section compared with Central European localities for glacial cycles B and C, corresponding to marine oxygen-isotope stages 2-5 and 6-7, for the genera (A) *Trichia* and (B) *Pupilla*. H = Hungary, CZ = Czech Republic, SK = Slovakia, A = Austria and D = Germany.

Fig. 3 : Comparaison des résultats aminostratigraphiques de la coupe de Miseluk avec ceux de sites d'Europe centrale pour les cycles glaciaires B et C, correspondant aux stades isotopiques 2-5 et 6-7, pour le genre (A) Trichia et (B) Pupilla. H = Hongrie, CZ = République Tchèque, SK = Slovaquie, A = Autriche et D = Allemagne.

AMINO ACID GEOCHRONOLOGY AND CORRELATIONS

Amino acid racemization geochronology (AAR) has been successfully applied using fossil gastropod shells in the stratigraphic correlation of loess-palaeosol sequences in different regions of the world (Oches and McCoy, 2001). The Miseluk profile is the second Serbian loess sequence in which AAR analyses have been carried out. Seven genera of terrestrial gastropod shells have been analysed, including samples from eight levels within the sequence of loess and palaeosols at Miseluk. Sampled genera include *Chondrula*, *Clausilia*, *Ena*, *Granaria*, *Orcula*, *Pupilla* and *Trichia*. Alloisoleucine/Isoleucine total acid hydrolysate (A/I – HYD) measurements on representative samples are shown in figure 2. Shells of the genus *Puipilla* and *Trichia* were the most abundant and offer the most direct aminostratigraphic comparison with data from loess units elsewhere in central and eastern Europe. HYD A/I values measured in *Pupilla* and *Trichia* from the Miseluk profile can be compared with data from Austrian, Czech, Slovakian, Hungarian and German sites (Oches and McCoy, 1995a, 1995b, 2001 ; Oches *et al.*, 2000) (fig. 3).

AAR geochronology results from Miseluk sections support the previous chronostratigraphic scheme proposed by Markovic' (2000). According to that chronostratigraphic model, loess-palaeosols sequences L1 and S1 formed during glacial cycle B (Kukla, 1975), and correspond to Marine oxygen-isotope stages (MIS) 2, 3, 4 and 5. The exposed part of L2 loess horizon was deposited during the later part of glacial cycle C correlated with MIS 6.

LOW-FIELD MAGNETIC SUSCEPTIBILITY

According to our investigations, the varations in the low-field magnetic susceptibility (MS) are related to the pedostratigraphy in the Miseluk section. High MS values observed in palaeosol S1 (average 44.6 x 10^{-8} $m^3 kg^{-1}$) are about three time higher than in the loess unit L1 (average 15.6 x 10^{-8} $m^3 kg^{-1}$) (fig. 5).

The basal penultimate glacial loess unit L2 shows MS values ~ 15 x 10^{-8} m^3 kg^{-1}. Readings in lower part of cambic B horizon of the S1 soil complex increase to 70 x 10^{-8} m^3 kg^{-1}, the highest values in the sequence. A sharp decrease occurs in the upper part of B horizon with MS ~ 45 x 10^{-8} m^3 kg^{-1}. The brown Ah horizon shows a decreasing trend of MS values from 56 x 10^{-8} m^3 kg^{-1} in lower part to less than 40 x 10^{-8} $m^3 kg^{-1}$ in upper layer. MS continuously decreased to ~ 20 x 10^{-8} $m^3 kg^{-1}$ at the top of S1 soil complex with one strong peak of 54 x 10^{-8} $m^3 kg^{-1}$ (465 cm depth).

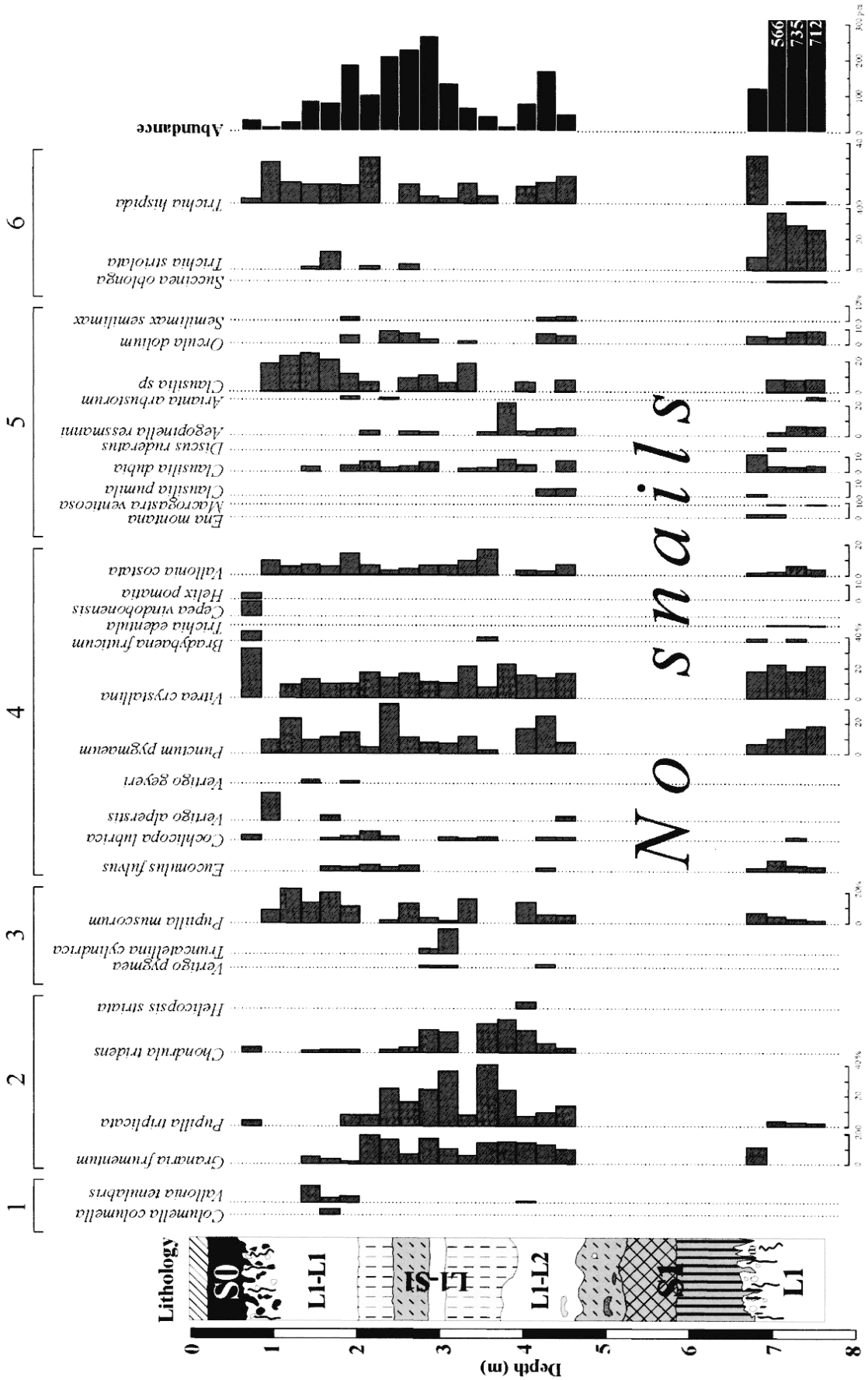

Fig. 4 : Abundance diagram of the identified mollusc species in the Miseluk loess exposure. The species are clustered in Ecological groups, as defined by Lozek (1964), but also extended with some local variants defined by Krolopp and Sümegi (1995) and Sümegi and Krolopp (2002) : 1. tundra-like ; 2. dry steppe ; 3. grassland ; 4. transitional zone ; 5. forest ; 6. wetland.

Fig. 4 : Diagramme d'abondance des espèces de mollusques identifiées dans la coupe de loess de Miseluk. Les espèces sont classées selon les groupes écologiques définis par Lozek (1964), complétés par des variantes locales définies par Krolopp et Sümegi (1995) et Sümegi et Krolopp (2002) : 1. «tundra-like» ; 2. Steppe sèche ; 3. Prairie ; 4. Zones de transition ; 5. Forêt ; 6. Zone humide.

MS of the loess L1L2 is the lowest of the sequence, with values ~ 10 x 10^{-8} m^3 kg^{-1}. The L1S1 (range of 26 to 9 x 10^{-8} m^3 kg^{-1}) shows higher values in the middle part. MS of the youngest loess layer L1L1 is low ~ 15 x 10^{-8} m^3 kg^{-1}. The Holocene soil S0 shows an increasing trend from ~ 20 x 10^{-8} m^3 kg^{-1} at the base to more than ~ 40 x 10^{-8} m^3 kg^{-1} in the uppermost level.

Finally, the MS pattern observed in the Miseluk sequence is similar to that described in Chinese and Central Asian loess deposits and reflects magnetic enhancement via pedogenesis and (e.g. Maher and Thomson, 1999).

GRAIN-SIZE DISTRIBUTION AND CARBONATE CONTENT

Variations in grain size (GS) distribution also coincides well with pedostratigraphy of Miseluk section. Generally, the pedogenic horizons have a lower proportion of coarse material than the loess layers. Variability in clay content (< 2 μm) parallels the MS record. The highest value of clay content is observed in lower part of palaeosol S1 (more than 40 %) in contrast with low values detected in loess layers (ca. 15 %). Variations of coarse material content (>20 μm) show many abrupt changes possibly linked to wind transport intensity, especially during the glacial intervals (fig. 5).

High values carbonate content are detected in loess units : more than 30 % in L2 ; L1L1 is greater than 20 % ; and L1L2 has more than 10 % carbonate, in contrast to very low values of carbonate (less than 5 %) in palaeosols.

MALACOLOGY

32 species (17 families) were identified among 3831 individuals of land snail fauna from 24 samples from the Miseluk section. Generally, the terrestrial malocological assemblages reflect humid and relative cold palaeoenvironmental conditions with mosaic vegetation (fig. 4).

The snail assemblage from upper part (final stage) of the L2 horizon (5,35-6 m depth) is characterised by a large number of shells per samples (more than 500 individuals per sample) with species of different biotopes. The dominant species include *Trichia striolata, Vitrea crystallina Punctum pygmaeum, Aegopinella ressmanni* and *Clausilia dubia*, which indicate humid closed to open environments. The species related to closed and humid environment *Ena montana* and *Discus ruderatus* were found with very low frequency in the rest of the samples.

No land snails were recovered from palaeosol S1 (4,50-6,55 m depth). Because of poor preservation and leaching in the palaeosol, this unit was not valuable for malacological investigations.

Within loess layer L1, fauna indicates the presence of closed vegetation, including species such as *Punctum pygmaeum, Aegopinella ressmanni* and *Clausilia pumila*. Numbers of individuals decrease compared with the L2 loess horizon.

During the last glacial period we note the presence of two cold episodes, indicated by the presence of the cold-tolerant species *Vallonia tenuilabris* and *Columella columella*.

The increase in the total mollusc number (richness : more than 200 individuals), and the dominance of the temperate species *Granaria frumentum* and *Pupilla triplicata,* indicates humid conditions during deposition of palaeosol L1S1.

The mollusc assemblage of the youngest loess layer L1L1 suggests a mosaic environmental character, with drier climate conditions than during the end of the penultimate glacial period, as indicated by samples from the exposed upper part of L2.

INTERPRETATIONS

PALAEOCLIMATIC AND PALAEOENVIRONMENTAL INTERPRETATIONS

Recent high-resolution studies of European loess-palaeosol sequences provided palaeoclimatic and palaeoenvironmental reconstructions based on sedimentological, rock magnetic and malacological evidence and revealed rapid climatic oscillations during the last glacial period (Antoine *et al.*, 1999, 2001 ; Rousseau *et al.*, 2001, 2002 ; Moine *et al.*, 2002).

Figure 5 presents the relationship between magnetic susceptibility, clay (<2 mm), coarse silt and sand (>20 mm) variations, and characteristic land snail assemblages in the Miseluk loess-palaeosol sequence. In general, the magnetic susceptibility record reflects changes in palaeoprecipitation and weathering intensity (e.g. Maher *et al.*, 2002 ; Nawrocki *et al.*, 1999). Relatively coarse aeolian sediments are associated with a dynamic environment typified by strong winds and cold and arid conditions, while fine-grained sediments are related to low-energy deposition and weathering under warmer and more humid conditions (Vandenberghe and Nugteren, 2001). Clay content is partly produced after deposition and according to that, also indicates intensity of weathering. Both these records are related to warming and increasing humidity, which correspond to an increase in abundance of temperate and hygrophylous land snails. High values of coarse particles (>20 mm) are related to brief cold and dry episodes and also correspond to a maximum abundance of cold resistant snails.

The snail assemblages from Miseluk loess layers suggest more humid and relatively colder environments than in other sites from the south-eastern part of the Carpathian (Pannonian) basin (Markovic´ *et al.*, 2000a, in press). The Miseluk loess site had an important role during the Late Pleistocene, probably as a refugium. It is one of those rare localities in the south-eastern part of the Carpathian Basin where the Palaeopreillyrian snail assemblage (*Macrogastra ventricosa, Aegopinella ressmanni* and *Trichia edentula*) survived (Sümegi and Krolopp, 2002).

In 1978, during excavation of brickyard raw materials 500 m away from the present section, fragments of a woolly mammoth skeleton (*Mammuthus primigenius*) were discovered at the base of L1-L2 loess, at depth 4.7 m below the present surface (Milic´, 1978), adding to the palaeoecological picture of Miseluk upper Pleistocene environment.

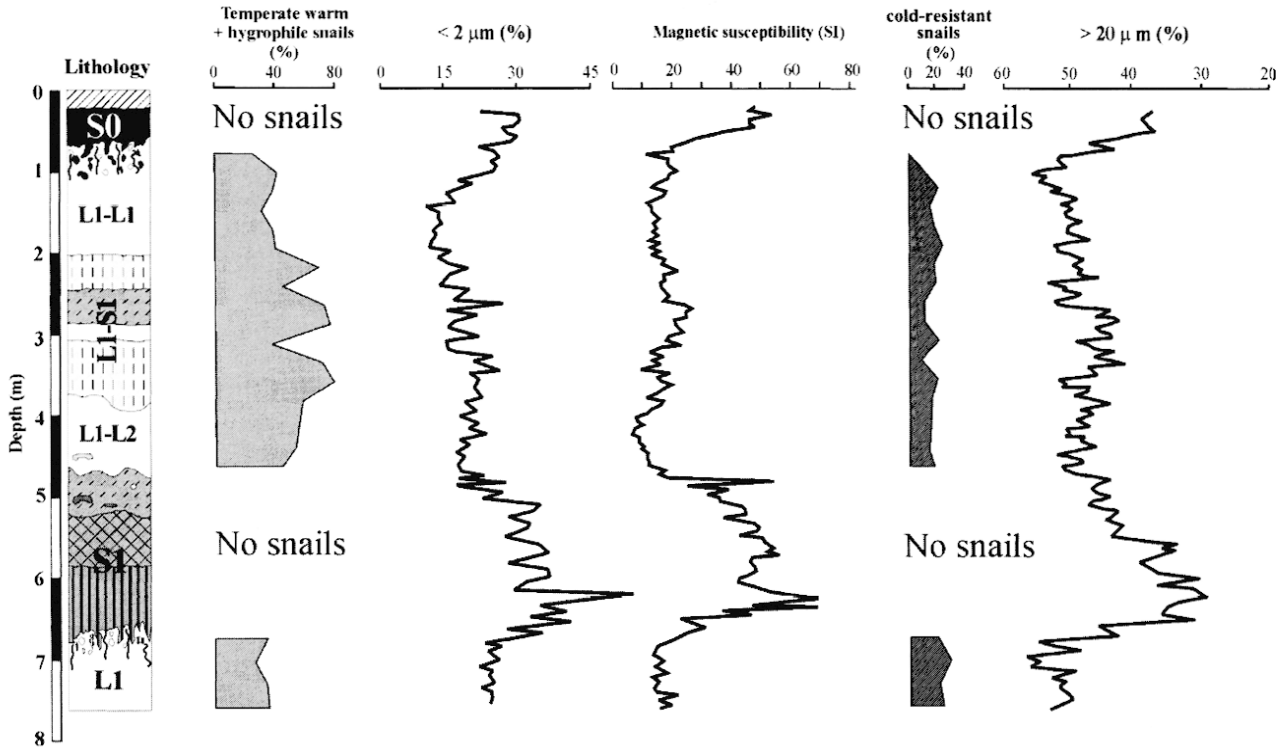

Fig. 5 : Depth plots of snail assemblage fluctuations, clay content, magnetic susceptibility and particle size fraction >20 µm.
Fig. 5 : Courbe de variation des assemblages de mollusques, de la susceptibilité magnétique, du contenu en argile et des particules supérieures à 20 µm.

Generally, data from the Miseluk section indicate following Late Pleistocene environmental changes. Final part of penultimate glacial loess (L2) represents more humid conditions than during the accumulation of the last glacial loess layer L1-L1. Pedological interpretation of pedocomplex S1 shows environmental succession from interglacial forest to Late early Pleniglacial steppe.

Palaeoclimatic and palaeoenvironmental record of composite loess unit L1 show the occurrence of two cold events interrupted by the development of weak palaeosol L1-S1 during the temperate middle Pleniglacial period. Compared with the L1-L2 loess sub-unit, data from the youngest loess layer L1-L1 indicates the coldest conditions during the last interglacial-glacial cycle. The Miseluk palaeoclimatic reconstructions agree with other interpretations of the last glacial maximum (Frenzel, 1964 ; Lozek, 1969 ; Rousseau *et al.*, 1998 ; Antoine *et al.*, 1999). The Holocene soil indicated return to an interglacial climatic mode.

COMPARISON WITH OTHER EUROPEAN RECORDS

The stratigraphical pattern of the Miseluk site is very close to those of the other Upper Pleistocene loess-palaeosol sequences of Europe (Kukla and Cilek, 1996 ; Antoine *et al.*, 1999 ; Rousseau *et al.*, 1998, 2001). However, all analysed proxies of Miseluk loess-palaeosol sequence indicate that Late Pleistocene palaeoclimatic and palaeoenvironmental evolution in this region was more stable than in other central, western and eastern European loess areas. According to palaeopedological interpretation and identified land snail fauna of Miseluk loess-palaeosol sequence, the Late Pleistocene was characterised by a mosaic environment, ranging from temperate warm interglacial to relative cold Late Pleniglacial climate. Pedogenesis of S1 pedocomplex was generally continuous during the whole MIS 5 without interruptions represented by loess markers as reported in central, western and eastern Europe (Kukla, 1975 ; Rousseau *et al.*, 1998, 2001) and with an absence of cryogenic features in the loess layers. In contrast with other European loess sites, the middle Pleniglacial palaeosol L1S1 at Miseluk, as in other loess sites in the Vojvodina region, (Markovic´ *et al.*, in press) is relatively weakly developed.

CONCLUSIONS

Investigations of Miseluk loess-palaeosol sequence during the last several years have allow to underline the importance of this site as a record of Late Pleistocene palaeoclimate and palaeoenvironment in south-eastern part of the Carpathian (Pannoian) basin. The amino acid dating of loess-palaeosol sequences in this region confirms stratigraphic and temporal correlations with other central European sites.

Miseluk magnetic susceptibility and grain size records showed many episodes of cold-dry and warm-wet palaeoclimatic conditions indicating possible connections with Dansgaard-Oechger (D/O) cycles in North Atlantic region which however remains to demonstrate.

Fossil gastropod fauna from the loess and palaeosols at Miseluk provide additional important palaeoenvironmental information. Establish fossil land snail assemblages preserved in loess also indicate the dominance of hygrophilous and shade loving species which suggest a relative humid palaeoclimate compared to conditions interpreted

from loess sediments elsewhere in the southern-eastern part of Carpathian (Pannonian) basin. Malacofauna from the Miseluk site includes species *Aegopinella ressmanni, Macrogastra ventricosa* and *Ena montana* in loess below and above palaeosol SL S1. There are significant similarities to Paleopreilyrian refugial fauna of the south Transdanubia region in Hungary, which suggests that Miseluk had a refugial character during the periods of loess accumulation.

Palaeoclimatic and palaeoenvironmental evidence from the Miseluk loess sequence suggests that the local slope exposure of the investigated area created relatively colder and more humid microclimatic conditions than in other parts of Vojvodina region during the Late Pleistocene.

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