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Environmental change indicated by grain-size variations and trace elements: examples from two different sections - the sandy-loess sediments from the Doroshivtsy site (Ukraine) and the loess section Semlac (Romania)

Philipp Schulte[1], Frank Lehmkuhl[1*], Holger Kels[1], Christa Loibl[1], Nicole Klasen[2], Thomas Hauck[3]

[1]*Department of Geography, RWTH Aachen University,52056 Aachen, Germany*
[2]*Institute for Geography, University of Cologne, 50923 Cologne, Germany*
[3]*Institute for Prehistoric Archaeology, University of Cologne, 50923 Cologne, Germany*

Abstract

Loess sequences provide important and at least a partial continuous record of Quaternary palaeoenvironmental change; some of the sequences even bury archaeological remains. In addition, loess-palaeosol sequences provide valuable information concerning environmental change and climate evolution. In this study, we compare two sections: (1) The Middle to Late Pleistocene loess-paleosol section of Semlac in western Romania (MIS 10 – 1), and (2) the sandy-loess section of Doroshivtsy in western Ukraine (MIS 2). To characterize these quite different sections we calculated individualized grain size (GS) ratios and compared them to the common U-ratio (Vandenberghe et al., 1985) and selected geochemical parameters.

Keywords: Loess; palaeosol; last glacial cycle; grain size analysis; ratio calculation.

Corresponding Author: flehmkuhl@geo.rwth-aachen.de
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1. Regional setting

It is well know that loess sequences may provide useful palaeoenvironmental information. In this study, we consider two sequences of loess occurring in Romania and Ukraine (Fig. 1). Their main characteristics can be summarize as follows.

1.1 Western Romania: the section Semlac

The loess section Semlac (46°7'12.97"N / 20°56'54.70"E / ~100 m a.s.l.) is situated in the Arad Plain (Câmpia Aradului) in western Romania at an undercut slope position on the right bank of the Mureş River (Fig. 1). The more than 10 m thick section contains four main palaeosol complexes developed in very homogenous loess with high silt content without any major discordance. A first chronological model which is based on luminescence dating and rock magnetics suggests an age from the MIS 10 to MIS 1 (Kels, 2012, Kels and Hambach, pers. comm.).

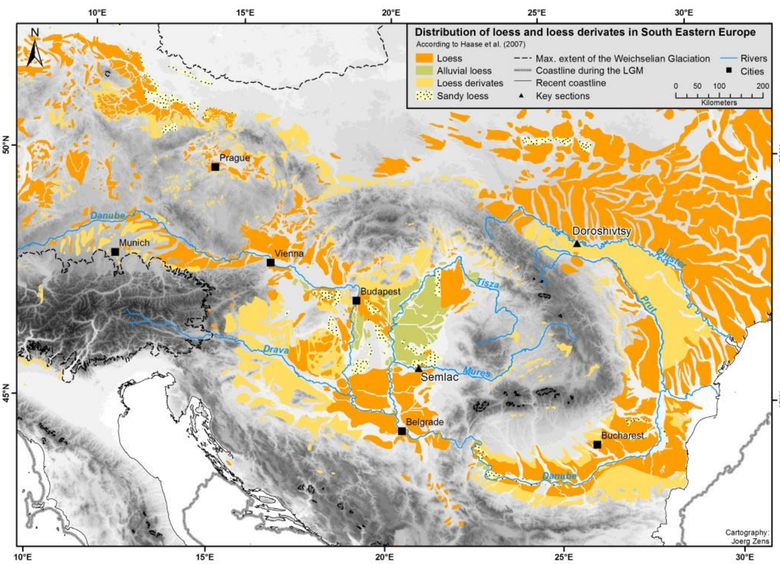

Fig. 1. Loess distribution in Europe (modified according to Haase et al., 2007), maximum extent of the Weichselian ice sheet, coastline during LGM and location of the sections Doroshivtsy in the western Ukraine and Semlac in south-western Romania.

1.2 South-western Ukraine: the section Doroshivtsy

The section Doroshivtsy (025°52'10.7''E, 48°35'37.6''N, Fig. 1) is situated in the south-western part of the Ukraine at the right bank of the middle course of the Dniester River. Bearing seven Upper Palaeolithic levels in its lower part, the Doroshivtsy sequence is archaeologically important as it documents repeated use of the site by Gravettian hunter-gatherers during the Last Glacial Maximum (LGM) (Kulakovska et al., 2012). The section represents a more than 9 m sequence of sandy loess with intercalated weak humic horizons. It is situated in a flat gully at an undercut slope of the Dniester River close to the village

Doroshivtsy. The less steep slope of the terrace-covering sandy loess indicates sediment accumulation of slope material in this position; therefore the section most probably represents a combination of formerly aeolian transported loess and of slope-wash material.

2. Methods

The particle size was measured with a Laser Diffraction Particle Size Analyzer (Beckman Coulter LS 13 320 PIDS) by calculating the mean diameters of the particles within a size range of 0.04 - 2000 µm with an error of 2 %. To remove the organic matter, the samples were treated with 0.70 ml 30 % H_2O_2 at 70 °C for several hours. To keep particles dispersed, the samples were treated with 1.25 ml $Na_4P_2O_7$ x 10 H_2O for 12 hours. The Mie theory was applied to determine the grain-size distribution (Fluid RI: 1.33; Sample RI: 1.55; Imaginary RI: 0.1). To determine the element concentrations of the fine-grained fractions, the <63-µm fraction was sieved and dried at 105 °C for 12 hours. An 8 g-quantity of the sieved material was mixed with 2 g Fluxana Cereox, homogenized and pressed to single pellets with a pressure of 20 t for 120 s. To determine the element concentrations by x-ray fluorescence, a Spectro Xepos was used. Every sample was measured twice. Mean values were calculated from the two measurements. To characterize the sediment layers of the two sections we calculated a section specific GS-ratio respectively (0.04 to 5.88 µm/ 11.29 to 26.15 µm for Semlac and 3.5 to 8.1 µm / 69.6 to 161.1 µm for Doroshivtsy). In order to ensure that each parameter of the ratio represents just one sedimentary or post sedimentary process, we narrow down the respective GS-range to the GS-classes which show constant variations with depth. For reasons of comparability we calculated the U-ratio of 44 to 16 µm versus 5.5 to 16 µm (Vandenberghe et al., 1985).

3. Results

3.1 Semlac

For the 10.70 m thick sequence, 10 different main units can be distinguished (Fig. 2). The documented loess body contains four loess-palaeosol-complexes with individual features. Generally, the loess is comparably homogenous with a distinctive dominance of silt for the whole section, higher amounts of clay in-between the palaeosols and two major events with an increase of sand. The lower part of the sequence from 7.10 m on was decalcified. The section is labelled in the loess units from L1 to L4 and in the fossil soil complexes from S0 to S3 following the Serbian loess classification (Marković et al., 2008, 2009). The individual GS-ratio shows clear variations between the weakly weathered loess units and the palaeosol complexes (Fig. 3). The numerator of the ratio appears to be related to pedogenic processes and particularly to the relocation and new formation of clay minerals. The denominator is obviously related to the strength of the loess accumulation (Fig. 2). In general, the Semlac-specific GS-ratio is lower in the loess sequences (especially in L1L1, L2, L3 and L4) and higher in the palaeosols (S0, S1, S2, S3). The L1S1 palaeosol, which was formed during MIS 3, is an exception; there is no distinct difference to the surrounding loess units. The results of XRF analysis showed comparable results to the GS-ratio. In particular, the Al/Na ratio which is shown in Fig. 2 showed a similar curve progression as a function of the loess units and the palaeosol complexes.

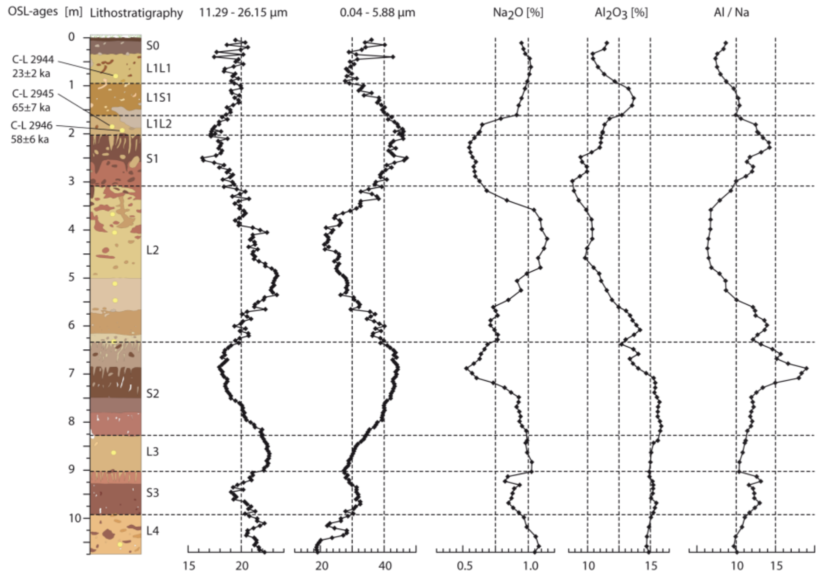

Fig. 2. Lithostratigraphy, sensitive grain size ranges and selected element concentrations of the Semlac section. OSL dating was carried out on silty quartz samples (grain size 40-63 µm) and a standard SAR protocol (Murray & Wintle, 2003). The central age model was used for De calculation.

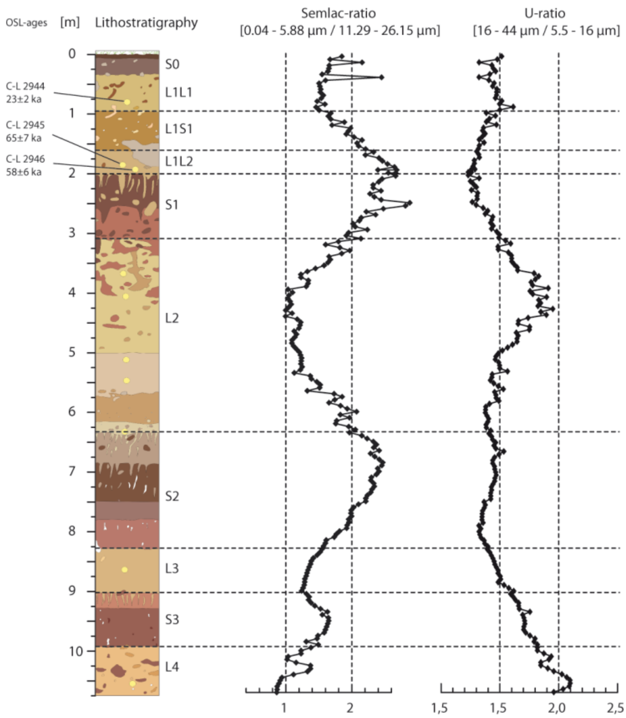

Fig. 3. Lithostratigraphy, specific GS-ratio, and U-ratio of the Semlac section.

3.2 Doroshivtsy

Based on the field description and the grain size distribution the profile can be divided into four main genetic units (I-IV) representing changes during the deposition (Fig. 4). Part I (1-3.2 m) of the profile is characterized by aeolian loess and sand deposition intercalated with a few gravel lines. Part II (3.2-6.1 m) of the profile is influenced by aeolian, denudative and weak soil forming processes. Part III (6.1-7.8 m) of the section represents a combination of aeolian loess and re-deposited slope material. Part IV (7.8-9.1 m) is mainly composed of clayey and silty layers of a tundra gley. The whole parts III and IV are affected by hydromorphic influences. As most of the sediment is rather homogeneous sandy silt the U-ratio did not show any distinct variations. However, the Doroshivtsy-specific GS-ratio shows clear peaks which represent environmental changes (Fig. 5). These variations of the Doroshivtsy-specific GS-ratio represent environmental changes which were also observed by structures and weak soil formations in the section during field work.

In addition, geochemical analysis show comparable results to the GS-ratio and provide further evidence for the differentiation of the stratigraphic units (Fig. 4). Summarizing we can detect 4 different main units and 11 sub-units which are related to palaeoclimatic and environmental conditions.

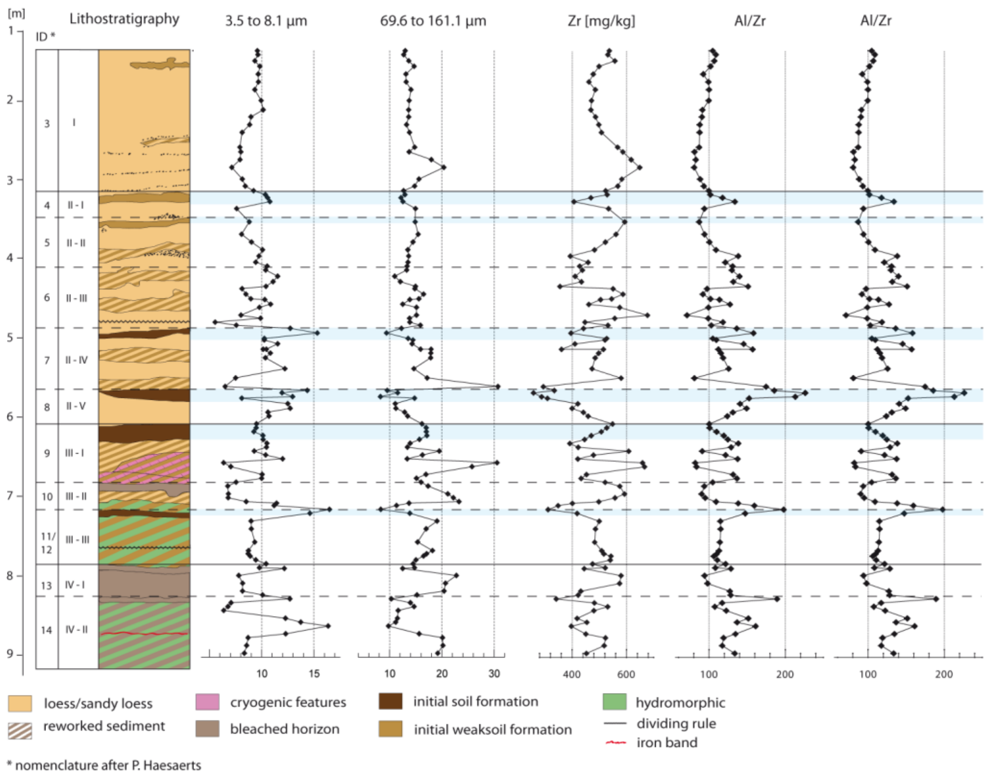

Fig. 4. Lithostratigraphy, sensitive grain size ranges, and Al/Zr ratio of the Doroshivtsy section.

Radiocarbon and luminescence ages from the lower part of the section were conclusive within the expected age range of the Gravettian period (22-28 ka). However, optically stimulated luminescence (OSL) ages of quartz minerals were younger than radiocarbon and post infrared stimulated luminescence ages (pIRIR, measured at 290 °C). This indicated sediment relocation for this part of the profile (Klasen et al., in review). The loess section is composed mainly of sandy silt and covers the time span from about 26 to 16 ka. This is one of the very few sections in Europe which provides a high resolution sedimentary record including traces of human occupation during the cooling maximum of the last glacial cycle.

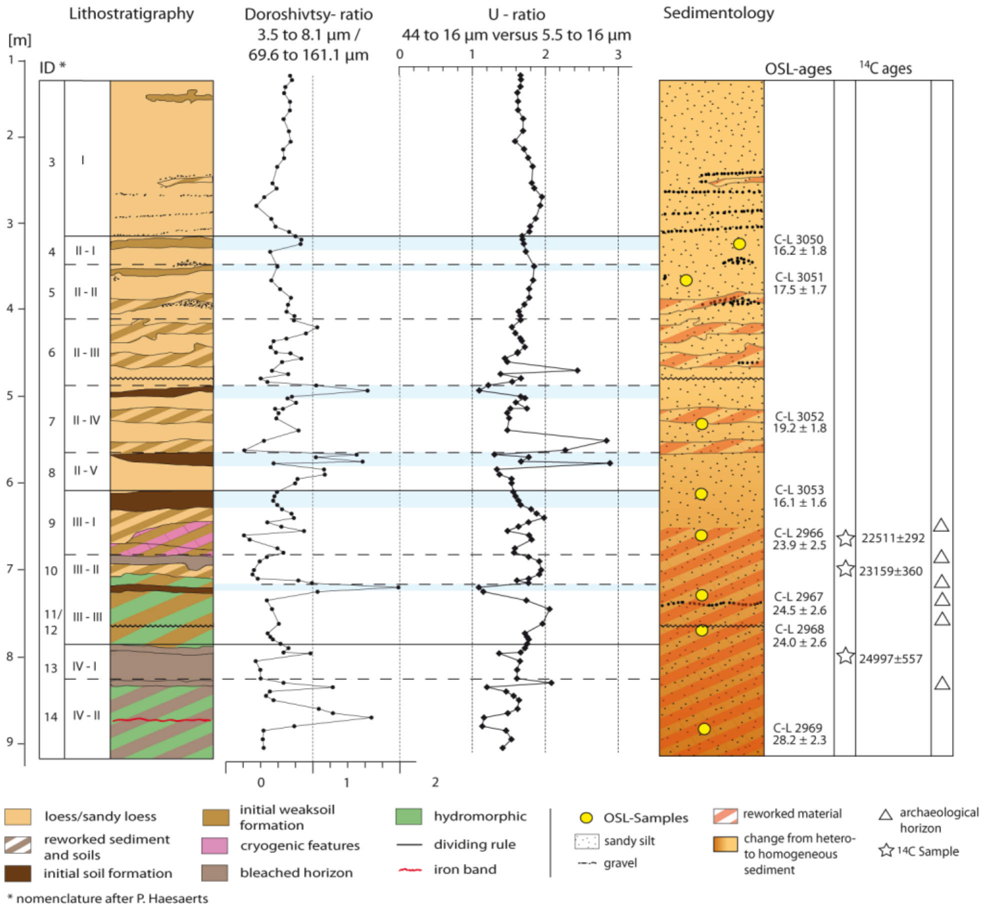

Fig. 5. Lithostratigraphy, specific GS-ratio, U-ratio, Sedimentology, OSL ages, and Radiocarbon ages of the Doroshivtsy section. OSL dating was carried out using OSL and pIRIR stimulation (Klasen et al., in review).

4. Conclusion

The two loess-palaeosol-sequences Doroshivtsy and Semlac differ especially in the geomorphological situation, the grain size composition and the temporal resolution. Therefore, both the GS composition of the individual units as well as the degree of weathering of the preserved buried sol-complexes is different.

In Semlac the natural outcrop is exposed at a plateau (Arad Plain) with likewise horizontal layers. The results from grain size measurements show that there was a very continuous accumulation of dust that took place under highly consistent circumstances of accumulation (source area and wind direction) since the MIS 10. During interglacial and interstadial periods well developed palaeosol complexes were formed. The GS-variation is mainly influenced by post-depositional processes (clay mineral relocation and -formation).

The Doroshivtsy section was developed with a high sedimentation rate in a relatively short period of time (MIS 2) on a terrace step in beneath the Canyon of the Dniester. The sedimentation was affected by both, aeolian and slope wash processes. The section was partly influenced and modified by hydromorphic and cryogenic processes. During short phases of warming some initial palaeosols were formed. In addition there are some layers of reworked soil material, which were eroded probably at the transition to dryer periods from the slopes. Essentially the Doroshivtsy section is dominated by sedimentary processes. Hence, GS and geochemical data show a high correlation.

For the calculation of a specific GS-ratio the ranges of the entire GS spectrum should be selected which react as sensitively as possible on individual processes. The advantage of the individualized GS-ratios compared to the U-ratio is their independency of firm boundaries and their higher sensitivity to individual sedimentary or post-sedimentary processes.

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References

Kels H. (2012). Stepping through the palaeolandscape: A transect from the Carpathian foothills to the lowland of the Romanian Banat. Quaternary International 279-280, 240-241.

Klasen N., Lehmkuhl F., Loibl C., Rethemeyer J. (2014). Testing feldspar against quartz luminescence dating of the sandy loess sediments from the Doroshivtsy site (Ukraine). In review.

Kulakovska L.V., Usik V.I., Haesaerts P. (2012). Doroshivtsy III - Gravettian Site in the Dniester Valley (Ukraine). Stratum plus 1, 131-150.

Marković S.B., Bokhorst M.P., Vandenberghe J., Mccoy W.D., Oches E.A., Hambach U., Gaudenyi T., Jovanovi M., Zöller L., Stevens T., Machalett B. (2008). Late Pleistocene loess-palaeosol sequences in the Vojvodina region, north Serbia. Journal of Quaternary Science 23 (1), 73-84.

Marković S.B., Hambach U., Catto N., Jovanović M., Buggle B., Machalett B., Zöller L., Glaser B., Frechen M. (2009). Middle and Late Pleistocene loess sequences at Batajnica, Vojvodina, Serbia, Quaternary International 198 (1-2), 255-266.

Vandenberghe J., Mücher H.J., Roebroeks W., Gemke D. (1985). Lithostratigraphy and palaeoenvironment of the Pleistocene deposits at Maastricht-Belvédère, Southern Limburg, the Netherlands. Mededelingen Rijks Geologische Dienst 39 (1), 7-18.