SAMPLING, SAMPLE PREPARATION, AND ANALYTICS

For the present study detailed paleopedological field descriptions as well as micromorphological analyzes, characterization of the grain size distribution and geochemical analyzes were performed to derive paleoclimatic information from these loess-paleosol sequences (LPSs). As to the sampling for micromorphological investigations, one representative, undisturbed sample was taken per each pedomember horizon of the Mircea Voda section. Due to already available detailed micromorphological studies and soil descriptions (Bronger, 1976; Marković et al., 2009) no further samples were taken from the composite Batajnica and Stari Slankamen section. Samples for grain size measurements and geochemical analyses were taken from all profiles. Pedocomplexes were sampled continuously. Moreover, several samples per intercalated loess layer were taken. The average depth of the sampling intervals can be taken from the data points indicated in figure 2. Further details on sampling strategy are described in Buggle et al. (2009).

Thin sections of ≥ 2.8 × 4.8 cm² were prepared by Th. Beckmann (Schwülper-Lagesbüttel, Germany) according to the procedures given in Beckmann (1997). Micromorphological description follows the terminology of Stoops (2003). Grain size analysis was performed using a Malvern Mastersizer S analyzer. Sample pre-treatment followed the procedure described in Konert and Vandenberghe (1997). The >600 µm fraction was removed by wet sieving and prior to laser measurements samples were subjected to ultrasonic treatment for complete disaggregation. The composition of major and trace elements was analyzed via XRF and presented in Buggle et al. (2008).

Determination of soil colors was performed on soil clods in moist and dry conditions, using Munsell soil color charts.

BACKGROUND INFORMATION ON APPLIED PROXIES

In the following we give supplement information on the applied proxies reviewing the essential rationales and definitions.

In paleopedologic studies micromorphological investigations have been established as tools to identify pedogenic processes und thus to characterize and classify fossil soils (e. g. Bronger, 1976; Tsatskin et al., 1998). Micromorphological parameters have also been used to describe the intensity of soil forming processes. Especially the type of b-fabric (birefringence-fabric) is applied as a valuable proxy in several studies. Starting from unmodified loess or weak unleached paleosols having a calcitic crystalline b-fabric, usually an undifferentiated b-fabric evolves, indicating a carbonate-free groundmass with low to moderate clay content. With increasing intensity of soil formation stipple-speckled, mosaic-speckled and striated b-fabrics usually develop, reflecting higher clay content and mobility of clays due to clay dispersion and orientation in clay domains (Magaldi and Tallini, 2000; Günster and Skowronek, 2001; Stoops, 2003). Besides the b-fabric also the coarse/fine (c/f) related distribution was selected as parameter, which reflects intensity of pedogenic clay formation. The c/f related distribution describes the relative distribution of coarse and fine fabric units in the groundmass and with increasing (pedogenically formed) clay content the c/f related distribution should evolve from a coarse-fabric supported pattern (e.g. coarse monic, close porphyric) to a fine-fabric supported pattern (e.g. open porphyric) (Stoops, 2003). We ranked the different types of c/f related distribution and b-fabric according to their appearance with increasing groundmass development and assigned numerical values to the different ranks. The sum of rank values for the c/f related distribution and b-fabric-type is implemented as micromorphological proxy of soil formation intensity (MPI) (see supplementary Table DR1).

As grain size proxy for pedogenesis we apply the <5 µm size fraction, as determined by laser analysis. The <5 µm laser grain size fraction shows the best correlation (minimum sum of squared residuals) with the clay content from pipette analysis as given in earlier published results for the Stari Slankamen section (Bronger, 1976). The 5 µm cut is slightly below the classically applied 8 µm laser-equivalent to the "pipette-clay" content (Konert and Vandenberghe, 1997). It is in between the clay-cut published for the Surduk section in Serbia (<4.6 µm fraction; Antoine et al., 2009) and the grain size proxy for pedogenic clay published for other loess-paleosol sites in Serbia and Ukraine (<5.5 µm). In general, this fraction is made of pedogenically formed clay particles as well as eolian detrital clay particles. As the present manuscript focuses on the comparison of peak interglacial proxy values in fossil soils, it is reasonable to assume that 1) the < 5µm laser grain size fraction is predominantly formed from clay of pedogenic origin and 2) background values of detrital clay are of low variability comparing peak interglacial conditions, as during these periods eolian input of detrital clay in the region is mostly derived from far distant dust sources (Varga et al., 2013). Hence, when discussing differences in peak values of the <5 µm fraction in interglacial paleosols of the studied loess sites, they can be accounted as suitable proxy for different intensities of pedogenic clay formation.

As chemical proxy of silicate weathering in loess archives, Buggle et al. (2010) implemented the molar ratio of Al_2O_3/ (Al_2O_3 + Na_2O) × 100 as Chemical Proxy of Alteration (CPA). In contrast to commonly applied weathering indices such as the Rb/Sr ratio or the Chemical Index of Alteration (CIA, see Buggle et al., 2010), it does not involve uncertainties due to dynamics of secondary carbonates.

LOCATION NAMES AND REFERENCES FOR OTHER IMPORTANT LOESS PALEOSOL PROFILES SHOWN IN FIGURE 1

1) Paks (Hungary); see Frechen et al. (1997) and Bronger (2003);

2) Loess sites on the Titel loess Plateau (Serbia); see Marković et al. (2012);

3) The Stari Slankamen / Batajnica sequence and other sites on the Srem loess plateau (Serbia); see Marković et al. (2009), Marković et al. (2011) and Marković et al. (2012);

4) Stalać (Serbia); see Kostić and Protić (2000);

5) Lubenovo (Bulgaria); see Jordanova et al. (2007) and Jordanova et al. (2008);

6) Viatovo (Bulgaria); see Jordanova et al. (2007) and Jordanova et al. (2008);

7) Mostistea (Romania); see Panaiotu et al. (2001) and Balescu et al. (2010);

8) Koriten (Bulgaria); see Jordanova and Petersen (1999), Jordanova et al. (2007) and Jordanova et al. (2011);

9) Durankulak (Bulgaria); see Jordanova et al. (2011) and references therein;

10) Mircea Voda and other loess sites on the Dobrodgea plateau of Romania; see Buggle et al. (2009); Balescu et al. (2010), and Fitzsimmons et al. (2012) and references therein;

11) Novaya Etulia (Moldova); see Tsatskin et al. (2001);

12) Primorskoje (Ukraine); see Nawrocki et al. (1999);

13) Loess sites Varnitsa, Khadzhimus, Kolkotova Balka and Tiraspol (Moldova); see Tsatskin et al. (2001) and Dodonov et al. (2006.);

14) Roxolany (Ukraine); see Tsatskin et al. (1998) and Tsatskin et al. (2001);

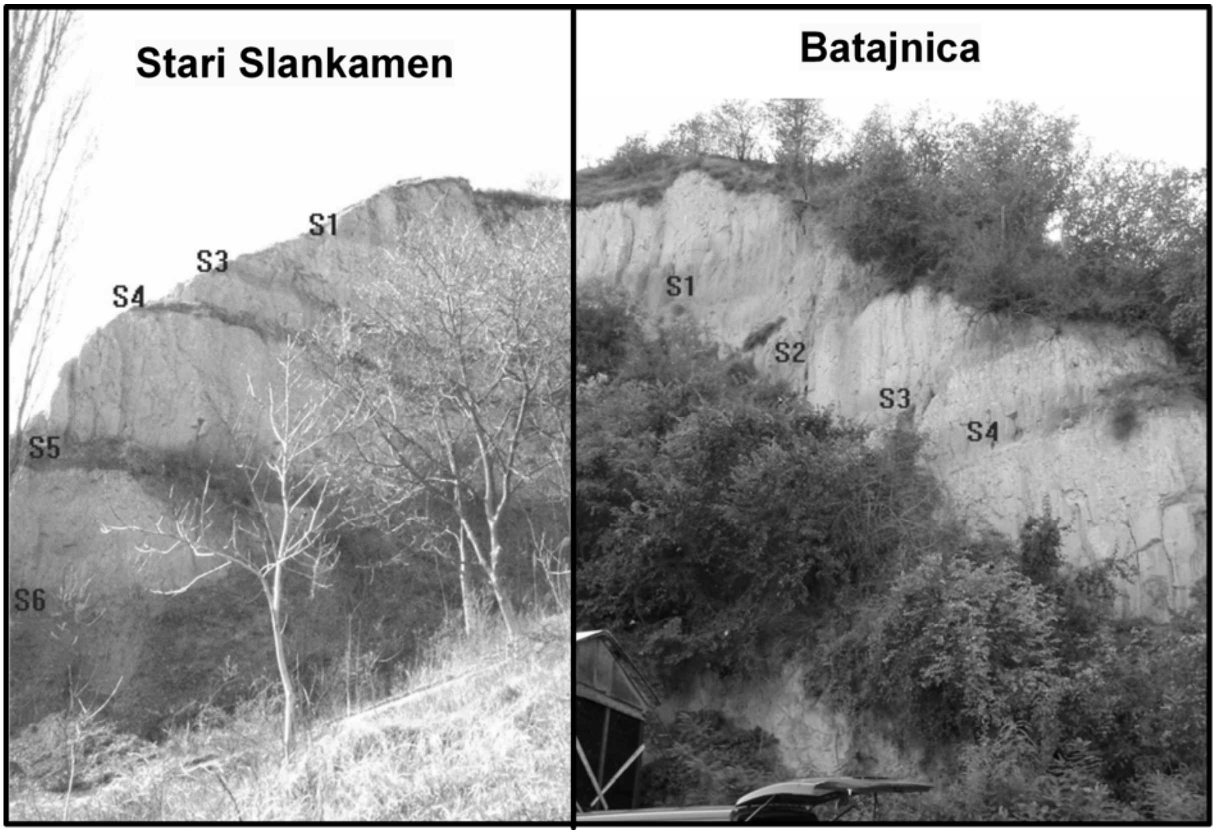

Figure DR1. Picture of the Stari Slankamen and Batajnica site (middle Danube Basin, Serbia, 44°55`29``N, 20°19`11``E / 45°7`58``N, 20°18`44``E). Both sites build the composite Batajnica / Stari Slankamen sequence. Thickness of loess paleosol successions at both sites is between 30 to 40 m. Pedostratigraphic units are denoted with S according to the S-L nomenclature for Chinese loess-paleosol sequences.

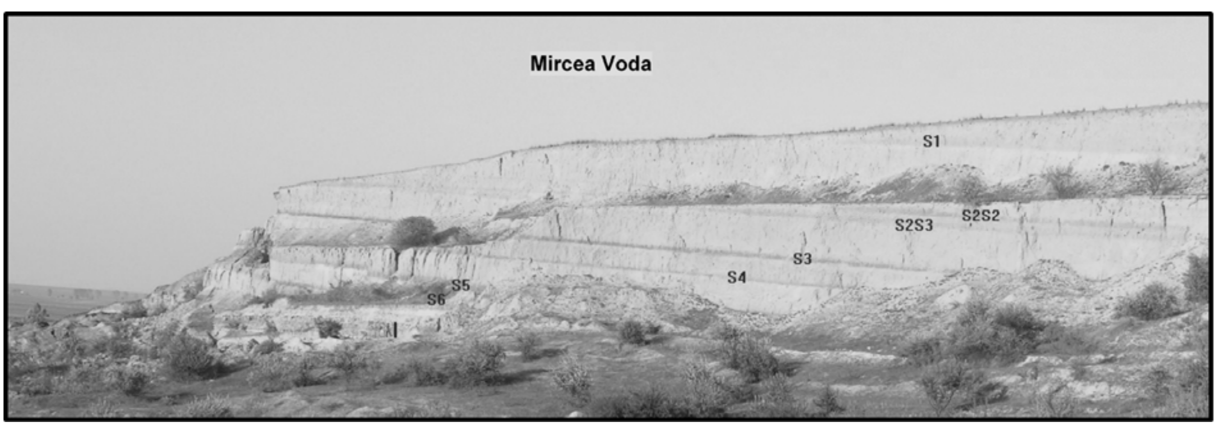

Figure DR2. Picture of the Mircea Voda site (lower Danube Basin, Romania, 44°19`15``N, 28°11`21``E). The vertical black line indicates the size of a man [~1.8 m] at the base of the profile. The thickness of the loess paleosol succession is about 26 m. Pedostratigraphic units are denoted with S according to the S-L nomenclature for Chinese loess-paleosol sequences.

Table DR1. Groundmass characteristics of soil thin sections and their ranking following increasing groundmass development intensity with soil formation (carbonate leaching, clay formation, clay translocation). The micromorphological proxy of soil formation (MPI) is obtained from the sum of rank values of c/f related distribution pattern and b-fabric. Intermediate rank values are assigned to transitional groundmass types.

Rank value	c/f related distribution pattern	b-fabric
0	Close porphyric	crystallitic
5	Single spaced porphyric	undifferentiated
10	Double spaced porphyric	speckled
15	open porphyric	striated

Table DR2. Summary of paleopedologic characteristics of the pedocomplexes at the Mircea Voda site and derived soil typological interpretation. The description of micromorphological features follows the terminology proposed by Stoops (2003). The abundance of humous and stains, clay cutans, detritic and secondary carbonates in thin sections is described semiquantitatively as follows: absent (No), few (I), frequent (II), very frequent (III). Furthermore, the lowest calcium carbonate values and highest values of clay content are given for each fossil soil horizon. High resolution records for calcium carbonate are given in Buggle et al. (2010). Paleopedologic characteristics and description of the Batajnica/Stari Slankamen site have already been published (Bronger, 1976; Marković et al., 2009) and high resolution grain size and carbonate records of the Serbian site are shown in S1 and described in Buggle et al. (2010).

Stratigraphic unit	Field observations		Micromorphological observations							Analytical data			Soil horizon	Soil typological interpretation
	Thickness [dm]	Munsel color wet// dry	Groundmass				Microstructure	Clay cutans	Secondary carbonates	Min. $CaCO_3$ [%]	Max. clay content [%]	Max. TOC Content [%]		
			Birefringence fabric	C/f related distribution	Humous matrix & stains	Detritic carbonates								
S0	9	10YR2/2 // 10 YR5/2	n.d	n.d	n.d	n.d	n.d	n.d	n.d	10	26.9	1.7	Ah	Chernozem
L1S1	5	10YR4/4 – 10YR5/4 // 10YR7/3	Crystallitic b-fabric	Close fine enaulic	III	III	Apedal channel to vughy microstructure	No	II	17,1	28.7	0.18	fAh	weakly developed fossil steppe soil
S1	15	10YR4/4 – 10YR5/4 // 10YR 7/3 - 10YR6/3	Crystallitic b-fabric	Close to single-spaced porphyric	III	III	Weakly separated subangular blocky microstructure; intrapedal channel to spongy microstructure	No	I	11.7	27.4	0.35	fAh	Fossil steppe soil
S2S1	11	10YR6/4// 10YR8/3	Crystallitic b-fabric	Close to single-spaced porphyric	III	III	Weakly separated subangular to angular blocky microstructure; intrapedal channel to spongy microstructure	No	I	9.4	27.5	0.19	fAh	Fossil steppe soil
S2S2	5	10YR3/4 - 10YR4/3 // 10YR5/3 - 10YR7/3	Undifferentiated b-fabric	Close to single-spaced porphyric	III	II	Channel microstructure superimposed on vughy microstructure	No	I	12.9	34.3	0.31	fAh	Fossil steppe soil
S2S3	5	10YR3/3 – 10YR 4/4 // 10YR 6/3	Undifferentiated b-fabric	Close to single-spaced porphyric	III	II	Channel microstructure superimposed on vughy microstructure	No	II	6.7	33.1	0.34	fAh	Fossil steppe soil
S3	10	10YR3/4 - 10YR4/3 // 10YR5/4	Stipple speckled b-fabric	Closed to double-spaced porphyric	III	I	Spongy microstructure	No	No	3.9	37.0	0.38	fABh	Fossil forest steppe soil
S4	9	10YR3/4 – 10YR4/4 // 10YR5/4 – 10YR6/4	Stipple speckled b-fabric	Single-spaced to open porphyric	II	No	Channel to spongy microstructure	No	II	4.4	38.4	0.26	fABh	Fossil forest steppe soil
S5	14	7.5YR4/6 // 10YR6/4	Stipple speckled b-fabric	double-spaced to open porphyric	II	II	Moderately separated angular-subangular microstructure; intrapedal channel to vughy microstructure	No	II	14	41	0.29	fBw	Fossil Cambisol
S6S1	3	7.5YR5/6 // 7.5YR6/6	Stipple speckled –striated b-fabric	Single-spaced to open porphyric	II	I	Weakly separated angular-subangular microstructure; intrapedal channel to vughy microstructure	No	No	6.0	44.4	0.14	fBw	Fossil Cambisol
S6S2	8	7.5YR4/6 // 7.5YR6/4	Stipple speckled –striated b-fabric	Double-spaced to open porphyric	II	I	Moderately to weakly separated angular microstructure with intrapedal channel tu vughy microstructure	No	II	16.0	52.6	0.18	fBw	Fossil Cambisol

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