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The Neolithic in the Middle Morava Valley

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In memoriam Radovan Petrović

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Geoarchaeological evaluation of the soil profiles and collapsed Neolithic structures in Trenches XIX, XXII and XXIII at Drenovac, Serbia

Abstract:

Evaluative geoarchaeological investigations using thin section micromorphology, physical, geochemical and infrared spectroscopy analyses of the Neolithic structures in Trenches XIX, XXII and XXIII at Drenovac have revealed that the site was built on disturbed clay-enriched brown forest soils. The collapsed structures were highly burnt and appear to have been kept very clean and free from the build-up of settlement-derived rubbish material, both inside and outside the buildings. These promising results suggest that further systematic geoarchaeological investigations of the floor and ground surfaces inside and outside the structures will provide very valuable new information on the use of space and activity areas in this Neolithic settlement.

Keywords: Geoarchaeology, micromorphology, phosphates, rubification, debris of living, turf, luvisol

Introduction

The Neolithic settlement site of Slatina – Turska česma, Drenovac, is located on the eastern flank of the middle Morava valley of central Serbia, on both sides of the small Drenovački stream and valley. It is believed to contain archaeological deposits of up to 6.5 m thick, which reflect its occupation during the Early Neolithic (6100–5900 BC) Starčevo culture and the Late Neolithic (5300–4500 BC) indicative of the Vinča culture, with an apparently lengthy hiatus in between[1]. A recent geophysical survey[2] suggests that the site may have been as large as 40 hectares by the time of the latest Vinča phase, with possibly as many as 700 structures present. From the current excavations, which began in 2014, it is clear that the architectural layout of the site is largely intact, with some substantial collapse of buildings *in situ* through some kind of massive conflagration. This implies that there will be excellent preservation of the artefactual evidence and activity areas inside and outside the structures. This kind of preservation context is rarely present in most plough damaged settlement sites of any age. Thus, although this Neolithic settlement site is one of a group of such sites within present day Serbia, such as Vinča near Belgrade, it may well be the most extensive and best preserved.

In terms of on-site geoarchaeological analyses using micromorphological and geo-chemical techniques[3], the collapsed houses and the external spaces around them provide an ideal opportunity to systematically examine the use of space inside and outside structures, and identify human

1 Vetnić 1974; Perić 2004, 2009, 2016.
2 Perić et al. 2016.
3 French 2015; Macphail, Goldberg 2018.

activities as well as how the structures were built, maintained and used through time. Moreover, this new data may be combined with the architectural, artefactual, zooarchaeological and palaeobotanical records to give a much better understanding of life in this settlement than is usually possible.

Accordingly, several of the collapsed and apparently burnt Neolithic structures were sampled during the 2016 excavation season for geoarchaeological evaluation. The techniques employed include thin section micromorohological, physical (pH, electrical conductivity, loss-on-ignition, total phosphate and magnetic susceptibility) and FTIR (Fourier Transform Infra-red Spectroscopy) analyses (Fig. 1; Tab. 1). A sub-set of samples were processed to act as an initial evaluation of the geoarchaeological potential for further analyses of the Neolithic structures on site. This study concentrated on Trench XIX, both inside and outside the structure, but also on deposits and features in Trenches XXI/XXII, including a combination of a soil profile, ditch features and cultural layers in Trench XXIII.

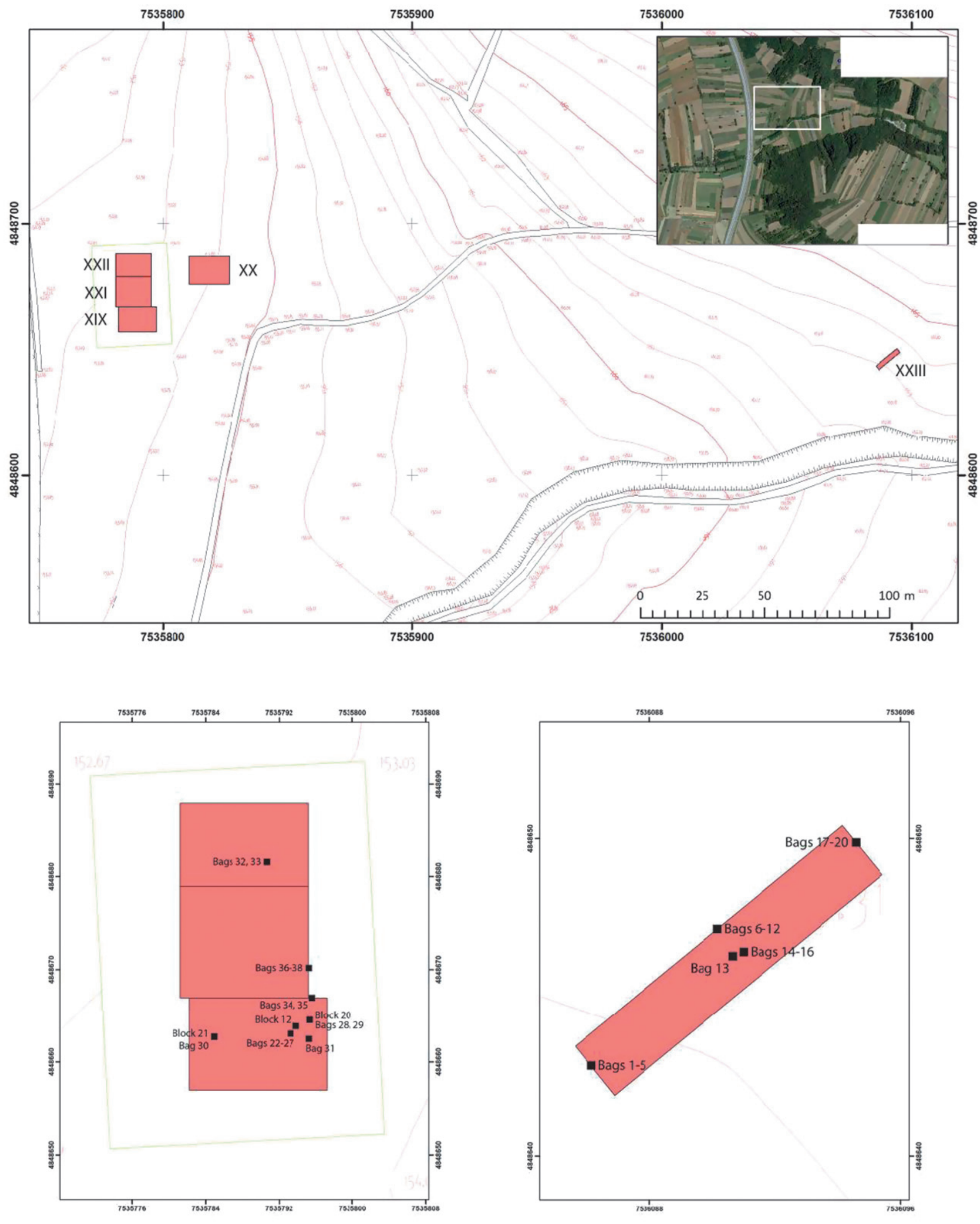

Figure 1. Sample location plan

Sample number	Context & field description	Micro-morphology	pH, EC, LOI, PO4, MS & ICP	FTIR
Block 12	Trench XIX: surface of destruction level beneath pottery vessel in middle of eastern room	✓		
Block 20 & Bag 29	Trench XIX: interior floor sequence from eastern room	✓	✓	✓
Block 21 & Bag 30	Trench XIX: post-hole fill in centre of western room	✓	✓	✓
Bag 24	Trench XIX: interior red floor		✓	✓
Bag 25	Trench 19: interior slightly burnt floor on southern side of eastern room		✓	✓
Bags 22, 23, 26–28 & 31	Trench XIX: interior collapse zone of structure		✓	
Bags 34–38	Trench XIX and XXI: house exterior deposits		✓	
Bags 32 & 33	TrenchXXII: house exterior deposits		✓	
Bags 1–5	Trench XXIII: South-western CD profile		✓	
Bags 17–20	Trench XXIII: North-eastern AB profile		✓	
Bags 6–16	Trench XXIII: North-western AD profile		✓	

Table 1 – Sample numbers, context locations and methods applied for the samples analysed

METHODOLOGY

The micromorphological evaluation involved the analysis of a selection of three intact sample blocks (12, 20 & 21), located spatially across the occupation/collapse zone of the house structure revealed in Trench XIX (Fig. 1). The thin sections were prepared according to the methods outlined by Murphy (1986) and French and Rajkovača (French 2015, App. 3). They were described following the conventions of Bullock *et al.* (1985), Courty *et al*. (1989), Stoops (2003) and Stoops *et al*. (2010). The results are discussed below, with the detailed descriptions in Appendix 1.

The physical characteristics of the bulk sediment samples taken from floor and structural collapse sequences in Trench XIX and a ditch profile in Trench XXIII involved the analysis of a suite of basic physical parameters, including pH, electrical conductivity (EC), loss-on-ignition (LOI), total phosphate (P) and magnetic susceptibility (MS), carried out on a series of small bulk samples taken in conjunction with the micromorphological block samples[4] (Tabs. 2–6).

The pH measurements were determined using a 10 g to 25 ml ratio of <2 mm air-dried soil to distilled water with a Hanna HI8314 pH metre. Determining loss-on-ignition followed the protocol of the Department of Geography, University of Cambridge, to record the percentages of calcium and carbon in the soil[5]. Sub-samples were weighed and heated to 105°C for six hours to measure water content, then heated to 400°C for 6 hours to measure carbohydrate content, then to 480°C for six hours to measure total organic matter content, and finally heated to 950°C for six hours to measure CO_2 content lost from $CaCO_3$ within the sediment[6]. The calcium carbonate content could then be calculated by stoichiometry[7]. A Malvern Mastersizer was used for the particle size analysis, using the same Geography facilities at Cambridge.

4 Avery, Bascomb 1974; Clark 1996, 99ff; Holliday, Gartner 2007; Wilson et al. 2008; Weiner 2010; French 2015; Redhouse 2015.

5 Partical size analysis – Malvern Mastersizer protocol (v1.3), www.geog.cam.ac.uk/facilities/laboratories/techniques/psd.html

6 Bengtsson, Ennell 1986.

7 Boreham et al. 2011.

Three types of phosphate measurements were recorded: phosphorous (P) and total phosphate (P_2O_5 & $PO4^{3-}$). These were measured using the same sample preparation methods and Hanna colorimeter. One gram of dried <2 mm fraction sediment was added to 100 ml of distilled water, stirred and left to sit for five minutes. Then the mixture was filtered through a cone of filter paper. 10 ml of the filtered liquid was placed into a cuvette, capped and placed into the colorimeter to calibrate the machine. After zeroing the colorimeter, 10 drops of Molybdate reagent A and one sachet of reagent B (sodium metabisulfite) were added and mixed into a solution by gently shaking the cuvette. The cuvette was placed back in the colorimeter for measurement. The data was displayed in mg/l $PO4^{3-}$ and then converted to mg/l phosphorous and mg/l P_2O_5 phosphate. This process was repeated for each sample. Phosphates relate to the organic content of a sediment and can, therefore, be used to investigate a variety of archaeological questions, including food preparation areas, organic waste deposits, cleanliness, sleeping areas and areas of high foot traffic[8].

For magnetic susceptibility measurements, a Bartington MS2B metre was used, giving mass specific calculations of magnetic susceptibility for weighed, 10 cm³ sub-samples[9].

Fourier transform infra-red spectroscopy (FTIR) is a method that measures and quantifies the absorption and transmission of all infrared frequencies simultaneously, such that the composition of a sample can be positively identified[10]. FTIR enables the identification of the organic and inorganic constituents and their abundance within a soil/sediment sample. The FTIR process begins by grinding a small soil sub-sample using a mortar and pestle, and pressing it with potassium bromide at two tons to form a crystalline lens. The sample is then placed into the spectrometer and run against an empty background sample for calibration. This reading produces a graph that charts absorbance on the Y axis, and wave numbers (expressed in cm^{-1}) on the X axis. A peak along the X axis is indicative of the absorbance of a particular wavelength.

FTIR analyses were completed on four samples from Trench XIX (24, 25, 29 & 30). Two (samples 24 & 25) came from floor layers of the southern side of the eastern room with sample 24 being labelled as 'red floor layer' and sample 25 being labelled as 'slightly burnt floor.' Samples 29 and 30 corresponded directly with the micromorphology slides from blocks 20 and 21, respectively. Each sample was processed three times to ensure an accurate measurement of absorption and transmission.

RESULTS

Physical and phosphate analyses

Trench XIX, house interior

Although systematic gridded sampling was not undertaken across the whole excavated surface in Trench XIX, spot sampling was able to yield some coarse-grained information about use of space variability within the structure (Fig. 2). In fact, sample 25 yielded the most enriched phosphate values and relatively highly alkaline pH values, while also yielding the lowest electrical conductivity values of the total sample set. In the floor sediments, there were occasional spots of high phosphate, such as in sample 25 of the slightly burnt floor sediments in the eastern room and sample 27 of the red burnt floor. High phosphate values generally reflect the former presence of large amounts of organic waste, but may also suggest loci of food preparation or areas that are not regularly cleaned[11]. However, the low conductivity (EC) values indicate that the phosphates are not derived from food waste, as often these are positively correlated with midden areas. Instead,

8 Bethell, Mate 1989; Holliday, Gartner 2007; Weiner 2010, 223ff; Milek, Roberts 2013; Fleisher, Sulas 2015.
9 *Geoarchaeology: Using earth sciences to understand the archaeological record* 2007; Redhouse 2015.
10 Weiner 2010, 275ff; Thermo Scientific 2013.
11 Holliday, Gartner 2007; Wilson et al. 2008; Weiner 2010, 223ff; Milek, Roberts 2013; Fleisher, Sulas 2015.

Figure 2. Sample locations within the structure in Trench XIX

Sample number	Context	pH	EC (µS)	MS (SI)	P (mg/l)	PO_4^{3-} (mg/l)	P_2O_5 (mg/l)
21	Eastern Room Floor Fill	7.45	**648**	N/A	0.5	1.4	1.1
22	Eastern Room Southern Side – Dark Floor Fill	7.87	522.6	0.06480	0.5	1.6	1.2
23	Eastern Room Southern Side Floor Fill	8.03	471.4	0.05980	0.5	1.4	1
24	Eastern Room Southern Side – Red Floor Layer	7.7	516.9	**0.09530**	0.5	1.4	1.1
25	Eastern Room Southern Side – ? slightly burnt floor	8.23	**286.3**	0.05310	**1.2**	**3.6**	**2.7**
26	Red burnt soil	7.94	365.8	**0.11800**	0.5	1.4	1.1
27	Red burnt soil mixed with light yellow soil	7.81	381.7	0.06550	0.9	**2.7**	2
28	Orange burnt (?) soil – floor?	7.34	978.1	0.03980	0.3	1	0.8
29	Light yellow soil – floor level and beneath	7.26	**2,170.1**	0.04100	0.6	1.8	1.4
30	Light yellow soil mixed with orange soil	7.89	635.6	0.06210	0.5	1.5	1.1
31	Light yellow soil	8	624.4	0.02280	0.1	0.4	0.3

*Table 2 – pH, EC, magnetic susceptibility and phosphate results from the interior of house in Trench XIX (with enhanced values marked in **bold** type)*

enriched phosphate values, but low conductivity and moderate magnetic susceptibility values, may suggest that the eastern room was kept very clean, perhaps as a sleeping location.

Unfortunately, other functional zones of the house are less clear in the available results. Broadly, the low phosphate and electrical conductivity values throughout indicate very regular cleaning of the floors and the sweeping out of hearth material. The only other aberrant areas within this dataset are the low phosphate and high conductivity values in samples 28 and 29 from the eastern room of the house. This could relate to a higher concentration of ash material in these areas and/or the absence of food preparation activity in this part of the house.

Sample number	Context	pH	EC (μS)	MS (SI)	P (mg/l)	PO_4^{3-} (mg/l)	P_2O_5 (mg/l)
34	1.175–1.36 m BD	6.86	164.25	0.01380	0.2	0.7	0.5
35	1.25–1.40 m BD	6.92	**306**	**0.02190**	0.2	0.8	0.6
36	20–25 cm below surface	6.25	102.375	0.00430	0.2	0.5	0.4
37	50–55 cm below surface	6.05	60.75	0.00363	0.2	0.7	0.5
38	105–110 cm below surface	6.84	94.5	0.01340	0.1	0.4	0.3

Table 3 – pH, EC, magnetic susceptibility and phosphate results from Trench XIX, house exterior (with enhanced values marked in **bold** *type)*

Trench XIX house exterior

The exterior of the house structure in samples 34–38 in Trench XIX (samples 34 & 35) and XXI (samples 36–38) exhibits relatively low phosphates values (even lower than the interior of the house) (Tab. 3). This suggests that waste materials were removed from the vicinity of the house and deposited elsewhere in/around the site (yet to be identified). This implies that the areas between the houses were also relatively clean and, potentially, regularly cleaned. In sample 35, there is an aberrantly high conductivity value which is unexplainable. Along the profile wall of the fill sediments covering the house, there appears to be a concentration of calcium carbonate material. Though this cannot be identified without the aid of multi-element analysis, it can be hypothesised that this horizon above the houses relates to more recent or contemporary land use at the site.

Trench XXII profile

The samples (32 & 33) from Trench XXII exhibit considerably lower conductivity values than within and around the houses in Trenches XIX and XXI, while the phosphate values are slightly enhanced (Tab. 4). The magnetic susceptibility values are considerably lower than those from within the houses, yet fairly consistent with the off-site values, especially from the upper layers of Trench XXIII, suggesting little anthropogenic influence on these values.

Trench XXIII cultural layers and soil profiles

The Trench XXIII samples 1–5 and 17–20 provide a useful baseline for the edge-of-site geochemical signature of the modern topsoil, although there is clearly a more alkaline pH signature in the lower levels of the South-western Profile and throughout the North-eastern Profile (Fig. 3; Tab. 5). The samples through the ditch fill show very similar pH, conductivity, magnetic susceptibility and phosphate values regardless of depth (Tab. 5). The relatively low to slightly enhanced phosphate values indicate a low anthropogenic and/or organic waste input to this ditch sequence. The cause of the high alkaline values in these areas is unknown, though it may relate to a source of calcareous groundwater and proximity to the loessic substrate.

Trench XXIII ditch feature and soil profile

Samples 6–16 from the north-western profile of Trench XXIII encompass a modern plough-soil and subsoil development in the upper *c.* 1.3 m, above the infilling of a stone-lined ditch in the lower portion of the profile (1.3–1.41 m) and the upper part of the geological substrate beneath (1.42+cm). The upper levels serve, in conjunction with samples from the north-eastern and south-western profiles, as a useful baseline for the site's topsoil physical and geochemical signatures. It appears that the fill sediments of the ditch begin to occur at about 1.3 m below the modern ground surface, coincident with where the pH becomes strongly alkaline. The conductivity and magnetic susceptibility values are lower than for the house samples, while the phosphate values are lower than the topsoil, but similar to some of the house interior samples in Trench XIX (Tab. 6).

Sample number	Context	pH	EC (µS)	MS (SI)	P (mg/l)	PO_4^{3-} (mg/l)	P_2O_5 (mg/l)
32	Trench XXII	6.97	59.625	0.01960	0.6	2	1.5
33	Trench XXII	6.92	153	0.01690	0.6	2	1.5

Table 4 – pH, EC, magnetic susceptibility and phosphate results from Trench XXII bulk samples

Sample number	Context	pH	EC (µS)	MS (SI)	P (mg/l)	PO_4^{3-} (mg/l)	P_2O_5 (mg/l)
1	South-western Profile 05–10 cm	6.15	100.125	0.01570	0.5	1.6	1.2
2	South-western Profile 30–35 cm	6.75	74.976	0.01790	0.5	1.5	1.1
3	South-western Profile 50–55 cm	6.97	92	0.01420	0.9	2.7	2
4	South-western Profile 67–72 cm	8.6	102.35	0.00735	0.7	2	1.5
5	South-western Profile 94–100 cm	9.03	79.52	0.00685	0.5	1.7	1.2
17	North-eastern Profile 05–10 cm	8.31	**156.375**	0.00991	0.1	0.3	0.2
18	North-eastern Profile 33–38 cm	8.43	121.5	0.00524	0.3	0.9	0.7
19	North-eastern Profile 43–48 cm	8.43	114.75	0.00420	0.1	0.3	0.3
20	North-eastern Profile 53–57 cm	8.44	113.625	0.00481	0.3	0.9	0.6

*Table 5 – pH, EC, magnetic susceptibility and phosphate results from North-eastern and South-western topsoil profiles in Trench XXIII (with enhanced values marked in **bold** type)*

Sample number	Context	Field description	pH	EC (µS)	MS (SI)	P (mg/l)	PO_4^{3-} (mg/l)	P_2O_5 (mg/l)
6	5–10 cm	Dark brown soil humus	7.22	**117.008**	**0.01030**	**0.8**	**2.4**	**1.8**
7	25–30 cm	Dark brown soil with chunks of daub (ditch fill)	7.32	54.528	**0.01070**	**0.4**	**1.1**	**0.8**
8	50–55 cm	Dark brown soil with chunks of daub	7.08	61.344	**0.00941**	**0.5**	**1.6**	**1.2**
9	85–90 cm	Dark brown soil with chunks of daub	7.13	65.888	**0.00878**	**0.4**	**1.2**	**0.9**
10	108–110 cm	Dark brown soil with chunks of daub	7.36	38.624	**0.00953**	0.3	0.9	0.6
11	120–125 cm	Dark brown soil with chunks of daub	7.49	52.875	**0.00678**	0.3	0.9	0.7
12	125–130 cm	Dark brown soil with chunks of daub	7.48	42.75	**0.00522**	0.2	0.7	0.5
13	Basal ditch fill 130–135 cm	Dark brown soil between the stones (the bottom of the ditch)	8.48	**79.875**	0.00481	0.3	0.8	0.6
14	Basal ditch fill 137–141 cm	Dark brown soil bellow the stones	8.74	**84.375**	0.00410	0.2	0.5	0.4
15	Substrate 142–147 cm	The upper level of yellow clay	8.81	**105.648**	0.00294	0.2	0.7	0.5
16	Substrate 148–153 cm	Yellow clay	8.38	**94.5**	0.00240	0.2	0.5	0.4

*Table 6 – pH, EC, magnetic susceptibility and phosphate results from the modern soil profile and ditch fill sequence in Trench XXIII (with enhanced values marked in **bold** type)*

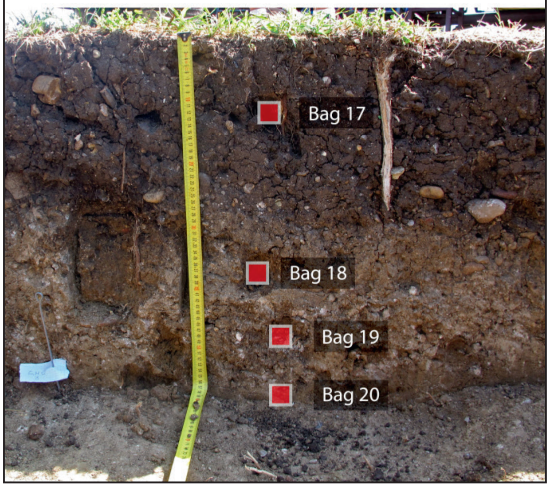

Figure 3.
Sections of the south-western CD and north-eastern AB profiles in Trench XXIII

Figure 4.
North-western AD profile in Trench XXIII

Interpretative discussion

With the relatively small number of samples processed and analysed as part of this initial geoarchaeological evaluation, patterning is difficult to assess, especially when so much of the floor surface area remains un-sampled. However, isolated spot sampling has yielded some tentative interpretations about the use of space within the house structure in Trench XIX.

The main result of this preliminary study is the relative cleanliness of the interior of the house and external spaces around it. The generally low phosphate and electrical conductivity values suggest very regular cleaning of any floors or surfaces present and a general absence of hearth material and 'waste of living'[12]. This suggests regular cleaning and waste removal from the immediate living spaces. This contrasts with many Neolithic sites elsewhere in Europe and the UK, where waste materials from cooking, food preparation/consumption and bedding refuse were sig-

12 *cf*. Fleisher, Sulas 2015; Milek 2012.

nificantly present in and around the lived-in site (e.g. at Crossiecrown, Orkney[13]). More work should be done to identify where refuse material at Drenovac was transported to and deposited, and whether it was managed in midden heaps or used in agriculture for fertiliser.

The results also provide information on the nature and origin of the ditch fill sediments in Trench XXIII. These sediments exhibit a considerably higher, strongly alkaline pH value than the rest of the samples from the site. From the archaeology, the morphology of the stone-lined ditch appears to be some kind of drainage feature. However, the low conductivity and phosphate values from these deposits suggest that the infilling soil material, presumably mainly derived from the upper/outer edges of the ditch itself, was relatively free from anthropogenic waste (i.e. neither a sewage drain nor a rubbish dump). The absence of finely laminar sediments in the base of the ditch could imply that the ditch was kept clean and/or was regularly flushed through with fast running water, and that the natural soil filling process is essentially a result of post-abandonment weathering of the ditch and fallen-in, adjacent soil material. Further work is required to better understand the function of this ditch feature.

It appears that the majority of samples overwhelmingly relate to the content and composition of the clay floor in the structure excavated in Trench XIX rather than the overlying occupation deposits and building collapse material. It would be beneficial to employ a systematic gridded sampling technique on this and future houses excavated. This approach needs to sample both the material accumulating on the floor (i.e. potential occupation debris from the last period of use and abandonment) and the floor itself. This would further assist in understanding the composition of the floors and human activity within the houses. In addition, the next stages of integrating these preliminary geoarchaeological results with the zooarchaeological, archaeobotanical and ceramic analyses should provide exciting and valuable results.

Thin section micromorphology

Sample block 12 is characterised by a heterogeneous mixture of two finely aggregated soil fabrics: 1) a reddish brown to crimson coloured, humified organic matter mixed with common fine to very fine quartz sand, and 2) a golden brown silty clay loam (Fig. 5a). Fabric 1 appears to be highly humified turf, and fabric 2 is a silty clay enriched soil fabric. The aggregated turf component is all uniformly and strongly rubified, indicating that it has been burnt at a prolonged high temperature[14] (Fig. 5b). The very abundant, often reticulate striated, pure to dusty clay coatings are present throughout the groundmass, but the dusty clay mainly coats the walls of the voids (Fig. 5c). This fabric is indicative of a silty clay dominated soil that was initially stable and well structured for a considerable period prior to becoming opened up and undergoing much physical disturbance[15]. This ‘destruction level’ soil material appears to have been deposited prior to a prolonged, high temperature burning event that led to the oxidation of iron oxides/hydroxides, probably predominantly haematite (Fe_2O_3)[16], resulting in the strong reddening of the whole buried soil/occupation/collapse deposit[17].

Sample block 20 exhibits a similar mix of strongly reddened and sesquioxide impregnated humified organic matter in large aggregates with aggregates of silty clay intermixed with a silty clay fabric. There are few to common fragments of silt and silty clay crusts (Fig. 5d), indicative of rapid drying of wet, compact surfaces, and common linings/coatings of the void space with micro-laminated dusty clays (Fig. 5d)[18]. In addition, there are a few inclusions of settlement related, very

13 Jones et al. 2010.
14 *cf*. Canti, Linford 2000.
15 Slager, van de Wetering 1977; Macphail et al. 1987; Macphail 1992; Kuhn et al. 2010.
16 Duchaufour 1982; Lelong, Souchier 1982.
17 *cf*. Canti, Linford 2000.
18 Kuhn et al. 2010.

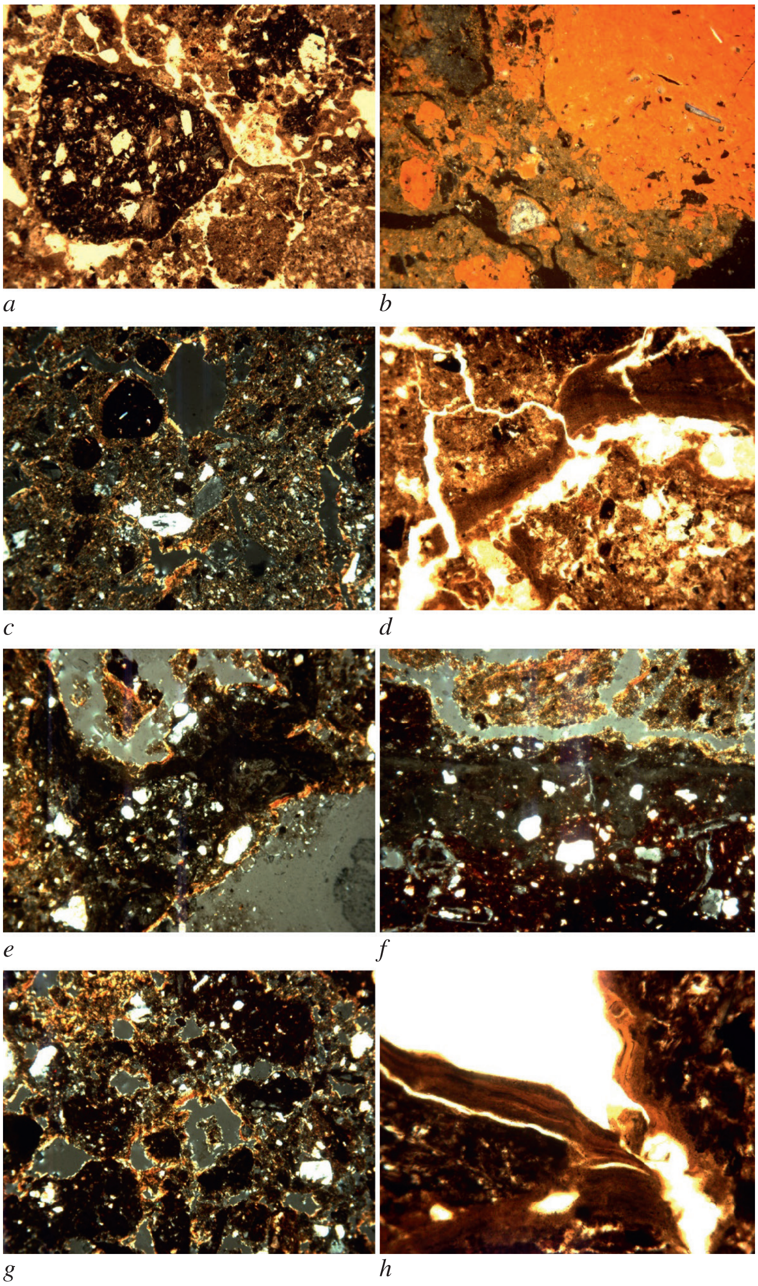

Figure 5. Photomicrographs a–h (C. French)

5a. Photomicrograph of aggregated humic matter in silty clay loam fabric, Block 12 (frame width = 4.5 mm; plane polarized light) (C. French)

5b. Photomicrograph of fire reddened aggregate of humic matter, Block 12 (frame width = 4.5 mm; oblique incident light) (C. French)

5c. Photomicrograph of reticulate pure to dusty clays in the groundmass and voids, Block 12 (frame width = 4.5 mm; cross polarized light) (C. French)

5d. Photomicrograph of dusty clay coatings and crust fragments, Block 21 (frame width = 4.5 mm; plane polarized light) (C. French)

5e. Photomicrograph of zone of mixed ash and fine charcoal, Block 20 (frame width = 4.5 mm; cross polarized light) (C. French)

5f. Photomicrograph of a thin calcitic ash 'crust' on a fragment of amorphous sesquioxide replaced and burnt turf fabric, Block 20 (frame width = 4.5 mm; cross polarized light) (C. French)

5g. Photomicrograph of aggregated burnt humic matter with between aggregate silty clay coatings, Block 21 (frame width = 4.5 mm; cross polarized light) (C. French)

5h. Photomicrograph of micro-laminated dusty clays in a channel, Block 21 (frame width = 2.25 mm; plane polarized light) (C. French) fine midden debris present such as charcoal, ash (Fig. 5e), plant tissue and burnt bone fragments[19]. In one clear instance (Fig. 5f), there is a thin calcitic ash 'crust' on a fragment of amorphous sesquioxide replaced and burnt turf fabric, which may well be a hearth fragment.

Sample block 21 is essentially similar to sample 20, but the fabrics are present in discrete, larger clods, composed of many smaller aggregates of burnt humic matter (Fig. 5g), which predominate. The channels and aggregates are commonly lined/coated with oriented and micro-laminar dusty to 'dirty' clay (Fig. 5h). However, there is almost no fine anthropogenic organic debris component in this sample.

Interpretative discussion

The former land surface present in sample 20 is mainly composed of a burnt turf intermixed in various sized aggregates with a calcitic, very fine sandy/silty clay loam soil matrix. Very similar turf and clay-enriched soil fabrics were also identified in the destruction level surface in sample 12. The extensive degree of mixing in these soil fabrics is suggestive of severe bioturbation by the soil fauna in the past. The micritic calcium carbonate content is probably derived from the alkaline groundwater/soil conditions reflected in the pH values (Tabs. 2–6). Near surface drying and the surface heating effects associated with the probable burning down of the structure(s) have contributed to the secondary formation of this silt-sized or micritic calcium carbonate material[20] and the very strong rubification of the humic fabric[21]. The latter effect is further corroborated by the FTIR analysis (below).

The clay-enriched or agric aggregates with reticulate pure to dusty clays suggest that these fabrics were derived from a clay-enriched or argillic Bt horizon of a soil from the vicinity. This implies that both the underlying and surrounding contemporary soil had been a stable, well vegetated and developed, clay-enriched argillic brown earth (or luvisol)[22]. The existing soil literature for the Morava valley considers that the most common and widespread brown forest soils have developed from the browning of chernozems, probably formed during the mid-7th to mid-5th millennia BC, corresponding with the earliest agricultural colonisation of the Balkans[23]. The soil evidence at Drenovac certainly suggests that this earlier Neolithic brown forest soil had became disturbed prior to burial, subject to first the illuviation of dusty clays in the voids, and then the incorporation of very fine micro-charcoal in the dusty clay coatings. There is also the mixing of irregular aggregates of humic A horizon fabric material in with the B horizon material. In combination, these features suggest greater and greater degrees of disturbance and openness of the surface of the pre-site soil, obviously implying deforestation and agricultural use, leading to surface crusting and micro-laminar successive dusty/dirty silty clay linings of the voids. Associated human activities led to the physical mixing of the soil horizon materials and the incorporation of fine anthropogenic debris into the soil, such as fine charcoal, burnt clay hearth fragments, burnt turf fragments, and plant and wood ash[24].

Whether the turf material is *in situ* or perhaps fallen from a roof above is harder to ascertain on the basis of the micromorphological analysis alone. Certainly, the burnt turf aggregate with an ash surface coating present in sample block 20 (Fig. 5f) suggests the former situation. On the other hand, it is hard to explain how all the turf fragments are burnt to a greater or lesser degree if it was indicative of a turf surface. There is also the possibility that turf material was an insulation component in the roof, and/or was used in some kind of mud plaster on internal surfaces of

19 Macphail, Goldberg 2010.
20 *cf.* Durand et al. 2010.
21 Canti, Linford 2000; Lindbo et al. 2010.
22 Fedoroff 1968; Bridges 1978, 62; Bullock, Murphy 1979; Kuhn et al. 2010.
23 Chapman 1990; Obradović, Bajčev 2016.
24 Slager, van de Wetering 1977; Wattez, Courty 1987; Macphail 1992; Macphail, Goldberg 2010.

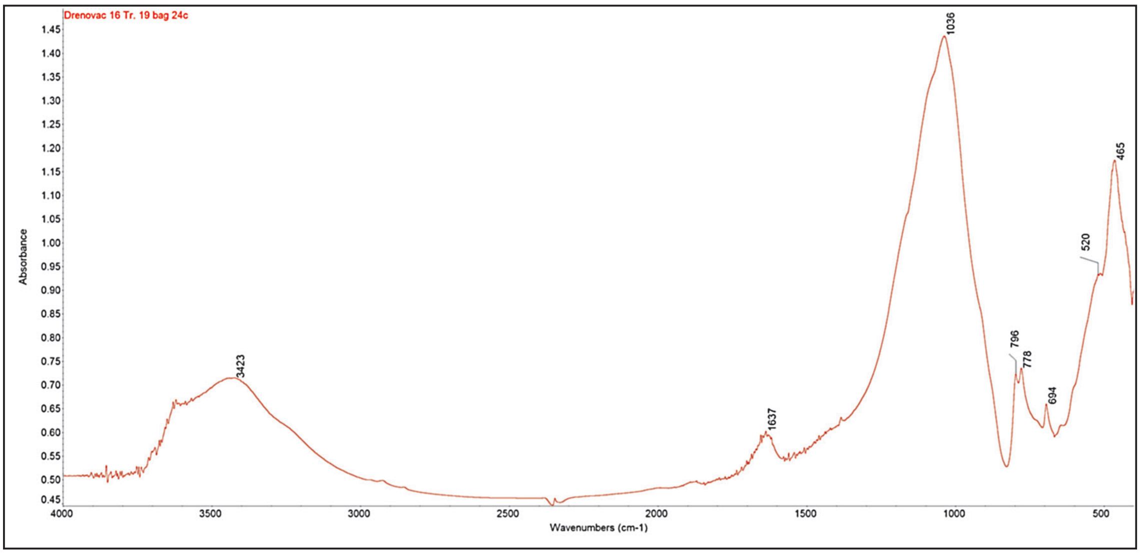

Figure 6. The shift in the silicate FTIR peak from c. 1032 to 1035 cm^{-1} and the absence of a peak at 914 cm^{-1} indicate burning in sample 24c (L. Murch after D. Friesem)

the structure, which subsequently became burnt in the house conflagration and collapsed into the interior area of the house structure present in Trench XIX.

In sample 21, the post-hole fill contained a similar mixture of burnt turf and calcitic very fine sandy/silty clay loam material, although it was more disorganised and in irregular large aggregates. The void space in this sample was particularly characterised by micro-laminated dusty clay coatings indicative of bare, disturbed soil surfaces above and within-soil illuviation[25] associated with rainsplash impact and/or a ground-/soil water movement down-profile.

Apart from the ubiquitous burnt turf present in all three sample blocks, there are only minor hints of the inclusion of other types of fine anthropogenic 'debris of living' material. This mainly comprises small amounts of very fine charcoal and some micritic ash. In combination with the basic physical/geochemical study, this suggests that the internal area of this house structure was kept very clean and free from the build-up of settlement derived fine rubbish material.

FTIR analyses

The FTIR analysis was carried out on four samples from trench XIX. Two samples (24 & 25) came from floor layers of the southern side of the eastern room with sample 24 labelled as 'red floor layer' and sample 25 labelled as 'unburnt floor.' Sample 29 came from Block 20, and sample 30, from Block 21; these last two samples correspond directly with micromorphology slides (Blocks 20 & 21). Each sample was assayed three times to ensure an accurate measurement of absorption and transmission. Essentially it appears that sample 24 from the interior area of the structure in Trench XIX is probably burnt because of the absence of the peak at 914 cm^{-1} and the shift of the main silicate peak from c. 1032 to 1036 cm^{-1} (Fig. 6). Samples 25, 29 and 30 exhibit a shoulder at 914 cm^{-1} indicating that there might be some mixing between burnt and unburnt materials.

According to Berna *et al.* (2007), when clay is altered, its major absorption peak of 1033 cm^{-1} moves towards a higher wavelength (365), and the 3620 cm^{-1} wavelength decreases in amplitude (364). When looking at further experimental work Berna *et al.* (*ibid.*, 364) conducted on burning clay at different temperatures, the 1036 cm^{-1} peak is indicative of altered clay burnt at temperatures

25 Macphail 1992; Kuhn et al. 2010.

between 400–500°C. All samples had a quartz-clay index of over 5, indicating that they were richer in clay than quartz (also seen in the micromorphological analysis above). More in depth comparative FTIR work on samples from the excavated houses is clearly essential in the future.

CONCLUSIONS

This report and the suggested interpretations are, of course, preliminary until they can be further corroborated with a wider and systematically sampled suite of physical, geochemical and micromorphological analyses of several excavated Neolithic houses/structures at Drenovac. Nonetheless, there are a number of clear interpretations and themes that have emerged from this geoarchaeological evaluation study, including:

There are strong hints that the pre-site earlier Holocene soil was probably a typical well drained, stable and well developed, clay enriched or argillic brown forest earth, associated with the development of woodland in the earlier Holocene and a calcareous groundwater system. There is suggestive evidence in the soil micromorphological record that this soil had became opened-up and disturbed at some point, but further analysis of the buried soils both beneath and around the site in the Drenovački valley are essential to take these suggestions any further.

There are also hints in the soil micromorphological record that this palaeosol incorporated some debris of living, associated with physical mixing and some truncation of the upper part of the soil profile. How much this was due to very early prehistoric use and occupation of this site, and how much was associated with the building and use of the house structures cannot be clearly ascertained at present.

There was clearly *in situ* burning of the house structure in Trench XIX leading to extensive and intensive scorching of the associated soil and the collapse of the building. Temperatures must have reached over 400–500°C consistently for perhaps as long as a 24+ hour period in order to result in such strong reddening of the whole soil matrix[26]. Small fragments of burnt clay roof tiles and burnt turf as well as unburnt turf with soil are incorporated in the soil beneath the building. This may indicate a period of weathering and incorporation after the destruction of the structure, and/or that there may have been turf insulation in the roofs of the structures.

Future work

There are a number of research targets with respect to further analysis of the structural collapse deposits observed and sampled in Trenches XIX–XXIII. These include:

- the identification and analysis of *in situ* old land surfaces, both beneath and in the vicinity of the settlement site
- determining the pre-Neolithic soil complex and its characteristic features with respect to past landscape type(s) and land-use(s)
- identifying structural elements of the house structures
- determining whether the turf was *in situ* or fallen roof/insulation material
- identifying any discrete areas of different uses, inside and outside the structures
- contributing to determining how the buildings collapsed
- and ascertaining the nature and temperatures involved of any burning events.

These questions are best answered through a combination of completing the soil micromorphological analysis of the whole assemblage of blocks taken in 2016 and further sampling of the site and its environs, complemented by further FTIR and multi-element ICP-AES analyses[27]

26 *cf*. Bellomo 1993; Canti, Linford 2000; Weiner 2010, 304.
27 Wilson et al. 2008; Weiner 2010.

to ascertain the potential different uses of space within the structures and the nature of the conflagration events involved in the collapse and/or destruction of the buildings on site.

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Резиме

Геоархеолошка истраживања профила и срушених објеката у сондама XIX, XXII и XXIII у Дреновцу, Србија

Геоархеолошка истраживања спроведена су на неолитским структурама у сондама XIX, XXII и XXIII на локалитету Дреновац, уз анализу микроморфолошких танких пресека, коришћење физичких и геохемијских анализа, као и инфрацрвене спектроскопије (FTIR). Детаљна анализа микроморфолошких танких пресека тј. микроморфолошка анализа археолошких слојева, показала је да је локалитет настао на развијеном смеђем шумском земљишту (гајњача), богатом вегетацијом и обогаћеном глином. Ово земљиште доживело је поремећај пред само подизање неолитских структура/кућа. Микроморфолошке и FTIR анализе дале су индикације да су винчанске куће гореле на температурама од преко 400–500°C, вероватно у трајању од 24 часа или више, што је резултирало јарко црвеном бојом у целокупном матриксу земљишта. Оно што је необично је да су поднице кућа биле одржаване чистим и без икаквог нагомилавања отпада насталом у току трајања насеља, а ова појава примећена је и у зонама изван кућа. У оквиру рушевинског слоја кућа идентификовани су агрегати травнатог слоја земљишта и песковите глине који су могли бити део крова и/или унутрашњих делова зида. Ови резултати указују на јединствени потенцијал за истраживање. Даља систематска геоархеолошка истраживања подница и тла унутар и изван структура пружиће изузетно вредна нова сазнања о природи употребе кућног простора, као и активности у домаћинствима у овом неолитском насељу.

Block 12
Structure: pellety to aggregated, <1mm, sub-rounded to irregular; *Porosity*: *c*. 10–20% interconnected vughy; *Mineral components*: two mixed fabrics; fabric 1: mix of 65% humified organic matter and 35% very fine-fine quartz sand, <200 µm; strongly reddened with amorphous sesquioxides and all strongly burnt (crimson red in OIL); *c*. 25–75% of total groundmass; fabric 2: *c*. 25–75% of total groundmass; 10% very fine quartz sand, 65% silt, 20–25% pure to dusty clay; golden brown (PPL/CPL); *Organic components*: in fabric 1: planar, vegetal voids common with thin dusty clay linings; in fabric 2: 5–10% fine (<100 µm) humified plant fragments, sub-rounded, with fine organic 'dust' (<50 µm) in silty clay; *Textural pedofeatures*: 20–25% pure to dusty clay as void linings and in groundmass, moderate to strong birefringence with clear extinction lines, weak to moderate reticulate striations evident; golden brown (PPL/CPL).

Block 20
Structure: pellety (<1mm) to small to large aggregated, <2.5cm, sub-rounded to irregular; *Porosity*: *c*. 10–20% interconnected vughy; *Mineral components*: two mixed fabrics in juxtaposed large aggregates; fabric 1: *c*. 50% of total groundmass; mix of fabrics 1 (*c*. 65–70%) and 2 (*c*. 30–35%) of Block 12; very dark reddish brown (CPL/PPL) or golden brown (CPL/PPL); fabric 2: silty clay with <10% very fine quartz sand, golden/orangey brown (PPL/CPL); *c*. 50% of total groundmass; with common (10%) dusty clay coatings of channels, micro-laminated and clear extinction lines; few to common (5–10%) silt crust fragments, few (2%) sub-rounded, pale greyish brown (CPL) silt aggregates (<5mm); minor fabric: *c*. 4mm wide zone of carbon-rich micritic ash; one aggregate of burnt turf fabric with thin calcitic ash crust on surface, <6mm; *Organic components*: rare (<1%) charcoal fragments, sub-rounded, <1mm; few (<2%) amorphous sesquioxide plant tissue fragments; rare (<1%) burnt bone fragments, <500 µm.

Block 21
Structure: pellety to aggregated micro-structure, <3mm, with two mixed, heterogeneous fabrics present as irregular clods, <4cm; *Porosity*: 10% vughy, irregular, <750 µm, often lined with dusty clay coatings; 10% channels, <500 µm, irregular, weakly serrated, partly accommodated, often lined with dusty clay; one large channel, <1.5cm wide and <7cm long, infilled with pellety fabric 2; *Mineral components*: fabric 1: crimson red turf (CPL/PPL); fabric 2: mix of reddened humic matter with silty clay, all aggregated/pellety, <2mm, golden/dark brown (CPL/PPL), with common, micro-laminated linings of dusty clay in voids.

Appendix 1: *The detailed soil micromorphological descriptions*

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