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SOIL MICROMORPHOLOGY IN ARCHAEOLOGY: HISTORY, OBJECTIVES, POSSIBILITIES AND PROSPECTS

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The history of applying soil micromorphology in archaeology in Russia and abroad is overviewed. The main objectives of soil micromorphological analysis of archaeological objects are specified. The possibilities offered by this method are illustrated by the example of a micromorphological study of a cultural layer of an Early Medieval settlement. The prospects of archaeological soil micromorphology development are outlined.

Key words: archaeological soil micromorphology, geoarchaeology, cultural layers.

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The soil micromorphology was first applied to archaeological objects about two decades following its establishment as a separate scientific discipline by Kubiena in 1938 (Cornwall, 1958; Dalrymple, 1958). For about three next decades, micromorphological studies in archaeological context remained very rare. In 1989, the University of Cambridge published a series of handbooks on archaeology including the first guidelines for applying soil science and, particularly, soil micromorphology in archaeology – "Soils and Micromorphology in Archaeology" (Courty et al., 1989). This textbook is still used at the present time. Its authors are the founders and leading specialists of archaeological soil micromorphology and geoarchaeology: Marie-Agnès Courty (National Centre for Scientific Research, France), Richard Macphail (Institute of Archaeology, University College London, UK) and Paul Goldberg (Hebrew University of Jerusalem, Israel; now at Boston University, USA). Already in 1989, on the basis of their broad experience of work on archaeological objects, the authors emphasized that soil micromorphology was one of the most effective and prospective methods of solving a wide range of geoarchaeological problems that could not be solved by other methods of pedology and Earth sciences.

In 1990, the Archaeological Soil Micromorphology Working Group was initiated by Richard Macphail with the encouragement of co-workers Marie-Agnès Courty and Paul Goldberg (Macphail, 2014). This working group has regularly been organising educational workshops since the early 1990s. The programme of such workshops traditionally includes both theoretical and practical sessions on studying thin sections from archaeological contexts. The workshop participants are provided with microscopes and have a chance to show their thin sections to the colleagues, exchange experience and consultmore experienced colleagues. Moreover, Prof. Macphail's Working Group regularly organizes intensive short courses in archaeological soil micromorphology for international students. Information on such courses is published on the University College London (UCL) web-site: http://www.ucl.ac.uk/archaeology/studying/continuing/courses/micromorphology. Within the last decades the Archaeological Soil Micromorphology Working Group has been closely associated with the International Union of Soil Sciences (IUSS) Commissions 1.3. – Soil morphology and micromorphology and 1.6. – Paleopedology, which regularly include sessions on soil micromorphology for archaeology in programmes of their regular meetings. It should be emphasised that geoarchaeology in general have originated and evolved in the frames of a number of Earth sciences: geology, geography, palaeogeography, pedology as well as within archaeology itself. So that until now geoarchaeology is developing along different directions on the corporate principle. Thus there is no unified theoretical base, terminology and methodology in geoarchaeology and particularly in archaeological micromorphology.

An exponential growth of soil micromorphological works in archaeology has started in the 1990s, firstly in Western Europe and later in the USA. Nevertheless, this method has not yet been integrated into routine archaeological practice worldwide. The micromorphological analysis is still being regarded as a new and advanced technique in geoarchaeology and soil archaeology. During the two last decades, in addition to soil micromorphological studies of specific archaeological objects, there have been several publications of general overviews on archaeological soil micromorphology as well as geoarchaeological handbooks on the soil micromorphological method applications (Sageidet, 2000; Courty, 2001; Macphail and Cruise, 2001; Goldberg and Macphail, 2006, 2010).

The archaeological soil micromorphology deals a wide range of natural and anthropogenic (man-made) objects, i.e., paleosols buried by natural and anthropogenic deposits, pedolithosediments (cultural layers), which reflect the environment at the time of archaeological site's construction and functioning, a material of a cultural layer itself, and artefacts made of earth materials (ceramics, raw and fired brick, rammed earth, daub, plasters etc. Marie-Agnès Courty (1992) divided soil micromorphological studies in archaeology into two groups: 1) regional-scale research with palaeoenvironmental reconstructions of the past climate, landscape, vegetation and soil cover and assessments of human impact on those components; 2) local-scale research on the history of cultural layers within a specific archaeological monument or its separate planigraphic and stratigraphic units.

The local-scale research tasks include individual diagnostics of anthropogenic and post-anthropogenic soil and diagenetic processes, particularly, degradation processes affecting preservation of artefacts and entire cultural layers; assessment of the past land use around the settlements; identification of building materials and ceramics, their petrographic composition and properties, production technologies and raw material sources; investigation of living floors within cultural layers; studies on microstratigraphy of cultural layers. Research of such kind is being extensively practiced in Western Europe (United Kingdom, Belgium, Spain and Germany), North America (the USA, Mexico and Canada), Northern and Eastern Europe (Czech Republic and Scandinavia) and also by European and local specialists in Arab countries (Syria, Egypt and Bahrain) and Iran. There are hundreds of published research papers devoted to local-scale soil micromorphological research on archaeological objects in aforementioned countries.

However, there are only very few local-scale research works in archaeological soil micromorphology in Russia, despite a growing number of interdisciplinary pedoarchaeological research projects in recent decades. The Russian soil micromorphology specialists are traditionally focused on the regional-scale research with palaeoenvironmental reconstructions and assessment of the impact of ancient people on palaeoenvironment (Golyeva et al., 1994; Sedov et al., 1999, 2010; Bronnikova et al., 2003; Geoarchaeological issues, 2012; Khokhlova et al., 2015; and many other authors). Less traditional subjects of Russian soil archaeology and geoarchaeology include natural and anthropogenic processes within cultural layers and artefacts and differentiated diagnostics of palaeoanthropogenic impacts (Kazdym and Verba, 2003; Aleksandrovsky et al., 2011; Dolgikh et al., 2012; Zazovskaya, 2013; Khokhlova and Nagler, 2015). There are only single micromorphological studies on archaeological building materials and artefacts in Russia (Bronnikova et al., 2008; 2014).

The soil micromorphology application in geoarchaeology is illustrated below by a specific example of studying the cultural layer of an Early Medieval settlement. The study site is located within the Dnieper River valley near the village of Gnezdovo, 14 km from the town of Smolensk. The Gnezdovo archaeological complex (from the 9th to the early 11th centuries AD) is one of the largest archaeological sites of the early period of Russian History. The settlement had an area of about 30 ha with well-developed infrastructure and sophisticated and diverse manufacturing industry. The cultural layer has been sampled by us from the BD-1 archaeological excavation pit on the north-eastern bank of the Bezdonka Lake within the floodplain sector corresponding to the unfortified part of the Gnezdovo settlement. Artefacts found within this sector indicate its past use as a river harbour on the way "from the Varangians to the Greeks". Those artefacts include numerous wooden and birchbark footways, parts of which are present in the BD-1 pit, and also unique finds of a rowlock, an oar and a rib of a rowing boat. The stratigraphy and macromorphology of the profile studied are shown in the Fig. a. Our micromorphological investigation was designed to confirm the genesis of stratigraphic units distinguished at a macro-scale, particularly, the natural and anthropogenic processes of their formation and to estimate the degree of anthropogenic impact during the formation of each archaeological layer. Archaeological characteristics of the layers and conclusions on their genesis based on generalized macro- and micromorphological data as follows:

Layer 6 (bottom of the profile) includes fragments of the earliest wooden footway, and a bottom of a birchbark basket ("tues") among other scarce artefacts. The layer is composed of bluish clay loam with banded basic distribution pattern, and inclusions of irregularly distributed small fibres of plant debris and lenses of amorphous organic matter. Such microstructure is typical of a floodplain-swamp genesis of the sediment. Indicators of anthropogenic impact are rare, but convincing: phytoliths of cereals (Fig. b), charcoal particles and single phosphate coating.

Layer 5 does not contain artefacts. There is a rhythmical stratification with alternating bands of well sorted sand (monic c/f-related distribution) and sandy loam (porphyric distribution) (Fig. c). Bands of finer material are impregnated with amorphous humus and contain subhorizontally oriented plant fibres. There are no features of anthropogenic disturbance. The layer was formed by fluvial processes within the outer margins of levee deposits along the Dnieper River at the time of the settlement existence.

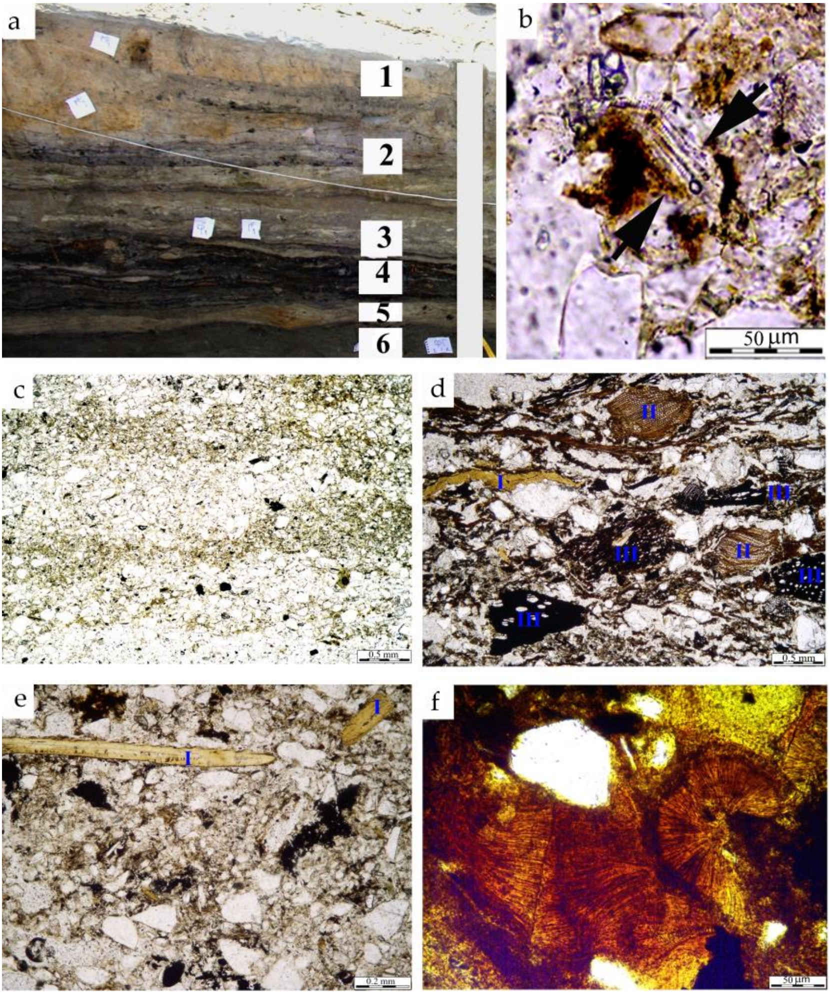
Layer 4 contains several interlayers of fragmented wooden footways from the early period of the settlement existence, a lot of wood peelings and hand-made ceramics. There is a rhythmical stratification of bands composed by coarser (sandy) and finer (loamy) material, which indicates the fluvial genesis of the sediment. An abundance of wood fragments and charcoal, sand and gravel with cracks and hematitization features (indicative of burning), an irregular distribution of the inclusions within soil and a presence of phosphate coatings – all these are clear indicators of anthropogenic inputs (Fig. d). However, a generally undisturbed appearance of the distribution pattern of minerogenic mass and a relatively few phosphate pedofeatures (compared to those higher up within the profile) are suggestive of only a passive anthropogenic presence without direct disturbance of sediments or significant inputs of phosphate-containing substances (organic matter of animal origin). A good preservation of the wood is an indicator of more or less constant water-logging within this layer during a whole period of its existence.

Layer 3 is an archaeologically “sterile” stratum between the earlier and the later cultural layers of the 10^{th} and 11^{th} centuries. It consists of floodplain alluvium with its rhythmical stratification being partly preserved, with a parallel orientation of skeletal grains and inclusions of perfectly preserved sponge spicules and a diatom shell. The rhythmical stratification has been significantly disturbed due to the human impact, i.e., anthropogenic inputs and irregular distribution of materials. There are irregularly distributed coarse grains, including the burned ones, charcoal particles and rare phosphate coatings. Some poorly defined redoximorphhic features (nodules and impregnation spots) are indicative of seasonal water-logging.

Layer 2 is rich in artefacts from the later period of the settlement existence. There is no alluvial stratification, but strongly heterogeneous composition and structure indicating that intensive anthropogenic pressure was the leading factor of this layer's formation. The anthropogenic inputs of sand, gravel and various organic materials transformed the original soil by moving, mixing, burning, etc. There are well-defined features resulting from the inputs of organic materials of animal origin with their subsequent decomposition and migration of phosphate compounds. The features of iron oxide redistribution together with the presence of phosphate and clay coatings are indicative of seasonal contrasts in moisture content with alternating periods of water-logging and free drainage.

Layer 1 is the material of a small rampart of unknown purpose. Its composition and microstructure result from intensive anthropogenic inputs and transformation. There is a characteristic irregular distribution of skeletal grains, with the zones enriched by of strongly weathered mica, angular quarts grains and single limestone fragments. There are abundant well-peserved charcoal pieces, occasional bone fragments (Fig. e), abundant phosphate and phosphate-clay coatings, impregnations and infillings, including those with fan-like internal pattern (Fig. f). The presence of iron oxide redistribution features together with the abundance of clay and phosphate-clay coatings are indicators of seasonally alternating water-logging and free drainage.

The above-presented results of the micromorphological analysis of the stratigraphic column containing the cultural layers have allowed us to make the following conclusions about the natural and anthropogenic processes and conditions of their formation. The lower clay loam layer 6 was accumulated under conditions of continuous water-logging, most probably, under a floodplain swamp by the rear of the floodplain. The locality under investigation and river bed was spaced far apart at those times. There were relatively low flood water levels during that period. A weak saturation of the layer 6 with artefacts and rare, but convincing features of human presence (cereal phytoliths) are indicative of the early non-intensive stage of human occupation of this floodplain. Higher up within the profile, the rhythmical stratification of the



The stratigraphy and macromorphology of the profile studied: a – the stratigraphy and macromorphological structure of the profile; b – Layer 6, cereal phytoliths, PPL; c – rhythmical stratification with alternating bands of well sorted sand (monic c/f-related distribution) and sandy loam (porphyric distribution), PPL; d – Layer 4, anthropogenic inclusions: phosphate coating (I), wood fragments (II) and charcoal (III), PPL; e – Layer 1, inclusions of bone fragments (I), PPL; f – Layer 1, a fragment of phosphate infilling with fan-like microstructure, PPL.

layer 5 and the sand lenses in the layers 4 and 3 with the features of low-intensity anthropogenic processes, which did not disturb the alluvial strata, are indicators of a gradual movement of the main channel towards the rear of the floodplain. It is not excluded that there was a gradual increase in flood water levels that caused a change from clay loamy to sandy loamy and sandy texture of the sediments. However, it is known that the period of the archaeological monument existence coincided with the Medieval Warm Climate Optimum of the Holocene, when floods were irregular and low, so that Retisols – soils typical of loamy watersheds in the region of study nowadays – developed within the floodplain (Bronnikova and Uspenskaya, 2007; Geoarchaeological issues, 2012). Therefore, an intensification of flooding could not be a key factor of change from homogenous clay loamy sediment to rhythmically-stratified sandy sediment, instead, the major factors were the gradual approach of the main channel towards the valley wall and the formation of a new levee corresponding to the new position of the main channel. The layers 2 and 1 containing artefacts from the later period of the settlement existence have the highest frequency of anthropogenic micromorphological features within the profile studied, i.e., these layers correspond to the most intensive land use period at this site. The composition and microstructure of these layers allow suggesting that human-induced processes (primarily, due to anthropogenic inputs) slightly decreased in intensity towards the end of the settlement existence. The site's water regime changed from continuous water-logging (manifested by the features of the layers 6–4) to seasonal alternation of water-logging and free drainage (the layers 3–1). An excellent preservation of wooden artefacts within the lower layers is an unambiguous indication of water-logging throughout the whole time of existence of these layers. The presented example has clearly demonstrated a high effectiveness of micromorphological analysis in describing the microstratigraphy of the cultural layers, differentiated diagnostics of natural and anthropogenic processes of formation and transformation of the cultural layers and reconstructing the local conditions of their development.

Finally, we shall outline the prospects of soil micromorphology in archaeology. There is widespread and steady demand for micromorphological analyses in archaeology and geoarchaeology in Western Europe and the USA, while the collaboration of pedologists and archaeologists has not yet become a regularly practice in Russia. To help the further introduction of soil micromorphology into Russian archaeology, it is necessary to organize training courses in archaeological soil micromorphology for our students and to popularize this method in our archaeological society. These two goals have already been achieved in many countries, where archaeological soil micromorphology has become a customary method. However, there is another obstacle to the further promotion of this method, which is common for Russian and foreign specialists: there is an absence of commonly available reference collections of thin sections of micro-artefacts and archaeological objects with anthropogenic types of microstructure (Courty, 1992). Being identified since the early 1990s, this obstacle still remains practically the same until the present time. Only a database on ceramic thin sections is currently available. Their brief descriptions are published in the "Pottery in Archaeology" handbook by Clive Orton and Michael Hughes (2013, second edition, p. 289) available online. Since 2009, a large international group under the supervision by Prof. Stoops has been designing and compiling the "Atlas for Archaeological Soil and Sediment Micromorphology". Its publication will be an important event in the development of this new branch of science. The Atlas will provide an indispensable guidance for specialists and students in archaeological soil micromorphology.

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