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MICROBIOMORPHIC ANALYSIS AS PART OF MICROMORPHOLOGICAL INVESTIGATIONS: COMPOSITION, DIAGNOSTICS AND INFORMATIVE CAPACITY FOR PALEOENVIRONMENTAL RECONSTRUCTIONS

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Microbiomorphic analysis is a detailed study of microscopic particles of biogenic nature (plant detritus, phytoliths, shells of diatoms, spicules of sponges, pollen, etc.). Each of such particles characterizes environmental conditions at the time of its formation and, therefore, provides useful information for palaeoenvironmental reconstructions. The Early Pleistocene deposits were studied in Armenia at the sites, where tools of ancient hominids (Early Acheulian) were found. The genesis of these deposits was identified. It was shown that these ancient alluvial-lacustrine sediments were transformed by soil-forming processes. The environmental conditions at the time of the ancient hominids' migration were reconstructed.

Key words: microbiomorphs, phytoliths, diatoms, reconstruction, Acheulian.

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INTRODUCTION

Microbiomorphic analysis is a study of microscopic biogenic particles with characteristic morphological features. This is a comprehensive analysis of the quantity and quality of plant detritus (wood and grass), fossil grass cuticules, phytoliths, shells of diatoms, spicules of sponges, etc. Each of such particles bears information on environmental conditions (natural or anthropogenic) at the time of its formation. The times of different particles' formation partly overlap, which allows independently control and supplement data from each source. As a result, multifaceted and valid information on palaeoenvironmental conditions within a specific site can be obtained.

This method of analysis is very useful for resolving problematic questions on soil genesis, with especially valuable applications in paleosol and archaeological research. It is most often applied to the Holocene soils and sediments of different genesis (Golyeva et al., 1994; Golyeva, 2009; 2011; Kiryushin et al., 2012). A good preservation of all the components analysed in this method is necessary for successful palaeoenvironmental reconstructions.

OBJECTS AND METHODS

A high informative capacity of a complex microbiomorphic analysis is illustrated in the present paper by the example of research on the Karakhach archaeological monument located in the north of Armenia, at the south-eastern foot of the Dzhavakhetsky Ridge (about 1800 m a.s.l.). A new series of Acheulian sites with stratified profiles was discovered at this location by an Armenian–Russian research expedition (Aslanyan et al., 2007; Lyubin and Belyaeva, 2011, 2012). The diggings revealed sites of the Early Acheulian stone industry (Belyaeva and Lyubin, 2012, 2013). The SIMS U-Pb dating of the lower part of an artefact-rich layer provided the following results: 1.750 ± 0.020; 1.799 ± 0.044; 1.804 ± 0.030 and 1.944 ± 0.046 million years (Presnyakov et al., 2012).

The aims of the research included reconstruction of palaeoenvironmental conditions within that unique area inhabited by the ancient hominids. According to one reconstruction (Trifonov et al., 2015), there was a small valley with a meandering river in between the hills that received regular inputs of volcanic ash from the growing Caucasus Mountains. However, it still remained uncertain whether the soil surface was stable within this area and all the local artefacts were found *in situ*, but not re-deposited by diluvial or alluvial processes.

Because of the very old age of the deposits studied, there were no proper palaeosols identified. However, there were thin soil-like layers between coarse stone and volcanic ash strata, which allowed suggesting that there were short periods of surface stability and soil formation (Sedov et al., 2011; Khokhlova et al., 2014; 2015).

The above hypothesis was verified with the use of the microbiomorphic analysis. Two samples were taken in two replications from one of the ancient soil-like layers (at a depth of 5.6–5.9 m from the modern surface). The standard sample treatment technique was used (Golyeva, 2008, 2012). The light fractions rich in biogenic silica were separated and studied under an optical microscope (magnification × 400) and also a scanning electron microscope (SEM). The latter provided additional information on the composition of the microbiomorphic fraction in the samples studied. The quantitative and qualitative analyses of the particles were conducted. The quantities of the particles were re-calculated for the slide area (24 × 24 mm) to allow the data standardizing and making comparisons between different samples.

The biogenic silica particles found in the samples included phytoliths, shells of diatoms and spicules of sponges. While the phytoliths generally characterise the terrestrial plant community composition, the diatoms and sponges are aquatic organisms. However, they prefer different aquatic habitats: diatoms are usually found in stagnant and slowly flowing waters, while sponges are more typical for fast flowing waters.

RESULTS AND DISCUSSION

The samples contained only biogenic silica particles. The absence of microbiomorphs of other genesis (e.g., plant detritus and fungal hyphae) can be explained by the very old age of the deposit. The quantity of phytoliths in the samples studied was higher than usual for soils. In total, each sample contained 5280–5470 particles of biogenic silica, whereas normally only 1560–1800 units of such kind could be found in topsoils. The increased quantity of these particles has probably resulted from the import of fine earth, e.g., with flowing water.

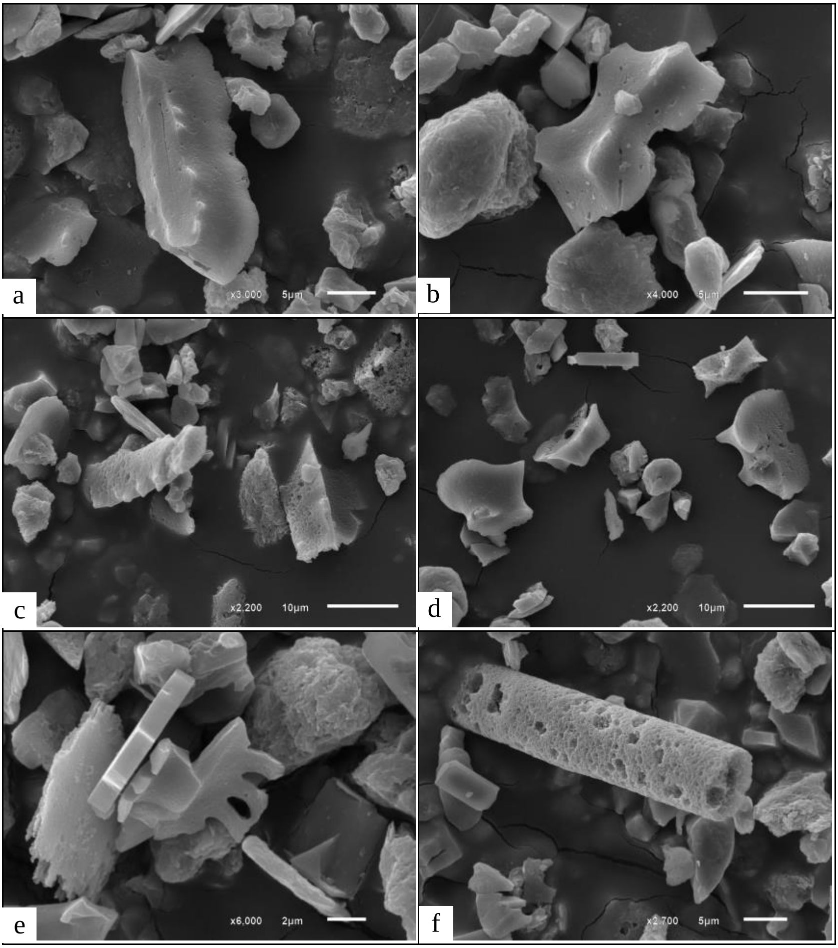
The assemblage of phytoliths had a complex composition (Table). There were phytoliths from plants that belonged to different ecological niches – dry steppe, wet meadows and subtropical ecosystems. Such composition is typical for topographic depressions, where various fine particles have been brought from higher grounds and accumulated. Such geomorphological position favours the formation of a mixed assemblage of phytoliths, which allows reconstructing the ancient vegetation cover not only at the site, but also over its surrounding lands at higher elevations. It should be mentioned that the preservation of phytoliths was surprisingly good in the samples studied, with even smallest details remaining intact (Fig. a–d). A high degree of phytoliths preservation allows suggesting with full confidence that the soil-like layers of the ancient deposits were remaining in place until their burial under the volcanic ash.

Apart from the phytoliths, there were shells of diatoms and single spicules of sponges in the samples studied. Revealing the diatom shells was only possible under a SEM with great magnifications, be-

The phytolith assemblage composition

Sample №	Depth, cm	Total (%)	*1*	*2*	*3*	*4*	*5*	*6*
1Krch	5.90–5.60	100	53	13	21	7	–	6
2Krch	5.90–5.60	100	48	10	26	10	4	2

Note: The numbers correspond to the following groups of phytoliths: *1* – dicotyledons, *2* – forest grasses, *3* – meadows grasses, *4* – steppe and arid grasses, *5* – reed grass, *6* – subtropical plants.



The diversity of silica microbiomorphs and their preservation degrees, where a–d are different forms of phytoliths; e – is a fragment of diatom; f – is a sponge spicule.

cause they were represented only by small fragments (Fig. e). The sponge spicules were corroded (Fig. f).

Such a discrepancy between the almost ideal preservation of phytoliths and the almost total destruction of diatom shells and sponge spicules can be given only one explanation. Originally this soil-like layer was formed within the lowland with a flowing watercourse and temporary stagnant water that provided for the accumulation of sponge spicules and diatom shells. Later the lowland became drier, which allowed for the development of automorphic soils. The pedogenic processes favoured the accumulation of phytolith assemblages as well as the fragmentation of diatom shells and the corrosion of sponge spicules within the ancient soil layer. Therefore, the fragmented appearance of diatom shells can be considered as independent evidence to support the hypothesis that the layer studied was ancient soil.

These are the general conclusions of the research conducted:

1. The ancient deposit at the Karakhach site was formed by alluvial and lacustrine sediments (including oxbow lake sediments).

2. These aquatic sediments gradually dried out and underwent automorphic soil formation processes.

3. The vegetation cover within the study area was represented by savanna-type grassland ecosystems that included wet meadow species, xenomorphic grasses and single foliate trees in automorphic topographic positions.

4. The palaeoclimate of the study area at the Early Acheulian times can be defined as humid subtropics.

Our conclusions on the Karakhach site independently coincided with the results of the phytolith analysis of the samples from the Dmanisi site in Georgia (Messager et al., 2010, 2011). An independent interpretation resulted from different methodological approaches to studying and identifying the morphological types of phytoliths. Therefore, it is very important that the conclusions and palaeoenvironmental reconstructions resulting from of both studies were completely similar. The Dmanisi site is located 30 km to the north of the Karakhach site, at similar altitudes. The coincidence of the conclusions from these studies confirms the following: about 1.9–1.8 million years ago along the modern border area between Armenia and Georgia there was humid subtropical climate that favoured the land colonization by the ancient hominids.

Thus, the given example illustrates the informative capacity of the microbiomorphic analysis for palaeoenvironmental reconstructions.

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REFERENCES

1. S. A. Aslanyan, E. V. Belyaeva, E. M. Kolpakov, V. P. Lyubin, G. M. Sarkisyan and A. V. Suvorov, "Research by the Armenian-Russian archaeological expedition 2003–2006", *The newsletter of the Inst. of Material Culture History, Russ. Acad. Sci.*, 2, 142–154 (2007) (in Russian).
2. E. V. Belyaeva and V. P. Lyubin "Preliminary data on the early stages of Acheulian in the Caucasus", *KSIA*, Iss. 227, 28–36 (2012) (in Russian).
3. E. V. Belyaeva and V. P. Lyubin, "The Early Acheulian monuments in the north of Armenia", In: *Fundamental problems of archaeology, anthropology and ethnography of Eurasia. Dedicated to the 70th anniversary of Acad. A.P. Derevyanko* (Novosibirsk, 2013) 37–52 (in Russian).
4. A. A. Golyeva, A. L. Aleksandrovsky, and L. K. Tselishcheva, "Phytolithic Analysis of Holocene Paleosols", *Pochvovedenie*, 1994, 3, 34–40 (in Russian).
5. A. A. Golyeva, "Microbiomorphic analysis of the cultural layers of ancient settlements in the Central Russia", In: *Archaeology of the Moscow area*: Proc. of scientific seminar. Iss. 5. (Moscow. Inst. of Archaeology, Russ. Acad. Sci. 2009) (in Russian).
6. A. A. Golyeva, *Microbiomorphic complexes of natural and anthropogenic landscapes. Genesis, geography, informative capacity* (LKI, Moscow, 2008) (in Russian).
7. A. A. Golyeva, "Microbiomorphic studies on soils and grounds from the burial mound of Filippovka 1", In: *Natural science methods of studying the burial mound of Filippovka 1.* Materials and studies on archaeology of Russia. No. 15, Munchaev R.M. and Yablonsky L.T. (Eds.) (Institute of Archaeology, Russ. Acad. Sci. TAUS, Moscow, 2011) 46–63 (in Russian).
8. A. A. Golyeva, "Phytoliths – sources of information on the nature and peoples life in the past", In: *Palaeosols, environment and their study methods*, G.V. Dobrovol'skii and M.I. Dergacheva (Eds.) (OFSET, Novosibirsk, 2012) (in Russian).
9. V. P. Lyubin and E. V. Belyaeva, "New data of the Early Paleolithic Age in Armenia", *Ancient inhabitants of Caucasus and distribution of ancient hominids over Eurasia* (St. Petersburg, 2010) (in Russian).
10. V. P. Lyubin and E. V. Belyaeva, "The Early Acheulian monument of Karakhach in the north of Armenia". *Archaeological newsletter*, 17, 13–19 (2011) (in Russian).

11. Yu. F. Kiryushin, K. Yu. Kiryushin, A. A. Golyeva and V.P. Semibratov, "Pedological and microbiomorphic studies on the Tavdinsky grotto", *Altai science newsletter*, 1, 123–127 (2012) (in Russian).
12. O. Khokhlova, E. Stolpnikova and N. Kovaleva, "Genesis of the Early Pleistocene paleosols of Armenia evidenced by set of methods", In: *Paleopedological record of postglacial soil and landscape evolution*. XIIIth International Symposium and Field Workshop on Paleopedology (ISFWP), 1–6 September (Torun, Poland, 2014).
13. O. S. Khokhlova, A. A. Khokhlov, A. M. Kuznetsova, E. M. Stolpnikova, N. O. Kovaleva, V. P. Lyubin, and E. V. Belyaeva, "Carbonate features in the uppermost layers of Quaternary deposits, Northern Armenia, and their significance for paleoenvironmental reconstruction", *Quaternary International*, (2015). doi: 10.1016/j.quaint.2015.07.035
14. E. Messager, D. Lordkipanidze, C. Delhon, and C. R. "Ferring Palaeoecological implications of the Lower Pleistocene phytolith record from the Dmanisi Site (Georgia)", *Palaeogeography, Palaeoclimatology, Palaeoecology*, 288, 1–13 (2010) doi: 10.1016/j.palaeo.2010.01.020
15. E. Messager, S. Nomade, P. Voinchet, R. Ferring, A. Mgeladze, H. Guillou, and D. Lordkipanidze "$^{40}Ar/^{39}Ar$ dating and phytolith analysis of the Early Pleistocene sequence of Kvemo-Orozmani (Republic of Georgia): chronological and palaeoecological implications for the hominin site of Dmanisi", *Quaternary Science Reviews*, 30, 3099–3108. (2011). doi:10.1016/j.quascirev.2011.07.008
16. S. L. Presnyakov, E. V. Belyaeva, V.P. Lyubin, N. V. Rodionov, A. V. Antonov, A. K. Saltykova, N. G. Berezhnaya, and S. A. Sergeev, "Age of the earliest Paleolithic sites in the northern part of the Armenian Highland by SHRIMP-II U-Pb dating of zircons from volcanic ashes", *Gondwana Research*, 21, 928–938 (2012).
17. S. N. Sedov, O. S. Khokhlova, and A.M. Kuznetso, "Polygenesis of volcanic paleosols in Armenia and Mexico: micromorphological records of climate variations in the Quaternary Period", *Eurasian Soil Science*, 44(7), 766–780 (2011).
18. V. G. Trifonov, V. P. Lyubin, E. V. Belyaeva, V. A. Lebedev, Ya. I. Trikhunkov, A. S. Tesakov, A. N. Simakova, R. V. Veselovsky, A. V. Latyshev, S. L. Presnyakov, T. P. Ivanova, D. V. Ozhereliev, D. M. Bachmanov, S. M. Lyapunova, "Stratigraphic and tectonic settings of Early Paleolithic of North-West Armenia", *Quaternary International*, (2016) (in press). doi:10.1016/j.quaint.2015.08.019

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