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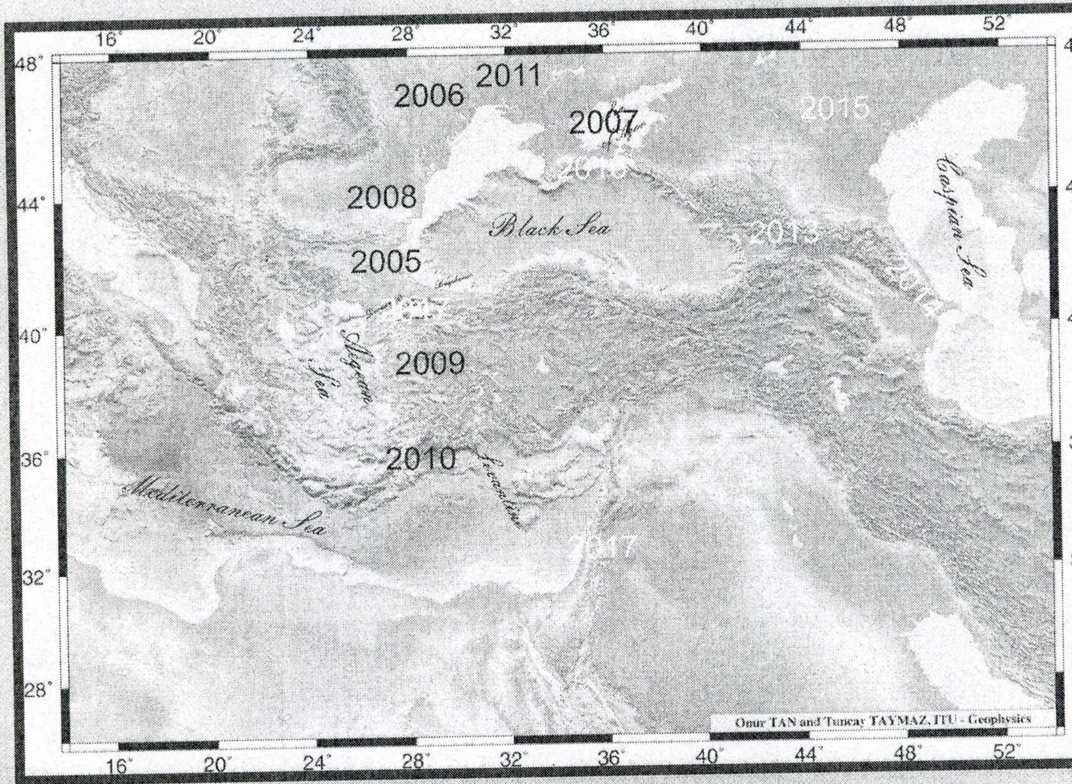
Georgian National Academy of Sciences, Department of Earth Sciences, Tbilisi, Georgia

2-9 October 2016

INTERNATIONAL GEOSCIENCE PROGRAMME



Proceedings of the Fourth Plenary Conference

IGCP 610 "From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary" (2013 - 2017)

http://www.avalon-institute.org/IGCP610

THE PALYNOCLIMATOSTRATIGRAPHY OF THE PLEISTOCENE DEPOSITS IN TRLICA CAVE AND ENVIRONMENTAL RECONSTRUCTIONS (THE NORTHERN MEDITERRANEAN, MONTENEGRO)

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Keywords: Early-Middle Pleistocene, palynology, environments, Mediterranean Sea Region

Introduction

In Montenegro, Paleolithic cave sites have been studied by specialists from Russia (the Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences, Lomonosov Moscow State University, and Borisyak Paleontological Institute of the RAS), and those from the Centre of Archaeological Studies of the Montenegrin Academy of Sciences and Arts since 2010. A significant part of the multidisciplinary investigations performed on the Trlica Cave site (43°20′38″ N., 19°23′00.2″ E., 2.5 km southeast of the town of Pljevlja) consisted of the palynological analysis of the cave site sequence. Paleobotanical data available for Pleistocene sediments of Montenegro are extremely scarce, so the data obtained from the pollen and spore assemblages make a noticeable contribution to our understanding of the Pleistocene environments in that region of the northern Mediterranean.

Material, methods, and previous studies

Trlica Cave is a karst cavity formed in Triassic limestones on the side of an intermontane depression at 925 m a.s.l. Studies of the loose sediments infilling the cave enabled us to identify 12 lithological layers grouped into three facies-genetic members dated to the Early and Middle Pleistocene, up to 5.5 m thick altogether (Derevyanko et al., 2011). The lithological characteristics and paleontological data suggest that the depositional process was repeatedly interrupted. The lower member up to 1.5 m thick (layers 11 and 12) accumulated in subaqueous environments, which is confirmed by the presence of freshwater green algae of the genera *Botryococcus* and *Pediastrum* in palynological slides. The middle member (layers 5 to 10) bears traces of mostly deluvial and proluvial processes. The uppermost member (layers 1 to 4) presents a red-colored pedo-sedimentological complex. The conclusion of the genesis of layers 1-4 is based on the field study results, taphonomic characteristics of the palynoforms recovered from the described layers, as well as on the ecological and phytocoenotic characteristics of the plants-producers.

A representative collection of mammal bones, both large and small, collected from layers 5-6 and 10-11 has been thoroughly studied by I.A. Vislobokova and A.K. Agadjanyan (2016). The specialists identified two faunistic assemblages corresponding to two large paleogeographic stages, which permitted us to determine the age of the enclosing deposits. The small mammal fauna recovered from layers 5 and 6 correspond, judging from its evolutionary level, to the beginning of the Middle Pleistocene (i.e., its age is approximately 0.780 Ma). The faunal assemblage from layers 10 and 11 is dated to the second half of the Early Pleistocene – from the Olduvai Subchron to the mid-Late Villafranchian (that is, from ~1.8 to ~1.4 Ma).

A comprehensive palynological analysis of the Pleistocene sequences hasn't been performed yet in Montenegro. Some important data, however, were obtained by J. Argant (Argant and Dimitrijević, 2007), who studied pollen retrieved from coprolites of hyaena (*Pachycrocuta brevirostris*) found in Trlica Cave together with bones of Early Pleistocene mammals. Two of the studied samples contained neither pollen, nor spores; the other three samples yielded 1-3 pollen grains. The only pollen-bearing sample produced an assemblage indicative of forest biotopes existing under conditions of a relatively cool and humid climate. The upper levels were presented by coniferous tree stands (*Pinus, Abies*) and those of beech (*Fagus*); widely spread were also open biotopes with *Juniperus*, heather (*Calluna*), ground box (*Buxus*), and various herbs (Poaceae and others). The slopes were overgrown with oak and hornbeam, and the valley floor was mostly occupied by wetlands with alder (*Alnus*) forest and *Sphagnum* in the moss cover.

To get accurate and better substantiated paleoenvironmental reconstructions, about 40 samples were taken from the Pleistocene series of Trlica Cave; besides, a series of subfossil samples from various facies of the recent deposits were collected in test plots occupied by various plant communities. The pollen analysis of 39 samples taken from all the layers of the Trlica Cave sequence showed a low concentration of pollen and spores. Consequently, to obtain statistically valid data, we had to repeat the procedure of separating the plant remains (pollen, spores, and other microremains) from the each sample (150-200 g) of loose deposits many times, each time taking a new portion of the material weighing 50 g. The representative pollen assemblages thus obtained provided the data necessary for reconstructing the climate and environments during the deposition of all the horizons of the series under study and enabled us to subdivide it into several climato-stratigraphic units.

Results and discussion

The list of the taxonomic composition of the palynoflora recovered from layers 1 to 12 includes about 100 species, genera, and families of arboreal plants, shrubs, dwarf shrubs, herbs, and grasses, as well as spore-bearing plants. Also found is pollen of relict plants typical of subtropical and temperate environments of the Neogene, such as *Cathaya* sp., *Podocarpus* sp., *Keteleeria* sp., *Tsuga* spp., *Cedrus* sp., *Parrotia persica*, *Celtis* sp., and some genera of Taxodiaceae (cf. *Taxodium*, cf. *Sciadopitys*, *Cryptomeria japonica*), Cupressaceae, and other families. The listed taxa are constituents indicative of the interglacial floras attributable to the Early and the first half of the Middle Pleistocene in the Mediterranean historical-floristic region, and their presence confirmed the conclusion of an Early-Middle Pleistocene age for the Trlica Cave deposits. Considering the chronology of the appearance, peak development, and disappearance of exotic taxa identified in the Pleistocene floras of the Mediterranean, palynologists noted a diversity of regional and local characteristics of those processes (Suc and Popescu, 2005; Popescu et al., 2010; Bolikhovskaya, 2011; Manzi et al., 2011; and many others). On the whole, the Early-Middle Pleistocene interglacial intervals in the central Mediterranean region were distinct for dominance of broadleaf and coniferous-broadleaf forests with some subtropical elements, while phases of dark coniferous trees (with hemlock, cedar, and other exotic plants) were typical of the transitional periods. Climatic rhythms of the glaciation rank corresponded to phases revealing an increasing importance of non-arboreal steppe elements, such as sagebrush (*Artemisia*), Amaranthaceae, Chenopodiaceae, etc.; these species indicate rather cold and dry environments. Coniferous forests of middle and high mountain type were widespread during cooler and more humid intervals (Joannin et al., 2007).

As follows from the newly obtained palynological data, forests were the dominant landscapes in the vicinity of Trlica Cave during the entire period represented by the cave series deposition. The species composition of the forests, however, changed depending on the climate fluctuations: coniferous-broadleaf forests prevailed at the time of warmings, while coolings featured purely coniferous forests or those with an insignificant admixture of broadleaf species.

At the present stage of our studies, three periods of relative cooling may be correlated with deposition of layer 12, the upper part of layer 9-lower part of layer 8, and the uppermost portion of layer 5.1 (sub-layer 5.1A), the latter abounding in rock fragments resulting from the desquamation process. Layer 12 began to form during the phase of predominant fir-spruce-cedar pine forests (*Abies* sp., *Picea* sect. *Picea*, *Pinus* subgen. *Haploxylon*) and pine (*Pinus sylvestris*) forests with a dense shrub layer of juniper (*Juniperus* spp.). Then, under conditions of relatively warmer climate, some warm-requiring species appeared in the tree stands, including Serbian spruce (*Picea* sect. *Omorica*), hemlock (*Tsuga* of *piccolo* type), beech, oak, and hazel. During the first warmer stage, at the time of the deposition of layer 9 (lower part) to layer 11, the region was mostly covered with coniferous-broadleaf forests predominantly of spruce, European cedar pines, European hornbeam (*Carpinus betulus*), oriental hornbeam (*Carpinus orientalis*), and lime trees (*Tilia* cf. *cordata*, *Tilia* cf. *platyphyllos*), with an admixture of beech (*Fagus sylvatica*), oak, hop hornbeam (*Ostrya* sp.), alder, hazel, mulberry, etc. An old age of the deposits is suggested by the presence of some relicts of the Cretaceous and Neogene periods in the pollen assemblages; among them, there are evergreen coniferous *Cathaya* sp. and *Keteleeria* sp., now extinct from the region and growing in SE Asia. The climate-controlled phytocoenoses dated to the second cooling (the upper part of layer 9 and the lower part of layer 8) were dominated by forests of fir, cedar, and spruce. At the time of deposition of layer 7, a temperate warm climate was favorable for mixed forests of spruce, pine, and broadleaf trees (lime *Tilia* cf. *cordata*, oak *Quercus* sp., *Quercus* cf. *ilex*, and hornbeam *Carpinus betulus*,) with hazel (*Corylus avellana*) and mulberry (*Morus* sp.) in the underwood, and with isolated tree stands of oriental hornbeam, birch, and alder. The coniferous group is diversified in composition and includes *Picea* sect. *Picea*, *Pinus* sect. *Cembra*, *P.* sect. *Strobus*, *P.* s.g. *Diploxylon*, *Pinus sylvestris*, and *Juniperus* sp.

Layers 5 and 6 (?) composed of ochreous loam ~130 cm thick were deposited at a warm stage correlatable with the first interglacial of the Brunhes epoch (MIS 19), when open broadleaf and coniferous-broadleaf forests grew in the greater part of the region under conditions of a warm and relatively dry climate. The broadleaf communities consisted mostly of taxa typical of montane xerophytic flora, such as *Ostrya* sp., *Carpinus orientalis*, *Celtis* sp., *Tilia argentea*, and others), as well as *Quercus* sp., *Carpinus betulus*, *Corylus avellana*, *Corylus* sp., *Ulmus* sp., *Alnus* sp., and *Alnus glutinosa*. The coniferous tree stands were dominated by pines (*Pinus* s.g. *Haploxylon*, *Pinus* sect. *Cembra*, *Pinus* s.g. *Diploxylon*, *P. sylvestris*), with a constant presence of Cupressaceae, *Picea* sect. *Omorica*, *Picea* sect. *Picea*, and *Abies* sp. The presence of subtropical coniferous exotics – *Cathaya* and *Podocarpus* – is quite possible. Pollen of Persian ironwood (*Parrotia persica*) suggests some ecotopes with wet soils; at present, this tree occurs in warm and wet climate, on the coasts of water bodies, or on wetlands in mountain valleys. The petrophyte-steppe biotopes were dominated by Chenopodiaceae, wormwoods (including *Artemisia* s.g. *Seriphidium*), and plants of the Liliaceae and Asteraceae families.

The third cooling (sub-layer 5.1A) was marked by the disappearance of subtropical coniferous and broadleaf species from the forests.

At the present stage of palynostratigraphic studies, one may state more or less confidently that the major part of the deposits (layers 1 to 4) was accumulated during the warm interval of the Middle Pleistocene, correlatable with the Noordbergum (Interglacial IV, Voigtstedt, Ferdynandowian) Interglacial of the West European scale and with the Muchkap Interglacial of the European Russia stratigraphic scale, the latter dated by the EPR technique to ~610-536 ka BP (Molodkov and Bolikhovskaya, 2010). The upper red-colored soil and deposit complex yielded a flora most diversified and rich in Neogene relicts. The warm and wet climate was favorable for the subtropical broadleaf-coniferous forests dominated by pines (including cedar pines *Pinus* sect. *Cembra*, *Pinus* sect. *Strobus*, and light coniferous pines), with a notable participation of Neogene relicts (*Cathaya* sp., *Podocarpus* sp., *Keteleeria* sp., *Cedrus* sp., *Cupressus* spp., etc.). Broadleaf dendroflora was abundant (*Parrotia persica*, *Fagus* sp., *Quercus* sp., *Quercus ilex*, *Quercus pubescens*, *Carpinus betulus*, *Carpinus orientalis*, *Carpinus* sp., *Ostrya* cf. *carpinifolia*, *Corylus avellana*, *Corylus* sp., *Tilia* sp., *T. cordata*, *T. argentea*, *Celtis* sp., *Ulmus* sp., cf. *Pistacia*, etc.).

Conclusion

The studies we conducted proved that the Trlica Cave deposits are a promising source of palynological information that may be used in climatic stratigraphy and reconstructions of the Early and Middle Pleistocene environments on the Balkan Peninsula.

Acknowledgments

The funding for this study was supported by a grant from the Russian Science Foundation (project No 14-50-00036).

References

Argant, J., and Dimitrijević, V. 2007. Pollen analyses of Pleistocene hyaena coprolites from Montenegro and Serbia. *Annales geologiques de la peninsule Balkanique* 68: 73-80.

Bolikhovskaya, N.S. 2011. The Pleistocene and Holocene of the North-Western Caspian Sea Region: climatostratigraphy, correlation and palaeoenvironments. *Stratigraphy and Sedimentology of Oil-gas Basins* 1: 3-30.

Derevyanko, A.P., Shunkov, M.V., Bulatovich, L., Agadzhanyan, A.K., Vislobokova, I.A., Ul'yanov, V.A., Anojkin, A.A., and Medenitsa, I. 2011. Issledovaniya v peshchere Trlitsa na severe Chernogorii [Studies in the Trlitsa Cave in the north of Montenegro]. *Problems of Archaeology, Ethnography, Anthropology of Siberia and Adjacent Territories* 17: 44-47. (In Russian)

Joannin, S., Quillévéré, F., Suc, J.-P., Lécuyer, C., and Martineau, F. 2007. Early Pleistocene climate changes in the central Mediterranean region as inferred from integrated pollen and planktonic foraminiferal stable isotope analyses. *Quaternary Research* 67(2): 264-274.

Manzi, G., Magri, D., and Palombo, M.R. 2011. Early-Middle Pleistocene environmental changes and human evolution in the Italian peninsula. *Quaternary Science Reviews* 30(11-12): 1420-1438.

Molodkov, A.N., and Bolikhovskaya, N.S. 2010. Climato-chronostratigraphic framework of the Pleistocene terrestrial and marine deposits of Northern Eurasia, based on pollen, electron spin resonance, and infrared optically stimulated luminescence analyses. *Estonian Journal of Earth Sciences* 59(1): 49-62.

Popescu, S.-M., Biltekin, D., Winter, H., Suc, J.-P., Melinte-Dobrinescu, M.C., Klotz, S., Rabineau, M., Combourieu-Nebout, N., Clauzon, G., and Deaconu, F. 2010. Pliocene and Lower Pleistocene vegetation and climate changes at the European scale: Long pollen records and climatostratigraphy. *Quaternary International* 219(1-2): 152–167.

Suc, J.-P., and Popescu, S.-M., 2005. Pollen records and climatic cycles in the North Mediterranean region since 2.7 Ma. In *Early-Middle Pleistocene Transitions: The Land-Ocean Evidence*, Martin J. Head and Philip L. Gibbard (eds.), pp. 147-157. Geological Society of London, Special Publication 247. Geological Society, Bath.

Vislobokova, I.A., and Agadjanyan, A.K. 2016. New data on age of the Pleistocene fauna from the Trlica locality (Montenegro, Central Balkans) and its correlation with other faunas of Europe. *Stratigraphy and Geological Correlation* 24(2): 188-202.