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Multi-proxy records of Holocene palaeoenvironmental changes in the Varna Lake area, western Black Sea coast

Mariana Filipova-Marinova [a, *], Danail Pavlov [b], Liviu Giosan [c]

[a] Museum of Natural History – Varna, 41 Maria Louisa Blvd., 9000 Varna, Bulgaria
[b] Society of Innovative Ecologists of Bulgaria, 10 Dr. Bassanovich str., 9010 Varna, Bulgaria
[c] Department of Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

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ABSTRACT

High-resolution spore-pollen analysis of laminated sediments of newly taken Core-3 (870 cm long) from Varna Lake (northeastern Bulgaria) is combined with multiproxy micropalaeontological analyses of dinoflagellate cysts, acritarchs, and other non-pollen palynomorphs (NPP), including fossil algal and fungal remains. The location of the core is close to several submerged praehistorical sites and the Varna Chalcolithic Necropolis, and permits more precise palaeoecological correlations of obtained results with available archaeological and geochronological data. The established Age vs. Depth Model shows that the formation of the lake started after 7870 cal. BP due to a rise of the Black Sea level, also known as the First Phase of the Vityazevyan Black Sea Transgression. After ca. 94 y, the Second Phase of the Vityazevyan Black Sea Transgression is registered by a major change in the sedimentation and formation of molluscan shell hash layer of *Mytilus galloprovincialis* that covers the interval 7776 to 6183 cal. BP. Mixed oak and hornbeam forests dominated the vegetation cover during the Atlantic, Subboreal and Subatlantic chronozones of the Holocene. An important change in the forest composition occurs at ca. 5518 cal. BP, when *Carpinus betulus* reached its maximum spread due to a climate change. The high-resolution geoarchaeological reconstruction of palaeovegetation also reveals the extent of anthropogenic influence in the Varna Lake area, with deforestation and agricultural practice. Two periods of significant presence of pollen from cultivated cereals, and secondary anthropogenic indicators (weeds and ruderals) were identified. According to the available AMS-radiocarbon data, these periods correspond to the Late Eneolithic and Early Bronze Age. The Transitional period without human activities between these two archaeological periods lasted ca. 319 y and coincides with a rise of the Black Sea level, reflected by the increase of euryhaline marine dinoflagelate cysts *Lingulodinium machaerophorum* and *Spiniferites belerius*, and acritarchs *Cymatiosphaera globulosa* and *Micrhystridium* cf. *ariakense* during the First Phase of the Kalamitian Black Sea Transgression. The increased values of *Corylus* coincidently with decrease of *Quercus* and *Ulmus* suggest clearance of forests and enlargement of arable areas during the Late Eneolithic. The NPP-record of spores of coprophyllous fungi *Cercophora*, *Sordaria*, *Podospora* and *Chaetomium* indicates the presence of domestic animals during the Early Bronze Age. The maximum of *Alnus*, *Ulmus*, *Fraxinus excelsior*-type and *Fagus* pollen at 717 cal. BP suggests an increase of humidity and cooling of climate during the Subatlantic.

1. Introduction

Over the last decades, archaeologists have faced the necessity to reconstruct ancient settlement history not only through the study of the material excavated, but also with the use of palaeoenvironmental parameters. The coastal lakes offer great possibilities for geoarchaeological studies of the Holocene sediments as reliable source of rich biostratigraphic information in order to trace out the palaeoecological changes and human impact on the natural vegetation. Pollen records could be useful to detect the human impact in several ways (Birks and Birks, 1980). Declines in arboreal pollen frequencies may hint at woodland clearances (Behre, 1981). Crop fields may be inferred from the occurrence of cereal pollen and weeds of arable lands such as *Centaurea cyanus*, while grazing pressure may show up as an increase in disturbance

* Corresponding author.
E-mail addresses: marianafilipova@yahoo.com (M. Filipova-Marinova), danailpavlov@gmail.com (D. Pavlov), lgiosan@whoi.edu (L. Giosan).

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indicative pollen types such as *Plantago lanceolata* and *Polygonum aviculare* along with a general increase in herbaceous pollen diversity (Birks and Line, 1992).

The Holocene vegetation history of the Bulgarian Black Sea coastal area was previously described by Filipova-Marinova (2006a,b). The studied cores were taken from coastal lakes and Black Sea shelf, continental slope and deep-water zone. Several trends in vegetation dynamics were traced based on the latitude, attitude, and local climatic and orographic features of the corresponding sites and the migration routes of the main arboreal species. The early Holocene forest development follows the Late Glacial steppe period dominated by non-arboreal communities of *Artemisia* and Chenopodiaceae (Atanassova, 1995, 2005; Filipova-Marinova, 2003). The transition to higher arboreal pollen values occurs at the Late Glacial/Holocene boundary, and the common taxa are *Quercus, Corylus,* and *Alnus*. During the last ca. 7000 years, the forest composition remains comparatively stable except for the migration of some temperate species and changes caused by human influence (Filipova-Marinova, 2006a,b).

For the northern Bulgarian Black Sea coastal area, palaeoecological data were retrieved from Durankulak Lake (Bozilova and Tonkov, 1985, 1998; Marinova, 2003; Marinova and Atanassova, 2005; Tonkov et al., 2014), Shabla-Ezeretz Lake (Filipova, 1985), as well as the Varna-Beloslav Lake system (submerged praehistorical settlements near Strashimirovo and Povelyanovo, and the Arsenala area) (Bozilova and Filipova, 1975, 1986; Bozilova and Ivanov, 1985; Bozilova and Beug, 1994). In general, the pollen diagrams show a steppe phase at the beginning of the Holocene with the prevalence of xerothermic and halophilous herbaceous communities composed by *Artemisia*, Chenopodiaceae, Asteraceae and Poaceae species, followed by a forest-steppe phase during the Holocene climatic optimum (Atlantic), characterized by the presence of deciduous forests (*Quercus, Corylus, Tilia, Carpinus betulus*).

Several stages of development of the Varna-Beloslav Lake system were delimited by Bozilova and Beug (1994), based on the character of sediments, hydrological conditions and radiocarbon dates. The palaeoecological data offered an opportunity for drawing a conclusion about the influence of the climate on the Black Sea transgressions and regressions and other palaeoenvironmental conditions. Based on a complex palaeobotanical and archaeological studies, the human influence on the natural vegetation was also traced-out. *Quercus* forests with some *Fraxinus* and *Fagus* are dominant in Preboreal and Boreal (Bozilova and Filipova, 1975; Bozilova and Beug, 1994). The destructive changes in the vegetation during the Middle Holocene (Eneolithic Age) were associated with the increased human impact (Bozilova and Ivanov, 1985; Bozilova and Filipova, 1986). Unfortunately, because of the lack of AMS- radiocarbon dates, precise and high-resolution geochronology was not established and it was not possible to correlate adequately the results with archaeological chronology. On the other hand, laminated sediments (varves) are not studied palynologically from the upper-mentioned sites.

With a view to addressing these unresolved questions, a new Core-3 with laminated sediments from the Varna Lake was dated by AMS-radiocarbon dating and an Age vs. Depth Model was created. The core was analysed for pollen, spores, dinoflagellate cysts, arcritarchs and other non-pollen palynomorphs. The main results of this high-resolution palaeoecological study are discussed aiming to throw additional light on climate and sea level changes, and vegetation dynamics during the Holocene. The aim is also to get more detail information about the human impact particularly during the Late Eneolithic and Early Bronze Age. The obtained geoarchaeological information is comparable with the results from the previous palaeoecological studies, the available archaeological evidences and radiocarbon chronology.

2. Regional setting

2.1. Physical and geological characteristics of the area studied

Varna Lake (43°11′25″N, 27°49′30″E – 43°12′28″N, 27°53′00″E) is the largest by volume and deepest firth along the northern Bulgarian Black Sea coast (Fig. 1) with area of 17 km^2, maximal depth of 19 m, and water volume of 166 million m^3. The lake is formed at the river valley after a rise of the Black Sea level during the Holocene. Nowadays, it is separated from the sea by the constantly growing Asparuhovo sand spit (Dachev, 2003). Varna Lake has an elongated shape, as its southern coast is high and steep, while the northern one is quite slant. Generally, its bottom is covered with thick (up to 10–30 m) alluvium deposits, which at the deepest parts passed into black hydrogen-sulphide silts. The topography of the lake is characterized by a number of valleys reaching from 30 to 120 m in width (Ivanov et al., 1964). This basin was a fresh-water lake with a limited flow into the Black Sea, supplied by groundwater and inflowing rivers until it was modified to a brackish lagoon due to a connection with Varna Bay through artificial channels after 1909. As a result, the salinity of the water subsequently rose to 15–16‰. The watershed belongs to an area with continental influence on the regime of the river water runoff and it is a sub-area with prevalent rainfall nourishment. The northern coast of Varna Lake is characterized with significant influence of groundwater nourishment (Stanchev et al., 2010).

2.2. Climate

According to Velev (2002), the Bulgarian Black Sea coast belongs to the Continental-Mediterranean climatic area and is strongly influenced by the proximity of the sea. Prevailing winds are northeasterly, and the annual precipitation is about 450–500 mm, with a maximum in June and a minimum in February. Mean annual temperature is 12 °C. Mean January temperature is 0 °C, and in July, it is 22 °C.

2.3. Recent vegetation

According to Bondev (1991), the study area of Varna Lake is part of the Black Sea region of the Euxinian province of the European deciduous forest area. The natural vegetation is characterized by dominance of xerothermic mixed oak and hornbeam forests, mainly *Quercus cerris* L., *Q. frainetto* Ten., *Carpinus betulus* L., *Tilia tomentosa* Moench and *Acer campestre* L. Reed formations along the lake are dominated by *Phragmites australis* (Cav.) Trin. ex Steud., *Typha latifolia* L., and *Typha angustifolia* L. Aquatics include *Zostera marina* L., *Potamogeton pectinatus* L. and *Potamogeton perfoliatus* L. The region is almost completely deforested at present and it is used for arable farming.

2.4. Archaeological background

There are no traces of human life in the area of Varna Lake during the Neolithic. The inhabitants reached their cultural and economic bloom in the late second half of the Vth millennium BC. Their material abilities and spiritual life differed from that of their neighbours, and this gave reason for development of a separate independent Late Eneolithic archaeological culture, named Varna (Todorova, 1985). The economic rise is associated with knowledge and mastery of the metallurgy of copper and gold, and the strengthening of trade contacts with the lands to the north and south. Intensive development of metalworking and trade led to the emergence of specialized groups, such as miners and blacksmiths,