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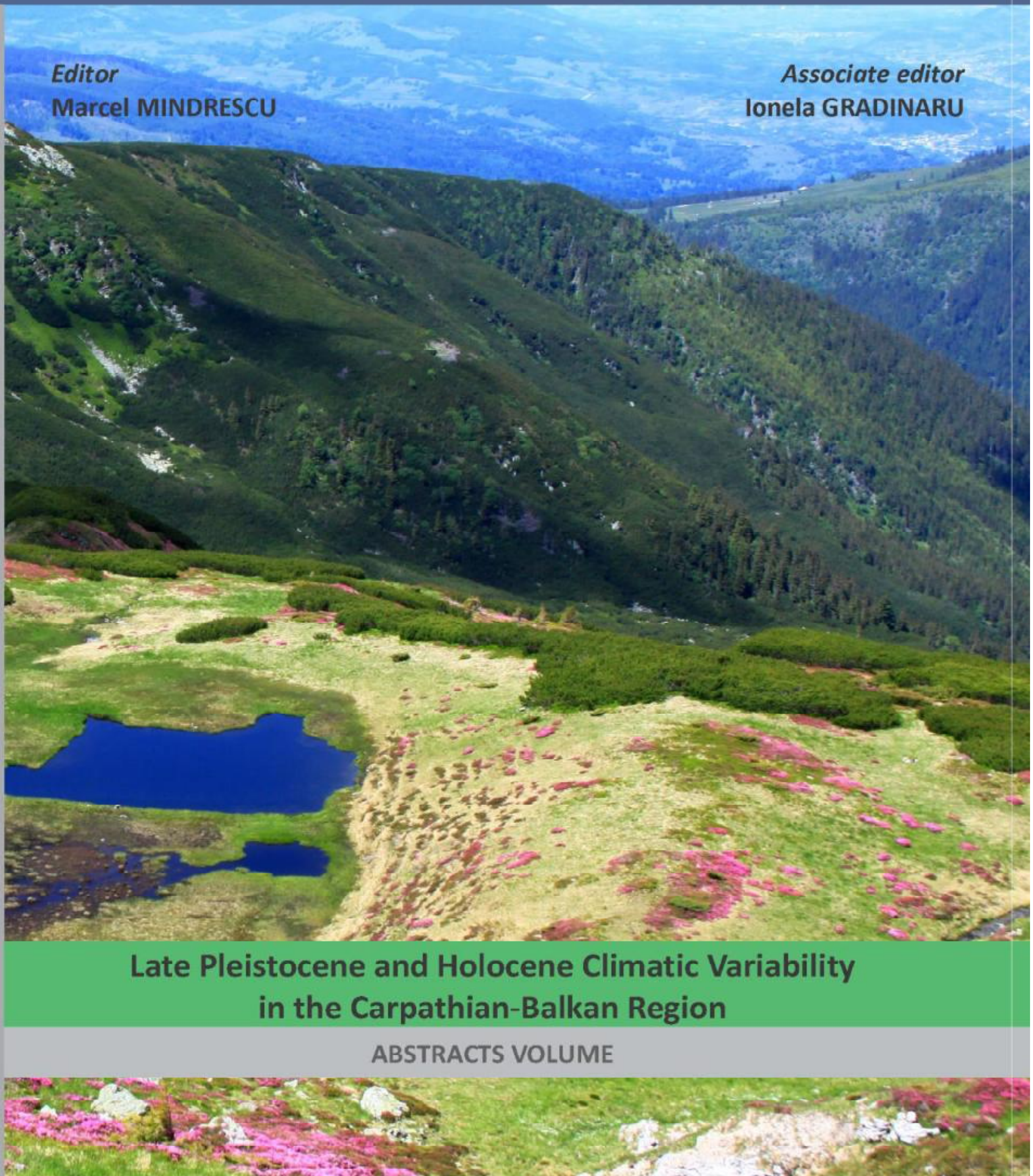

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Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

ABSTRACTS VOLUME

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Late Pleistocene and Holocene climatic variability in the Carpathian-Balkan region. Abstracts volume

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Palaeoecology and geoarchaeology of the Varna Lake, northern Bulgarian Black Sea coast

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The coastal lakes are rich sources of biostratigraphic information that is very useful in palaeoecological reconstructions of climate changes and human impact on the natural vegetation. This information is of great importance for the archaeological descriptions of submerged praehistorical settlements found in the northern Bulgarian Black sea area. There are 4 archaeological sites in this area that have been palynologically studied for the last 30 years: the Durankulak Lake, the Shabla-Ezeretz Lake system, the Lake Bolata, as well as the Varna-Beloslav Lake system. Because of the lack of AMS radiocarbon dates for these sites, it was not possible to correlate adequately all palaeoenvironmental results with the available archaeological chronology.

Aimed to receive additional information on the Holocene vegetation dynamics and lake level changes, as well as on the anthropogenic impact during the Late Eneolithic and Early Bronze Age, the high-resolution spore-pollen analysis of AMS dated laminated sediments from a new Core 3 – Varna Lake was combined with analyses of dinoflagellate cysts, acritarchs, and other non-pollen palynomorphs.

The location of the core is close to several sites of submerged praehistorical settlements and the Varna Late Eneolithic (Chalcolithic) Necropolis, which is famous with the oldest hand-made gold treasure in the Worlds, and permits the palaeoenvironmental correlations of obtained results with available archaeological and geochronological data. The core is 995 cm long, but its palynologically investigated length is 870 cm. It contains dark grey clay and laminated sediments (varves). Seven samples of sediments were submitted for radiocarbon dating to the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) Facility of Woods Hole Oceanographic Institution (WHOI). The dates have been calibrated using the program CALIB version 6.1.0 of using the IntCal09 curve. An Age Model for the sedimentation rate was created by the newest version 1.17.16. of the TILIA software.

Thirty-five samples for spore-pollen analysis were processed according to the standard acetolysis laboratory method, slightly modified to remove the mineral components with sodium pyrophosphate and hydrofluoric acid. One-hundred-and-seventeen taxa have been determined. The dinoflagellate cysts and other NPP were counted in the samples prepared for routine spore-pollen analysis. The percentage values of the pollen taxa were calculated on the basis of AP + NAP pollen sum (arboreal plus non-arboreal plants excluding spores, aquatics, dinoflagellate cysts and other algae, acritarchs, and other NPP), and a spore-pollen diagram has been plotted (Fig. 1). The frequency of the dinoflagellate cysts and NPP is also presented in percentages based on this pollen sum. The percentage spore-pollen diagram of Core-3-Varna Lake is divided into three local pollen assemblage zones (LPAZ) and five subzones (LPASZ) to facilitate description and understanding of vegetation palaeosuccession. Version 2.0.1. of TGVIEW software was used for all percentage pollen calculations. Cluster analysis program CONISS was applied for more precise zonation as well as the Blytt-Sernanders' northerneuropean climatostratigraphic subdivision of the Holocene, the regional archaeological chronology, the regional palynostratigraphy, and pollen data of cores from submerged praehistorical settlements from the southern Bulgarian Black Sea coast were used for the correlations of assemblages (Table 1).

The established Age Model and the high percentage values of marine dinoflagellates *Lingulodinium machaerophorum* and *Spiniferites belerius*, as well as acritarchs *Cymatiosphaera globulosa* shows that the accumulation of lake sediments started after 7870 cal. BP and is connected with a rise of the Black Sea level during the First Phase of the Vityazevyan Transgression. Most probably, the Provadiyska River valley was submerged and turned into firth, connected with the sea.

The vegetation palaeosuccession started from 7870 cal. BP and could be correlated to the Early Atlantic chronozone of the Holocene. Mixed oak forests were widespread and reached their maximal distribution. The extremely high values of arboreal pollen suggests dense forests dominated by *Quercus* with abundant other temperate species such as *Ulmus*, *Corylus*, *Tilia*, *Carpinus betulus*, *Fraxinus excelsior* and *Fagus*. The presence of indicator species such as *Hedera* suggests high humidity and temperature. Single pollen grains of *Juglans* found in this subzone confirm that the walnut was preserved along the Bulgarian Black Sea coast during the Late Glacial.

After a short time of ca. 94 yrs, a change in sedimentation and formation of molluskan shell hash layer of *Mytilus galloprovincialis* Lamarck occurred after ca. 7776 cal. BP during the Second Phase of the Vityazevyan Black Sea Transgression.

According to the AMS date 5360±50 yrs BP, the palaeoecological record of the subzone *Vn-1b* corresponds to the Late Eneolithic. Arboreal taxa are presented with lower percentage values compared to the previous *LPASZ* Vn-1a, despite the increase of humidity and temperature indicated by the presence of *Hedera*. Human impact was the main reason for deforestation. The appearance of *Carpinus orientalis* and *Fraxinus ornus* is connected with degradation of forests due to a strong anthropogenic influence. The increased values of *Corylus* coincidently with decrease of *Quercus* and *Ulmus* also suggest clearance of forests and enlargement of arable areas.

The absence of microcharcoals and fungal spores of *Neurospora* during the interval of deforestation provide evidence for clearance of oak woodlands by cutting. This is also confirmed by archaeological finds of stone tools such as axes and adzes from the Varna Lake area for that period. Palynological data confirm the archaeological information that agriculture was the basis of Late Eneolithic economy along the Bulgarian Black Sea coast. Significant pollen percentages of cultivated cereals including *Cerealia*-type and *Triticum*, and to a lower extent *Hordeum* are registered. Weeds such as *Centaurea cyanus*-type and *Papaver* are also presented. Ruderals *Plantago lanceolata*, *Polygonum aviculare*, Cichoriaceae, *Carduus*-type and *Urtica* confirm well-developed farming, pasture formation, and stockbreeding. The high anthropogenic influence on the palaeoenvironment is also confirmed by dung indicators such as *Podospora*-type, *Cercophora*-type, *Sordaria*-type, and *Chaetomium*.

The low percentage values of marine dinoflagellate cysts *Lingulodinium machaerophorum*, the presence of coenobia of *Pediastrum boryanum*, and pollen of aquatic species such as *Myriophyllum spicatum* and *Potamogeton* suggest the brackish-water environment and shallow open relatively eutrophic waters during the Late Eneolithic. The Black Sea level was low and soils around the Varna Lake were humid, rich in humus and suitable for cultivation during this time of inhabitance of the area.

The AP/NAP ratio of *LPASZ Vn-2a* suggests enlargement of area covered by mixed oak forests. A characteristic feature is the significant increase of *Carpinus betulus* after the decrease of *Quercus* at ca. 5598 cal. BP. The decrease of pollen of cereals and other anthropogenic species such as *Plantago lanceolata*, *Polygonum aviculare*, Cichoriaceae, *Carduus*-type and *Urtica* and the gap in human activities confirm a cultural hiatus of ca. 319 yrs between the Late Eneolithic and Early Bronze Age.

The maximum values of cysts of euryhaline marine dinoflagellates *Lingulodinium machaerophorum* and *Spiniferites belerius,* acritarchs *Cymatiosphaera globulosa* and *Micrhystridium* cf. *ariakense*, as well as Foraminifera at 5598 cal. BP suggest influx of marine waters and increase of salinity in the brackish-water lake. Most probably, the sea level became higher and influenced the Varna Lake area during the First Phase of the Kalamitian Black Sea Transgression. This supports the assumption that settlements near the Varna Lake were abandoned. According to the archaeological chronology this subzone corresponds to the Transitional Period (Posteneolithic, Protobronze) of the northern Bulgarian Black Sea coast. For the southern part of the Bulgarian Black Sea coast and especially for the area of submerged praehistorical settlement in the harbor of Sozopol the same period is about 650 years.

LPASZ Vn-2b is marked by another decrease of arboreal vegetation with re-expansion of cereals and anthropophytes. Low values of AP could be explained as a succession, related to a climate change during the Subboreal, but also as an indicator of strong human impact. The decrease of AP mainly of *Quercus* and the constant presence of *Carpinus orientalis* could be associated with degradation of the mixed oak forests. The maximal presence of cultivated cereals *Cerealia*-type, *Triticum* and *Hordeum* marks their significant abundance and indicates the intensity of human impact. Cereal crop weeds such as *Centaurea cyanus*-type and *Papaver* also occur in the pollen record and are most probably connected with wheat cultivation. The increase of secondary anthropogenic indicators suggests stockbreeding and enlargement of meadows and pastures.

Additional evidence for grazing comes from the dung-inhabiting taxa. The record of spores of these coprophyllous fungi indicates the presence of domestic animals. The maximum of coenobia of *Pediastrum boryanum* that is dominant in brackish waters with salinity of 6 – 8 ‰ could be connected also with human impact. The occurrence of NPP such as algal spores, *Valsaria variospora*-type and *Diplotheca rhizophora* indicates eutrophic conditions and shallow open waters. The presence of fungal cells and ascospores which proliferate on drying sediments and dead plant remains indicate low lake level during the growing season as well. The increase of local elements such as *Typha*/*Sparganium*, *Typha latifolia*, Cyperaceae, *Alisma*, *Potamogeton*, *Myriophylum spicatum* and *Polygonum persicaria* during this period is probably also connected with lowering of the water level.

The decrease of dinoflagellate cysts *Lingulodinium machaerophorum* and acritarchs *Cymatiosphaera globulosa* indicates that after the Transitional period the Black Sea level started to decrease and make area around the Varna Lake inhabitable again. The soil was damp and settlers needed to build their dwellings on wooden platforms.

The AMS-radiocarbon date 3030±50 yrs BP, the characteristic vegetation succession and the maximum values of acritarch *Pseudoschizaea circulata* that is characteristic for the Late Holocene marine sediments, allow the correlation of zone *LPASZ Vn-2c* to the end of the Subboreal and the beginning of the Subatlantic. Mixed oak and hornbeam forest were still dominant. The main characteristic feature is the increase of *Ulmus* togenther with the increase of *Hedera* as indicator of increased humidity. The human impact during this period could be associated with the Late Bronze Age, when a decrease of percentage values of *Cerealia*-type, *Hordeum* and other anthropogenic indicators is registered. Dung indicator species decrease at the same time as coenobia of *Pediastrum boryanum* and confirm a decrease of intensity of human impact. Spores of *Glomus* that occur on roots of variety of arboreal host plants indicate erosion of soils in the catchment of the Varna Lake.

The marine dinoflagelate cysts of *Lingulodinium machaerophorum* and *Spiniferites belerius* and acritarchs *Cymatiosphaera globulosa* are regularly presented together with *Typha/Sparganium*, *Typha latifolia*, Cyperaceae, *Potamogeton* and *Myriophylum spicatum* that are tolerant to brackish-water conditions. At the end of the subzone, the increase of marine dinoflagelate cysts suggests a significant marine influence.

LPAZ Vn-3 reflects vegetation dynamics during the Subatlantic. The most characteristic feature is the formation of the recent vegetation communities along the coast. Mixed oak and hornbeam forest decrease probably due to the human impact during the Iron Epoch. This is confirmed by the increase of cereals and other anthropophytes such as *Plantago lanceolata, Polygonum aviculare,* and *Filipendula.* Most probably, *Carpinus orientalis* enlarged its spreading in the areas covered by oak after their degradation. The increase of *Alnus*, *Ulmus*, *Fraxinus excelsior* and *Fagus* is due to the increase of humidity and cooling of climate as suggested by the presence of single pollen grains of *Hedera*, *Vitis*, *Humulus/Cannabis*-type and *Ephedra*. This is connected with the formation of riverine-flooded forests along the river valleys of the Bulgarian Black Sea coast.

The sharp decrease of marine dinoflagelate cysts together with the presence of cysts of stenohaline dinoflagelate *Spiniferites cruciformis* coincides with the decrease of sea surface salinity of the Black Sea waters.

The main conclusions that could be drawn are:

(1) The lake sedimentation started after ca. 7870 cal. BP due to an increase of the sea level during the First Phase of the Vityazevyan Black Sea Transgression;

(2) The formation of molluskan shell hash layer of *Mytilus galloprovincialis* occurred after 7776 cal. BP during the Second Phase of the Vityazevyan Black Sea Transgression;

(3) The vegetation cover was dominated by mixed oak forests during the Early Atlantic;

(4) An important change in the forest composition occurred at ca. 5598 cal. BP, when *Carpinus betulus* increased its spreading due to a climatic change;

(5) The anthropogenic impact on the natural vegetation has been identified by micropalaeontological indicators of deforestation and agricultural practice for the Late Eneolithic and Early Bronze Age;

(6) The Transitional Period without human activities lasted ca. 319 yrs and is connected with the increased Black Sea level after ca. 5598 cal. BP during the First Phase of Kalamitian Black Sea Transgression.

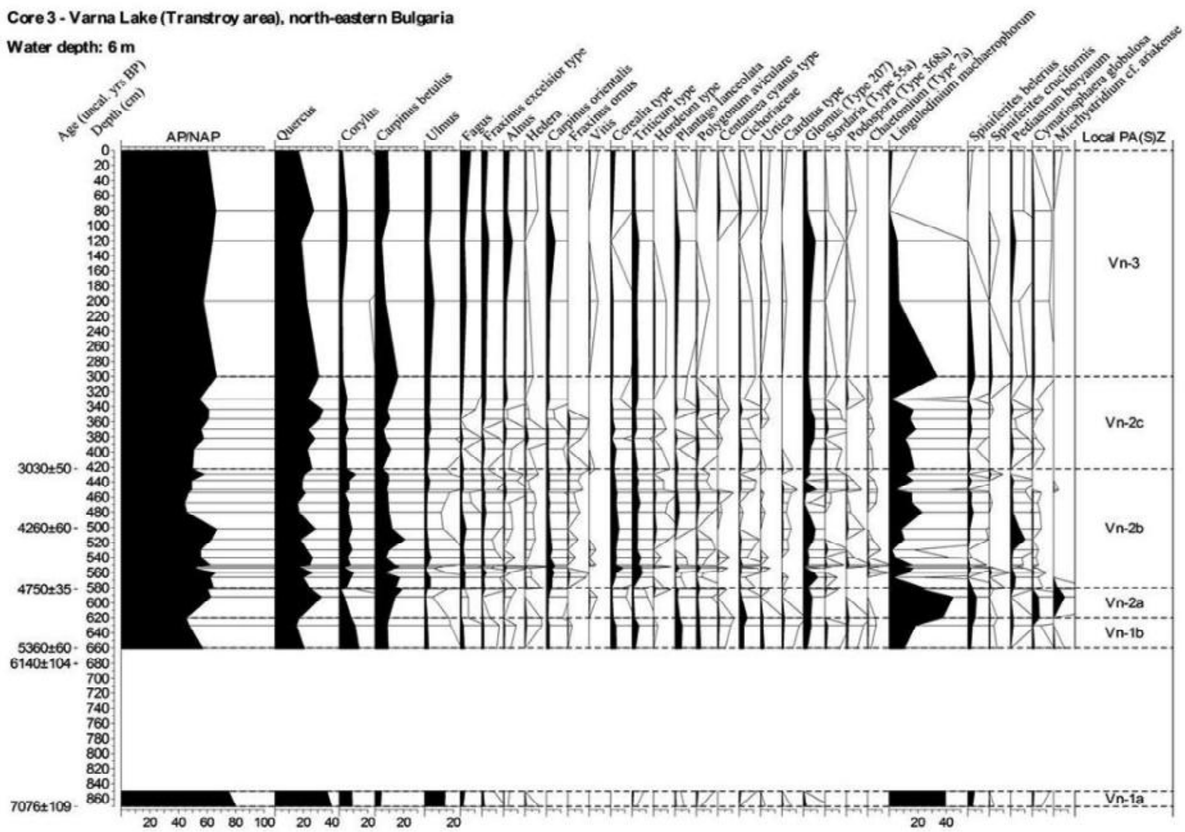

Fig. 1 Simplified percentage spore-pollen diagram of Core 3 - Varna Lake (analyzed by M. Filipova-Marinova)

Table 1 Correlation of local pollen assemblage zones from Core 3 – Varna Lake and pollen data of cores from submerged praehistorical settlements from the southern Bulgarian Black Sea coast, the regional Black Sea palynostratigraphy, the regional archaeological chronology, and Blytt-Sernanders' northerneuropean climatostratigraphic subdivision of the Holocene

uncal. kyrs. BP	Northerneuropean climatostratigraphy of Blytt – Sernander		Archaeological chronology	Regional pollen assemblage zones (PAZ)		**Varna Lake-3** Local PAZ	**Varna Lake-3** Pollen assemblages	Urdoviza-F Local PAZ	Urdoviza-F Pollen assemblages	Sozopol-D Local PAZ	Sozopol-D Pollen assemblages	Sozopol-I Local PAZ	Sozopol-I Pollen assemblages	Sozopol-F Local PAZ	Sozopol-F Pollen assemblages
3	HOLOCENE	Subatlantic	Iron Epoch	IX	*Q-U-Al-Cb-Sa-F*	3	*Q-U-Al-F-Cor-Tr*							4	*Q-Cb-Co-U-F-Al*
						2c	*Q-Cb-Co-U-Tr-Ce*					4	*Q-Cb-Co-U-F-Tr*	3	*Q-Cb-Co-F-Cor-Ce*
5		Subboreal	Bronze Age	VIII	*Q-Cb-Co-F-Cor-Ce*	2b	*Q-Cb-Co-F-Tr-Ce*	2	*Q-Cb-F-Ce*						
		Atlantic	Transitional Period	VII	*Q-Co-Cb-U-Tr-Ce*	2a	*Q-Cb-Co*	1	*Q-Cb-Co-F-U*			3	*Q-Co-Cb-Ti-F*	2	*Q-Cb-Co-U-F*
			Eneolithic			1b	*Q-Co-Cb-Tr-Ce*			2	*Q-Po-Tr-Ce*	2	*Q-Ti-F-Po-Tr*	1	*Q-Co-Cb-Ce*
						shell hash				1	*Q-Co-Cb-U-F*				
8			Neolithic			1a	*Q-U-Co*								