

FOSSIL HUMUS MUD AND ITS NOVOCHERNOMORIAN BASE AT THE ATANASOVSKO LAKE, BURGAS LAKES COMPLEX, BULGARIA

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ABSTRACT. Fossil humus mud horizon covering Novochemomorian beach deposits crops out at the eastern shoreline of the Atanasovsko Lake 1 m above the modern lake surface. It is identified by the Nymphaean accumulative terrace, formed during the Middle Ages about 1000 years ago, when the Black Sea surface was 2 m above the present sea level. The mud sediments are underlined by sandy-clayey-silty deposits that are considered to be bottom lake deposits which represent evidence of post Kalamitian sea-level decrease. In depressions such as the Burgas bay, part of which were the Burgas Lakes at that time, these deposits are commonly 2–4 m thick. Obviously, during the Late Kalamitian age the central part of the Burgas bay was a submerged shoreline with a sandy-clayey-silty sedimentation. Novochemomorian (Dzhetmetinian) sediments are deposited in shelf environment when the Black Sea level was slightly higher compared to the present sea level. The boundary between the sands and the overlying humus mud is a clear erosion surface 1 m above the present lake level formed during the Fanagorian regression, when the sea level dropped. The humus is 1 m thick with shells of modern fauna, characteristic for the present humus mud in the Atanasovsko Lake.

Keywords: Atanasovsko Lake, Late Chemomorian deposits, fossil humus mud

ФОСИЛНА ХУМУСНА КАЛ И НЕЙНАТА НОВОЧЕРНОМОРСКА ПОДЛОЖКА В АТАНАСОВСКОТО ЕЗЕРО, БУРГАСКИ ЕЗЕРЕН КОМПЛЕКС, БЪЛГАРИЯ

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РЕЗЮМЕ. На източния бряг на Атанасовското езеро се разкрива фосилен хумусен хоризонт, покриващ Новочерноморските отложения на 1 m над съвременната повърхност на езерото. Той се идентифицира с акумулационната Нимфейска тераса, образувана през Средновековието преди около 1000 години, когато повърхността на Черно море е била с 2 m над съвременното морско ниво. Той се подстила от пясъчливо-глинесто-алевритови отложения, които се считат за дънни езерни утайки, представляващи доказателство за следкаламитско понижение на морското ниво. В депресии като Бургаския залив, част от който по това време са и Бургаските езера, тези отложения обикновено са с дебелина 2–4 m. Очевидно, по време на Късноаламитската епоха централната част на Бургаския залив е била потопена брегова линия с пясъчливо-глинесто-алевритова седиментация. Новочерноморските (Джетметински) седименти се отлагат в шелфова обстановка, когато нивото на Черно море е малко по-високо от сегашното. Границата между пясъчливо-алевритовите утайки и покриващия ги хумусен слой на 1 m над сегашното ниво на езерото е рязка и вероятно е образувана по време на Фанаторийската регресия, когато морското ниво спада. Хумусът е с дебелина 1 m и съдържа черупки от съвременна фауна, характерни за днешната хумусна кал в Атанасовското езеро.

Ключови думи: Атанасовско езеро, късночерноморски отложения, фосилна хумусна кал

Introduction

Identification of Quaternary sea terraces along the sea coast and lake shores is part of the preliminary studies on the creation of Geopark "Burgas Lakes". The Atanasovsko Lake, which is part of the Burgas Lakes Complex, is the subject of investigation because of its interesting Holocene development as a firth basin. Due to their connection with the Black Sea basin, the Burgas Lakes have been sensitive to the sea-level changes during the last 7000 years when at least two transgressive-regressive stages occurred.

The present investigation is devoted to fossil humus deposits cropping out near the Atanasovsko Lake, located 2 m

above the modern sea level and considered to be part of the Nymphaean accumulative terrace.

Location

The outcrop is located on the eastern shoreline of the Atanasovsko Lake on the canal linking the lake with the Black Sea in the area called "Kyusheto" (Fig. 1). This outcrop was mentioned in our short communication published in the proceedings of last years' scientific conference "Geosciences" of the Bulgarian Geological Society (Sinnyovsky et al., 2018)

dedicated to the Nymphaean terrace in the area of Burgas Lakes Complex.

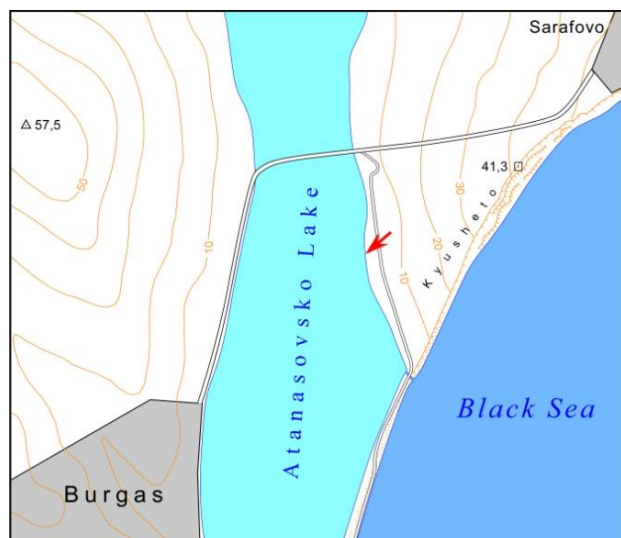


Fig. 1. Location of the investigated outcrop of the Nymphaean terrace on the eastern shoreline of the Atanasovsko Lake in "Kyusheto" area between the lake and the Black Sea

The accumulation of fine-grained deposits during the Nymphaean transgression is especially characteristic of the closed Burgas Lakes Complex. Its weak connection to the sea provided a calm environment for a clayey-silty sedimentation accompanied by humus deposits, characteristic of the modern deposits of the lakes. The outcrops of these factually modern deposits are very rare, because they are usually covered with soil and cane. For this reason, the artificial outcrop preserved on the canal slope provides good material for exploring the processes that took place during the high sea level during the Middle Ages.

Sea-level changes during the Late Chernomorian transgressive interval

The sea level rise during Novochernomorian transgression occurred at different speeds, with rapid rise periods alternating with periods of stagnation during which underwater terraces were formed (Larchenkov, Kadurin, 2011). According to these authors the Late Chernomorian transgressive interval is subdivided into two transgressive-regressive stages: Calamitian, between 7100 and 4100 years ago, and Dzhemetinian, between 4100 years ago and present days (Fig. 2).

The melting of the Wurm glaciers about 11000 years ago caused a massive influx of fresh waters to the Neueuxinian basin and marked the start of postglacial Novochernomorian Holocene transgression (Fedorov, 1976). The maximum sea level of the transgression in the Bronze Age (5600–4300 years ago) was 4–5 m higher than today. At that time the Novochernomorian terrace was formed, which is abrasive on the capes and accumulative in the bays (and firths such as the Atanasovsko Lake). Between 2500–1000 years ago during the so-called Phanagorian regression the sea level dropped to 3 m below the present sea level. The Nymphaean transgression (Fedorov, 1960), which occurred some 1000 years ago, raised the sea level up to 1.5–2.0 m above the present sea level, immersing many archaeological monuments along the Black Sea coast.

The firth sedimentation in the Burgas Lakes Complex resulted in accumulation of sandy-clayey-silty deposits and humus mud containing recent bivalve shells. After the sea level dropped to the modern sea level these deposits remained in the form of a flat terrace named after the Nymphaean transgression.

Transgressive interval		Transgressive-regressive stage	Time (ka)	Depth of sea (m)
Chernomorian	Late Chernomorian	Dzhemetinian	0-4.1	-2 to +2
		Kalamitian	4.1-7.1	-7.5
	Early Chernomorian	Vityazevian	7.1-8.9	10.5-12.5
		Bugazian	8.9-10.0	-25 to 22,5
Neueuxinian		Late Neueuxinian	10.0-18.0	-37 to -35
		Early Neueuxinian	18.0-30.0	-55 to -57

Fig. 2. Neoeuxinian and Chernomorian transgressive intervals and transgressive-regressive stages after Larchenkov and Kadurin (2011)

Table 1. Results of the granulometric analyses of two samples (Sample 1 and Sample 2 of the section in Fig. 4)

№ sample	Weight of sample g	Dissol. Comp. %	Undissol. Comp. %	Fractions [mm]			Granulometry		
				1–0.1	0.1–0.01	<0.01	psammite	silt	clay
				%	%	%	%	%	%
1	20.00	17.40	82.60	21.35	33.35	27.70	21.35	33.55	27.70
2	20.00	23.25	76.75	6.60	36.60	33.55	6.60	36.60	33.55

Results

The section of the sediments investigated includes 1 m carbonate-sandy-clayey-silty deposits, 20 cm carbonate-clayey silt and 1 m humus mud (Figs 3, 4).



Fig. 3. Outcrop of the Nympean sediments on the western slope of the channel near the Atanasovsko Lake

The granulometric analyses, represented in Table 1 revealed that the underlying sandy deposits (Sample 1 in Fig. 4) are sediments of mixed type, containing 17.40% carbonate and 82.60% insoluble residue, consisting of 21.35% psammite, 33.55% silt and 27.70% clay. According to this composition, the sample may be classified as carbonate-sandy-clayey hyposilt. The transitional interval (Sample 2 in Fig. 4) between the underlying sandy hyposilt and the overlying bituminous mud is composed of 20 cm yellow carbonate-clayey hyposilt composed of 23.25% carbonate, 33.55% clay, 36.60% silt and very low content of psammite component – only 6.60%.

The overlying black bituminous mud lies with an abrupt boundary over the carbonate-clayey silt. It contains shells of bivalves representing mainly the genus *Cardium*. These shells are not contemporaneous with the present shells of the genus because they are with dissolved inner and outer glaze layer.

The data from the granulometric analyses testify to a regime of fine-grained terrigenous sedimentation, which shows that Atanasovsko Lake had no broad connection with the sea, regardless of the higher sea level during the Nympean transgression. This is an evidence of sedimentation in a calm firth environment.

Right interpretation of the results is of important value for the future investigation of the Nympean terrace, which depends on the access to reliable outcrops. The first impression during the field investigation of the lake shoreline was that sediments underlying the humus mud can be related to the Novochernomorian beach sands. However, the laboratory analyses revealed rather complicated composition of the granulometric fractions.

The soluble component is in the frame of the normal contents, taking into account biotrititic enrichment of the beach deposits. The psammite/silt amount is also within the normal range. With respect to all the variety of beach environments, the high content of clay fraction is not characteristic for the beach sands. Regardless of the proximity of the sea, it is more likely that these sediments are deposited

at the bottom of the Atanasovsko Lake in conditions close to the modern environment.

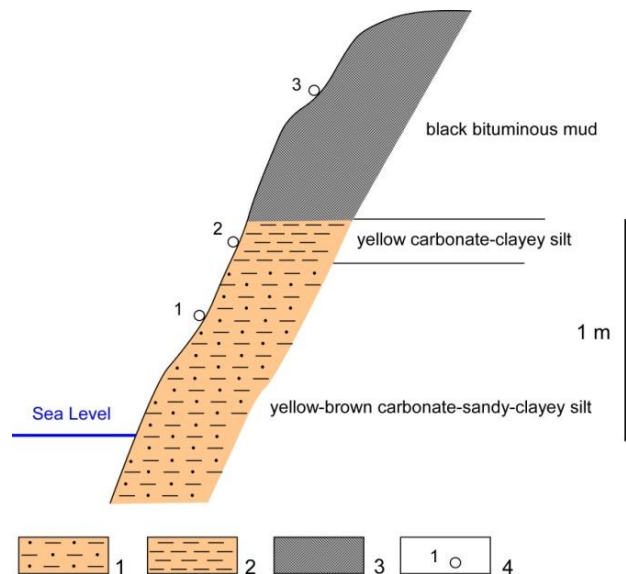


Fig. 4. Section of the Nympean terrace at the Atanasovsko Lake 1, yellow-brown carbonate-sandy-clayey silt; 2, clayey silt; 3, bituminous mud; 4, sample

In general, the drastic decrease of the sandy component in the next sample reveals sea level rise, corresponding probably to the Nympean transgression in the Middle Ages. The sea level rise should cause wider connection with the sea basin and better correspondence of the salinity between the lake and the sea.

Unfortunately, the total lack of outcrops does not allow successive investigation of this level, which can reveal more circumstances about the Nympean paleoenvironment in the Burgas Lake Complex and can give answers to many questions about the existence of the Nympean terrace. It is well outlined around the shoreline of the Burgas Lakes, forming a flat surface about 1.5–2 m above the lake water level covered by cane (Fig. 5).



Fig. 5. The Nympean terrace is well expressed at the northern shoreline of the Atanasovsko Lake, forming a flat surface covered by cane about 2 m above the water

As Fedorov (1985) noted, the assessment of sea level fluctuations is based on studying the hypsometric level of ancient coastlines, with particular attention to neotectonic movements and mollusc fauna. However, the morphological expression of this terrace is not enough proof for its existence. Because it is about an accumulation terrace, the evidence of medieval sedimentation in the area is very important.

The artificial exhumation of such sediments is a very rare event since they are not developed in the urban area of Burgas where construction works are being developed. The Nymphaean terrace is the result of a slight fluctuation at sea level, which is hardly noticeable along the coastline that falls within the hypsometric range of the modern wave zone (Sinnyovskiy et al., 2018). Its identification is easier along the shorelines of Burgas lakes, which are protected by the wave activity of the sea. Here, in many places, there are well-marked reed overgrown lobes lying 1.5-2 m above the water surface. They can be identified, with a high degree of reliability, to be with a higher level of the water surface in the limans that are connected to the Burgas Bay and they follow the sea level fluctuations. In some places, the lowest terrace level is formed between the modern lake surface and a well-known old cliff of Upper Cretaceous volcanic fundament of agglomerate and bomb tufts forming the ancient coastline (Fig. 6).



Fig. 6. The lowest terraced level near the Burgas Lakes is formed between the modern lake surface and a well-known old cliff of Upper Cretaceous agglomerate tufts and bomb tufts representing the ancient coastline

Finally, on the basis of archaeological data, the possible influence of sea level changes on late Holocene human societies of the Black Sea littoral areas was also documented. The aim of this investigation was to develop a basis for future investigations to link the geological events to the events engraved in human memory. There are many historical events confirming the higher sea level during the Middle Ages. Popov and Mishev (1974) cited historical facts from K. Škorpil, such as the position of the Asparuh Shaft in Northeast Bulgaria, which was built near the shoreline and now it is 600 m away from the modern coastline. There is also an evidence of swamping of the area between Varna and Asparuhovo quarter when the knights of Vladislav Varnenchik sunk with their

horses in the swamps in the battle during the Varna Crusade in 1444.

This historical evidence corresponds to the data from numerous points of the Black Sea coastline about the higher sea level during the Middle Ages.

Conclusions

The available evidence of modern transgressive deposits at the Atanasovsko Lake strongly suggests a sea level rise during the Middle Ages period that caused accumulation terrace around the shoreline of the Burgas Lakes. This sea level rise is related to the so called Nymphaean transgression. In the final Dzhemetinian transgressive-regressive stage of the Late Chernomorian transgressive interval the sea level rise caused carbonate-sandy-clayey hyposilt sedimentation which ended with humus deposits, elevated 1.5 m above the present sea level. The granulometric analyses show a fine-grained terrigenous sedimentation, which is an evidence that Atanasovsko Lake had no broad connection with the Black Sea, regardless of the higher sea level during the Nymphaean transgression. This has contributed to sedimentation in a calm firth environment. The present study of the youngest Holocene deposits in the Burgas Lakes Complex provides a basis for scientific investigation of the last transgression in the geological history.

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