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MĚKKÝŠI PLISTOCENNÍ A HOLOCENNÍ MARINNÍ TERASY
ČERNÉHO MOŘE U BALČIKU V BULHARSKU A MARINNÍ MĚKKÝŠI
BULHARSKÉHO PLISTOCENU

THE MOLLUSCS FROM ONE PLISTOCENE AND ONE HOLOCENE
TERRACE OF THE BLACK-SEA AT BALČIK IN BULGARIA
AND THE MARINNE MOLLUSCS OF THE BULGARIEN PLISTOCENE

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J A R. P E T R B O K

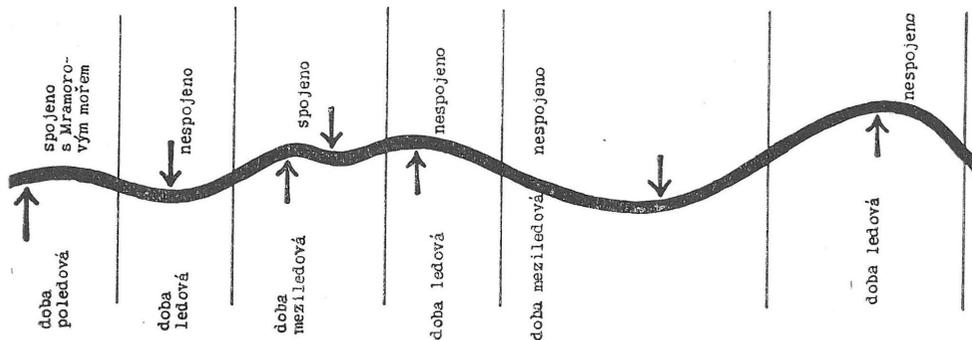
**Měkkýši plistocenní a holocenní marinní terasy
Černého moře u Balčiku v Bulharsku a marinní měkkýši
bulharského plistocenu**

**Две морские террасы Черного моря в близи Балчика
в Болгарии**

(Předloženo 18. I. 1951.)

Po prvé byli skutečně plistocenní marinní měkkýši Bulharska zjištěni teprve 1924—5 a to na Galatě u Varny, 1927 u Mesemvrie-Nesebru a u Ses Sevmes. Ale tu běželo pouze o marinní conchylie větrem do plistocenních spraší zavlečené, nikoli o marinní - terasové - sedimenty plistocenní. Ty byly tedy v Bulharsku nalezeny mnou po prvé a to u Balčiku v Tuzle 1949. Studovaná terasa jde do výše asi 20 metrů a je asi jeden km dlouhá. Nedovedu ji vložit do přesného horizontu plistocenního a to proto, poněvadž jednak není kryta jinými plistocenními vrstvami, jednak nemohu ji srovnat faunisticky s jinou známou dříve již horizontovanou prací jiných autorů, zejména ruských. Poněvadž není kryta spraší, kterou jsem na úbočí těchto strání nenašel — ač na náhorní rovině kolmo nad touto terasou jsou spraše i s ulitami suchozemských měkkýšů — nemohu tedy ani rozhodnout, patří-li tato terasová fauna marinní skutečně do zdánlivého interglaciálního stupně KARAN-GAT zvaného, anebo zda neběží snad o faunu mladší. Také na mysu KALIAKRA jsem po každé marinní plistocenní terasové sedimentaci pátral marně téhož roku, ač jsem měl k tomu podmínky co nejprůzračnější. Proto nezbyvá mi nic jiného, než spokojit se dnes tím, že prostě tuto faunu jako takovou zde registruji a každý další výzkum jsem nucen odkázat budoucnosti.

JARANOV sice tvrdí, že Varna leží na terase KARANGATSKÉ, ale toto své tvrzení neprokázal ani faunisticky, ani stratigraficky a soudil tak pouze morfologicky při pohledu s plovoucí lodi. Já jsem pátral marně po jakékoli terasové sedimentaci plistocenní ve Varně samotné i jejím okolí i v nejkrásněji otevřených profilech a našel jsem



The oscillation of the sea-level of the Black-Sea (according to Grahmann).
Oscilace vodní hladiny Černého moře.

pouze tercierní — snad lutetienské — terasy obnažené u pomníku Vladislava Varnenčika.

Grahmann vypracoval sice křivku oscilace vodní hladiny Černého moře, avšak každé takovéto kolísání vodní hladiny moře, je pouze výsledkem pohybu ker jeho vlastního dna. A tu nesmíme zapomenout, že není nezbytně nutno, aby se všechny ty kry pohybovaly ve stejném rytmu současně a proto není také nutno, aby všude na celém pobřeží byla ta která marinní terasa skutečně i zachována.

Víme velmi dobře, že někde jsou pohyby pobřežní čáry mnohem rychlejší, než jinde. Tak je tomu s pohybem pobřežní kry u Balčiku, kde je dnes pohyb nejprudší, kdežto v zátocě Varnenské je toho času nepatrný, nebo ustrnulý.

Je možno, že místy mohla být taková marinní terasa prostě následnými pohyby mořského dna i smyta. Nemáme pro to sice ještě dokladu, ale teoreticky to možno je, jak vidíme právě u Balčiku, kde na dně moře u samého pobřeží leží silou příboje sesuté trosky skal, na kterých se dá předpokládat terasa marinní. Zde totiž sjíždí ve vlnovitém tvaru velký kus břehu do moře. Tento pohyb je vyvoláván tektonickým děním a všechno ostatní, co se tu projevuje, jsou procesy následné.

Grahmannovu vlnovku „oscilace vodní hladiny“ Černého moře nesmíme tedy brát jinak, než jako důsledek pohybu ker a to periodického pohybu těchto ker dna a nikoli jako difference v kubickém obsahu vody jednotlivých geologických období.

V plistocenní marinní terase u Balčiku snažil jsem se sice vysbírat co nejvíce materiálu, ale i tak považuji tento svůj sběr za neúplný a to proto, že místy byl přístup k terénu pro kolmost břehu úplně nemožný.

Holocenní terasy moře na bulharském pobřeží jsou mnohem přístupnější, ale nevěnovali jsme jim dosud náležitou pozornost a tak nemáme přesného obrazu jejich fauny. To nám chybí právě při studiu této terasové asociace plistocenní. Ale i s těmito nedostatky je moje sdělení velkým, protože dnes jediným příspěvkem k poznání fauny plistocenních měkkýšů Černého moře.

*

В июне 1949 года, мной, впервые была установлена, как палеонтологическая, так и стратегическая морская болгарская терраса Плистоцени, в длине около одного километра и в ширине до 20 метров, вблизи селения Тузла недалеко Балчика. Её точный горизонт, как в палеонтологическом, так и в стратегическом смысле, мы ещё не можем определить, а то потому, что неимеем никаких сравнительных доказательств, но предполагаем впрочем, на некоторый последний Интерглюциал, возможно Карангат, но наши предположения остаются под вопросом оговорки. Решительно отвергаем так называемый Интерстадиал, где перемена в морской фауне произойти немогла.

Скалистый бок этой террасы в двух местах пробита сильными морскими волнениями, где возникло два прохода, которыми море вникло за скалистый берег и таким образом образовало залив, который все время имел сообщение с морем. В этот то залив и вникла морская фауна, по которой здесь остались в большинстве слизняки — следовательно Цопхылие. В этом новом просторе, залив нам оставил новую террасу, моложе вышеуведенной — предполагаемая Карангантская, с полным содержанием касающихся Цыпхилии. Это общество иное, чем в террасе вышеуведенной, хотя нельзя утверждать о перемене фауны. Возраст этой террасы можно было бы точно определить — сравнением с фауной Фоссильных, а то Голосенних террас в Несебру а волок Варненских, но за неимением материалов, невозможно произвести определения. Карангантская терраса Черного моря у Варны в 1940 году была предполагана Ярановым, но оказалась ошибочной, так как терраса небыла морской, но наносом речных щелбней, частью Лутетинской террасы открытой у памятника Владислава Варненчика, а частью валины с развалившихся слоев морского Сармата. У нас нет никаких доказательств как стратегических, так и палеонтологических находок на этом участке.

Терраса вблизи Балчика-Тузлы, оказывается, первой в Болгарии, установленной морской террасой Плистоцени.

The molluscs from one Plistocene and one Holocene Terrace of the Black-Sea at Balčik in Bulgaria and the marine Molluscs of the Bulgarian Plistocene

Though J a r a n o v,¹⁾ 1940, maintained that V a r n a lies on a Plistocene marine terrace of the so-called K a r a n g a t i a n, he did not prove the existence of this terrace either paleontologically or stratigraphically. Nor have I been able ever to do so, though I have tried to especially in 1948 and 1949 in the magnificently exposed and easily accessible sections on the B l a c k S e a coast. I did not find anywhere terrace material, not even gravels and sand or clayey sediments of the sea, just as marine conchyliia deposited at the time by the sea were nowhere to be found.

On an excursion with his students J a r a n o v once observed the low step on which V a r n a stands from the steamer on which they

travelled. He concluded simply from the site of the town morphologically to the existence of this assumed and up till now non-proved Plistocene terrace. Already in 1922 I showed in my sections that in Varna there are on the Sarmatian beds here and there nests of quartz pebbles. But these pebbles were not sedimented here in the Quaternary (i. e. at the time of the Karangatian, corresponding to the last Interglacial in Central Europe, i. e. to the Riss-Würmian-Plistocene). They are only surf accumulations derived from the locally exposed river terrace of probably Lutétian age, or were washed out by the surf from destroyed marine Tertiary sediments.

In them find marine conchylia set free by the disintegration of these sediments, i. e. from different stages of the local Tertiary. Thus they are not marine terrace sediments of the Black Sea of the Plistocene (here according to Jaranov of the Karangatian) or of another Plistocene period, though it is not a priori excluded that this secondary redistribution could take place in the Plistocene itself.

Nor does the literature until 1949 speak anywhere of Plistocene marine terrace on the Black Sea coast in Bulgaria. Of a Holocene marine terrace I speak for the first time in my article of 1938 ("Le développement de la baie de Nesebr") and I place these sediments in the Atlantic, or more correctly in the pre-subboreal Litorinian, just like the Varna ridge between the present Black Sea and the Varna Lake, in my article of 1948/9.

In 1932 I had found on the coast of the Black Sea up to about 15 meters, between Sozopol and the Arkutino Lake, also a slightly exposed, forest-covered marine terrace with a material of pebbles and sand, but as I did not find in it any paleontological material I did not speak of this terrace and left its exploration for a later year; then however because of the war I did not get back to the place.

Similarly I did not find on the coast of the Rumanian Dobrudja and the Black Sea coast of European Turkey any trace of a Quaternary marine terrace. Therefore I consider my find of June 1949 of Quaternary marine terraces at Balčik in Bulgaria to be the first for this area really proved paleontologically and stratigraphically.

There are here two terraces, one older, the other younger. The older one reaches to an estimated — not measured — height of 20 m., the younger one to an estimated height of 2 m. above the present level of the Black Sea and the so-called Tuzla Lake there, which in Turkish means salt, i. e. a salt lake.

The older, certainly Plistocene terrace has an estimated length of about one kilometer. Its ridge descends sometimes to 10 m., but it has in its whole length the same fauna.

I do not venture of course to determine the accurate Plistocene horizon of this marine terrace because of the lack of any personal knowledge especially of the Russian terraces; admission to the Russian coast was granted to me in autumn 1938, but the visit became impossible through the tragic political events in CSR. Further the whole literature on the marine Quaternary of the Black Sea does

not supply a sufficiently clear criterion for determining without doubt the horizontal age of these terrace sediments capable also of secondary movements (for it is known that marine terraces can be uplifted by some subsequent secondary movement of a block to a greater height than the one to which they belong primarily).

Therefore I place this terrace for the present, because of its altitude above the present sea level, simply in the Plistocene without determining its horizon. I place it in the Plistocene also because it has been pierced in two places by the surf, which thus opened a way to the sea water for drowning the bay formed.

Also paleontologically we cannot venture to determine more in detail at least per analogiam the age of the horizon of this Plistocene marine terrace, as we cannot base ourselves on other observations, either our own or recorded in the literature. Up till now we know the Plistocene marine fauna of the Bulgarian coast exclusively from my own finds of eolian loamy sediments, i. e. from the loess of the last Glacial (Würmian), since 1922 from a few places: Nesebr 65,2 (= Mesemvrie), Galata 3, 79, Ses Sevmes 4,64 (= Asparuchovo), and Baba Burun, all near Varna, 5,61.

But the marine fauna of these Plistocene deposits is very scanty, for of larger conchylia only fragments could be sedimented in this way, and even these only very sparily. In 1949 I found in a deep military trench about 1 km. long a for local conditions fairly large number of these fragments, yet they are not sufficient for a knowledge of the whole association of this geological period owing to the small number of species represented in them.

In determining the accurate age of any horizon of Plistocene marine terraces the vertical height alone is not sufficient, as it is known that this may be changed by later oscillatory movements of the shore line, and thus the historical height sequence of the whole evolution and real age of any terrace can be changed.

What we know of the marine terraces, Plistocene as well as Holocene, of the Black Sea in Bulgaria is still too little, stratigraphically as well as paleontologically, for us to attempt accurately to determine any horizon, especially a Plistocene one.

With regard to the Holocene terraces we are — after the analysis of the age and development of the bay of Nesebr — a little better off, as we have here more criteria — such as the washing off of the upper loess, which is preserved where the basin of this bay did not reach.

Thus I was able to determine also the age of the Varna Dam between the Black Sea and the Varna Lake at a place near Baba Burun. Similarly I could determine also the age of the “undercut coasts” of the Black Sea at Kara-kiöj in the northern Dobrudja above Mamai, as here too the youngest loess was denuded.

Here at Kara-kiöj we have therefore a proof of the oscillation of the water level of the Black Sea in post-Plistocene time. In

post-Pleistocene time, because the layers of the youngest loess are here denuded by lateral wave abrasion.

It would be possible to determine this sinking of the sea level accurately to the decimeter by levelling measurements, and at the same time it would also be possible to calculate the rate at which it takes place. Such a sinking of the water level in one place must of course result in the raising of the water level of the same sea in another place. It would certainly be better if we spoke rather of a movement of the sea bottom, as this movement is the primary one, whereas the corresponding oscillation of the sea level is only the consequence of the movement of the bottom.

Such a subsidence of the bottom near the coast I ascertained in 1948 on the shore of the V a j a L a k e at Burgas, where sherds of culture pits of the stone-copper period — or Eneolithic — were settled by *Balanus* sp. For we assume that the coast of the (Black) Sea lay at the time of this culture far seawards from the present coast. From the article G r a h m a n n it is besides quite clear that the Black Sea was several times a pure inland basin, i. e. closed, and several times by a movement of the bottom the B o s p o r u s opened so that this basin became again an open sea.*)

Just because of this the Black Sea is the best, straight-out test-proof of these elevations and subsidences by oscillations of the bottom of this sea.

Of course this oscillating of the bottom of the Black Sea is a phenomenon restricted to this sea itself. In it is only a dynamic part-process, and this is of course connected with the movements of the C a u c a s i a n block, which today has already reached the altitude of high mountains, and whose movement in the present geological period is not yet even periodically terminated or stopped. Thus of

Of course we speak here of an oscillation of the water level of this sea, although the "oscillation" of this water level is simply secondary, as it is due to orogenic movements of the bottom of the basin, caused in their turn by movements of whole land blocks, and here on the Black Sea especially by the movements of the Caucasus.

Here we have of course to refute the opinion that the water in the seas increased in the Interglacial periods. We must not forget that in these periods the water volume increased in the atmosphere as well as in the soils, and that also vegetation formed a great water reservoir. Thus during the warm periods the circulation of the water was greater and therefore also its effective consumption.

Graham's table assumes "a rise of the sea level" of the Black Sea during the last Glacial period — perhaps only because this sea was not connected by the Bosphorus (nor of course in any other way) with the Marmara Sea; but we have not yet one single stratigraphical proof in Bulgaria of such a "rise" of its water level. On the contrary, from the last Ice Age (Würmian), i. e. from the last period of loess formation, we know from here only loess, very thickly developed (Varna and vicinity, Nesebr and vicinity), which never lies on Pleistocene marine terraces.

And it is just from Nesebr as well as from Kara kiöj in the Dobrudja that we have proofs from the postglacial Litorinian (Atlantic) period that the movement of the blocks of the sea bottom were not only parallel with the coast but under an angle to the coast; if it were different no such changes of the shoreline as we know just from Nesebr, Kara kiöj, the Varna Bay could have taken place, even if we take into account a variation of the surface currents of the sea and of course an analogous variation of the regular winds.

course also the movement of the bottom of the Black Sea cannot be terminated. Of course, when we remember that whole continental blocks are in movement, then we can be certain that also the bottom of all oceans is in constant movement, and at present we can only follow the different traces of these changes on the coasts, but cannot yet formulate any law according to which these movements take place.

One of the proofs of such oscillations is not only Tuzla near Balčik for the Plistocene and Holocene, but also the Vaja Lake at Burgas. Here I found in 1948 the following profile:

- gray loam ($\frac{1}{2}$ m.) without prehistoric finds
- black earth (— 1 m.)
 2. Hallstadt sherds
 1. fragments of eneolithic structure
- brown loam (— 2 m.)

The water level of the lake has risen, for the sherds loosened by the wave abrasion and projecting from the black earth into the water of the lake are covered with *Balanus*. And this *Balanus* has settled only on those parts of the sherds which got into the water, i. e. which were laid bare by the waves. If there had been water here earlier, *Balanus* would have settled on the whole sherds.

I was able to follow only part of this settlement, and for a final conclusion it would be necessary to uncover the whole of it at least by soundings.

Of course we also know already that the swamps at Arniberg in the Reutal have dried out (just like the dried out "gyttja", in the Krutzelried in the Glattal, the drying out of the peat bogs in Norway and Northern Germany are also a proof of the climate optimum of Blytt-Sernander, 1923, which dates in Central Europe from the subboreal Litorinian, i. e. practically from before the Central European Neolithic, and ends in the early Hallstadt, but we certainly cannot say that the rising of the level of the Vaja Lake has its cause in the same climatic change, for the Vaja Lake it not an end-lake, and we have not yet any proof that it ever was one.

The cause of the rising of the water level of this lake we see in a subsidence of the coast line of the sea bottom. At the same time we are of course aware that the substratum of the Quaternary beds of the Vaja Lake are Tertiary marine sediments, clayey earth, not solid rock. In these Tertiary beds I found a mandibula of *Equus stenonis* and a colophonitised tusk of *Mastodon sp.*

At Balčik-Tuzla no loess is preserved at the coast, perhaps because this whole coast has already for long been sliding into the sea. Its rock substratum consists of loose beds of brackish Sarmatian, which either carried the loess where preserved with it or buried it. On the upper plateau above them this loess is however to this day preserved in the whole Dobrudja in thick layers as is well known already from the literature.

For all these reasons I was able to determine the geological age of the younger terrace at the Tuzla Lake beyond Balčik as

Holocene, and according to the loamy covering layers as older than the subboreal Litorinian.

The difference in altitude between this terrace and the beds of the same geological age in the bay of Nesebr and of the Varna Dam does not matter here at all, as everywhere we have here purely local conditions. Besides, because of the paleontological material of Nesebr as well as of Varna not having been worked, we do not try to solve here the age relation between the terrace of Tuzla and those at Nesebr and Varna. For this it would be necessary to collect in detail this material here just as at Nesebr and Varna (though I was aware of this in 1949 at Tuzla, I was unable to collect the material necessary for this purpose in the two latter places owing to a sudden heavy attack of dysentery. Previous to finding the terrace at Tuzla I did not pay any greater attention to this material.

Here we must not forget either that at each place and at the same depth the same mollusc association does not live everywhere. Thus, chiefly according to Veska Kaneva, assistant of the "Biologična stanica" at Varna and an expert on the marine molluscs of the Black Sea, it has never been possible to catch a living *Cerithium vulgatum* LINNÉ and only empty shells washed up by the surf from the sea are found, and even these only sporadically. On the other hand this species was certainly very abundant during the sedimentation of the youngest loess at the bay near Baba Burun, for I found there in the military trench mentioned above 91 specimens, i. e. several times more than all terrestrial *Gastropodes* living there at the same time.

In the interpretation of marine terraces we must further not forget, that the sea sometimes retreats from one coast and invades another. A proof of this are just the Holocene undercut coast at Kara-Kiőj, from which the sea has retreated, just as the already mentioned Varna Dam heaped up by the sea in the Holocene, since the time before the subboreal Litorinian, and whose sedimentation has not yet ended today! We know more such cases from the western coast of the Black Sea, f. inst. at the dam of Lake Lac Siut⁷ = Lac di Canara in the Dobrudja, in the bay of Nesebr, at the mouth of the river Tiča, etc. In all these places the sea then leaves all its deposits, pebbles, sand and marine conchylia.

When the coast rises because of tectonic block movements, fossil terraces are formed.

This applies to the younger terrace of Lake Tuzla at Balčik. As I already pointed out the dam of the Plistocene terrace on the coast in front of this lake was broken through by the waves in the Postglacial, and thus a bay was formed, in which a magnificent fauna of marine molluscs lived, of which *Cardium edule* LINNÉ has for the Black Sea the most remarkable shape, because its shells are here, of the whole Bulgarian and Rumanian coast of the Black Sea, unusually strong; this may of course be a consequence of the fact that this relatively little open bay had much more salty and warmer water than the sea here. The shells of this species,

especially from the Varna Lake, are on the contrary very small, as the water is here brackish with a low percentage of salt.

But as soon as the two gates were closed by the surf forming the youngest terrace material, the water quickly evaporated, and thus the percentage of the salt increased until the lake thus formed became a salt lake = tuzla, in which of course the molluscs cannot live.

As far as exposed profiles and the shortness of my stay allowed I collected in the Holocene lake terrace the following conchylia:

<i>Nassa reticulata</i>	<i>Venerupis irus</i>
<i>Nassa reticulata</i> var. <i>modesta</i>	<i>Cardium edule</i>
<i>Nassa reticulata</i> var. <i>modesta</i> f. <i>minor</i>	<i>Cardium simile</i>
<i>Nassa reticulata</i> var. <i>mediterranea</i>	<i>Mytilus galloprovincialis</i>
<i>Cyclonassa nerita</i>	<i>Mytilus lineatus</i>
<i>Cerithium lineatum</i>	<i>Ostrea taurica</i>
<i>Cerithium variegatum</i> var. <i>exile</i>	<i>Ostrea sublamellosa</i>
<i>Gibbula divaricata</i>	<i>Tapes lineatus</i>
<i>Rissoa</i> sp.	<i>Barnea candida</i>
<i>Petricola lithophaga</i>	<i>Capsa fragilis</i>
<i>Venus gallina</i>	<i>Syndosnysa ovata</i>

Far less accessible was the fauna of the Plistocene terrace, as the undercut coast of the sea is here completely vertical. Only in one place was it possible to collect freely, and here very numerous and quite undamaged shells of *Pholas dactylus* LINNÉ were a surprise.

Molluscs of the Plistocene Marine Terrace of the Black Sea at Lake Tuzla beyond Balčik:

1. *Nassa reticulata* LINNÉ var. *mediterranea* RISSO
2. *Nassa reticulata* var. *modesta*
3. *Cerithium reticulatum* Bruguière var. *exile*
4. *Gibbula divaricata* LINNÉ
5. *Cyclonassa nerita* LINNÉ
6. *Pholas dactylus* LINNÉ
7. *Petricola lithophaga* RETZIUS
8. *Venus gallina* LINNÉ
9. *Cardium edule* LINNÉ
10. *Mytilus galloprovincialis* LAMARCK
11. *Mytilaster linneatus*
12. *Ostrea sublamellosa*
13. *Ostrea taurica* KRYNICKYJ

The Marine Molluscs in the Upper Plistocene Loess.

At different places of the Black Sea coast as at Ses Sevmes = Asparuchovo near Varna, Baba Burun above the Varna Lake, Nesebr = Mesemvrie, as well as on the road below Galata near Varna marine conchylia were found. These marine conchylia got

into this loess exclusively by wind-drift. I have earlier called this case a "stratigraphical paradoxon", as non-terrestrial, marine fossils got into the loess, not however by being washed out from beds above this loess, but rolled by the wind on the ground from the coast upwards.

The most magnificent and richest material is found in the former military trench, about one kilometer long, between Baba Burun and the highway to Ses Sevmes.

The following species were found here:

1. *Nassa reticulata* LINNÉ var. *marginulata* LAMARCK
2. *Cerithium vulgatum* Bruguière var.
3. *Ceritholium reticulatum* Bruguière var. *exile*
4. *Cyclonassa nerita* LINNÉ
5. *Rissoa* sp.
6. *Cardium edule* LINNÉ
7. *Mytilus galloprovincialis* LAMARCK.

Of course though the age of all this loess is accurately determined as youngest loess (= Würmian), yet the age of these marine conchylia need not be identical with the age of this loess, though it is probably so. But it is possible, that it came also to the erosion of some today already completely destroyed older marine terrace. Remarkable is only that I found here also *Cerithium vulgatum* LINNÉ var., not yet collected in the Plistocene marine terrace at Tuzla beyond Balčik, and not known either up till now from the Holocene terraces of the Black Sea at Nesebr and Varna. It is known besides only from isolated shells, always without the animal, found on the Bulgarian coast of the Black Sea.

Of course a numerous fauna of terrestrial conchylia is often found with this marine fauna, and it corresponds to the age of the youngest Plistocene loess.

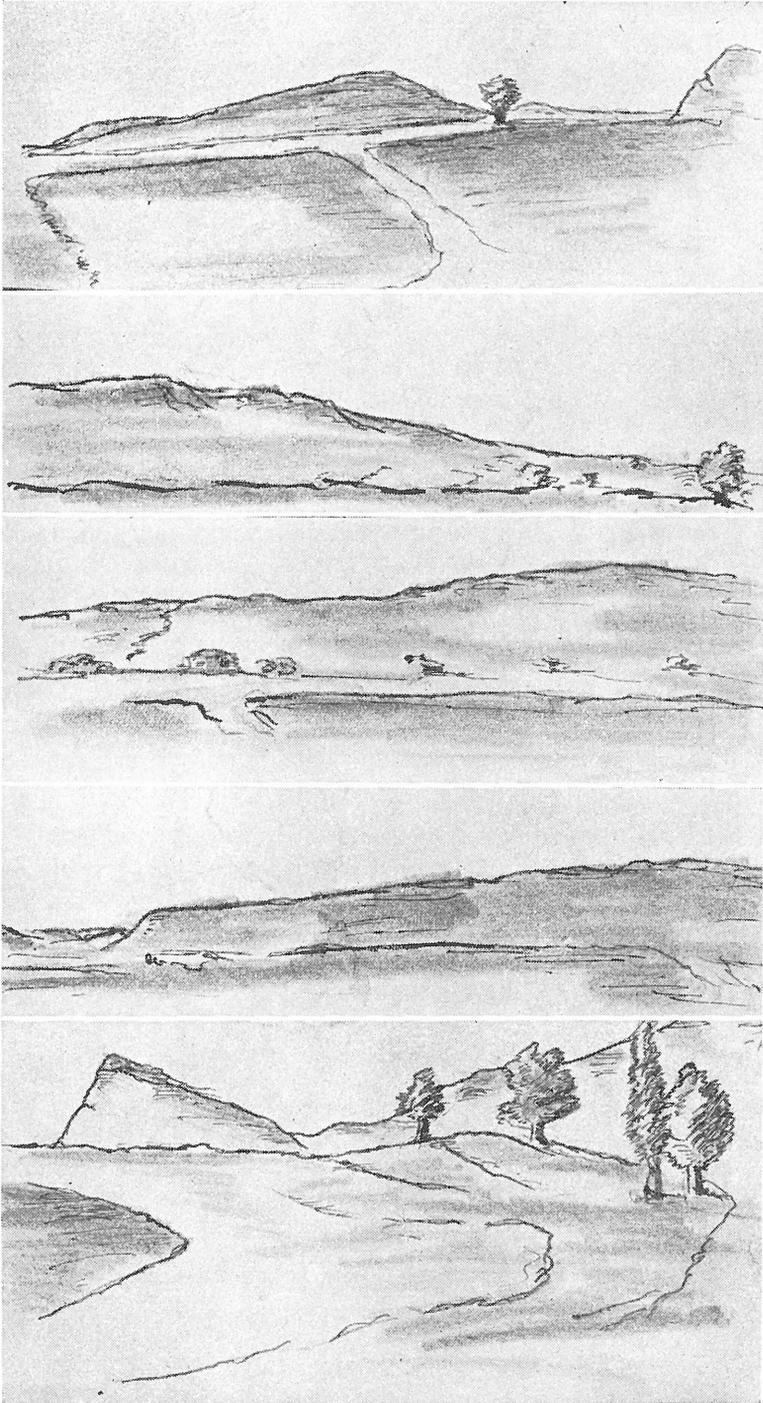
When we now compare all Plistocene marine species known up till now of Bulgarian terrace and loess molluscs, we get the following table.

Nassa reticulata LINNÉ, var. *marginulata* LAMARCK
syn.: *Nassa marginulata* LAMARCK.

Of 14 shells one attains the height of
14 mm. with a width of 8 mm.
15 mm. with a width of 9 mm.
the largest 17 mm. with a width of 9 mm.

It is thus LAMARCK's *Nassa marginulata* which is "thick-walled, stocky, with less numerous ribs" (quoted from H. C. WEINKAUFF: Die Conchylien des Mittelmeeres, Cassel, 1886). As however LAMARCK's *Nassa marginulata* described by him as a separate species is only a variety of *Nassa reticulata* LINNÉ, I record it as: *Nassa reticulata* LINNÉ var. *marginulata* LAMARCK.

WEINKAUFF emphasizes that this variety comes from brackish waters, which would correspond to the general situation in this bay in



Orig. Jar. Petrboč
The bank of the Black Sea at Balčik with the pliocene marine terrace.

which enter the Provadija and the Devna Rivers, both flowing through the Varna and Beloslav (= Gebedže) Lakes formed by them.

From other places I have from the Plistocene of the Black Sea — Tuzla near Balčik — from the terrace a shell 25 mm. high and 12 mm. broad (*var. mediterranea*), and from the Holocene terrace there one of 21—12 mm. (*var. modesta*).

For the Black Sea coast of Bulgaria, Rumania and European Turkey this finding is new.

Nassa reticulata LINNÉ *var. mediterranea*

This broad variety occurs in this Plistocene terrace more rarely than the following variety:

Nassa reticulata LINNÉ *var. modesta*

I believe that there are many transition forms between them as well as to the type, so that both are only extreme forms of one evolutionary line, which perhaps begins to divide more sharply in the Black Sea; this is only natural with its great geographical distribution and its historical evolution since the Miocene. It would be worth while to study this monographically.

Ceritholium reticularum BRUGUIÈRE *var. exile*

Very rare in the Plistocene terrace here as well as in the loess at Galata near Varna, Ses sevmes and Baba Burun. Otherwise very abundant in the Holocene terrace just here at Tuzla beyond Balčik; this is natural for this terrace was in a bay with a very quiet sedimentation protected against the surf.

Ceritholium vulgatum BRUGUIÈRE *var. exile*

All in all I collected in the Plistocene loess of this trench 94 larger or smaller fragments of shells.

According to Veska Kaneva, assistant of the "Morska biološka stanica" at Varna this species has not yet been found alive on the Bulgarian coast of the Black Sea; only sporadically its empty shells have been found, and this proves that they are either shells from the younger Quaternary or that this species lives at greater depths, so that its shells do not reach the coast by normal waves.

The fossil shells collected also in the trench of Baba Burun-Ses Sevmes belong all to a narrow to very narrow form, and this proves it to be a form of a certain geological period and of certain local conditions. But for giving a more concrete opinion we lack material from different localities of the Black Sea. When we consider that this species with its great geographical distribution and considerable geological age must show a considerable variability, we cannot draw any conclusions without a larger comparative material, for shells are known from Algiers 71—20 mm., from the Miocene of Vienna 75—35 mm., fossil from Palermo 100 mm., as well as on the other hand shells only 10 mm. long (Weinkauff).

Therefore we have to restrict ourselves to the recording of the form found in Plistocene loess.

Gibbula divaricata LINNÉ

Rare in the Plistocene terrace, abundant in the Holocene one for reasons mentioned already elsewhere (*Cerithium reticulatum* etc.).

Cyclonassa nerita LINNÉ

Rare in the Plistocene terrace, more abundant in the Holocene terrace (cf. the above reasons).

Rissoa sp.

Rare in the Plistocene terrace as well as in the loess, also in the Holocene terrace.

Pholas dactylus LINNÉ

Numerous and magnificently preserved shells in the Plistocene terrace.

Petricola lithophaga RETZIUS

Rare in the Plistocene terrace.

Venus gallina LINNÉ

In the Plistocene terrace surprisingly rare (in the Holocene terrace of Tuzla-Balčik very abundant and in magnificent specimens).

Cardium edule LINNÉ

In the Plistocene terrace infrequent (but in the Holocene terrace Tuzla-Balčik extremely abundant and in very beautiful specimens). Elsewhere fragments in the loess: Nesebr (= Mesemvrie), Baba Burun.

Cardium sp.

According to Veska Kaneva the 14 shell fragments do not belong to any of the four species of *Cardium* of the Black Sea. Thus they belong to some fossil species. As they were transported here from some unknown locality, for which I searched in vain in the neighbourhood, we cannot decide for the present from which fossil horizon it derives. Its shells are very strong, strongly convex, and very coarsely ribbed.

Venerupis irus LINNÉ

Found in a fragment of one shell.

Mytilus galloprovincialis LAMARCK

Only a fragment of one shell.

In the Plistocene terrace mostly only in fragments, just as in the loess (and here rare). In the Holocene terrace (Tuzla-Balčik) very abundant and in large specimens.

Mytilaster linneatus

In the Plistocene terrace infrequent (more abundant in the Holocene terrace Tuzla-Balčik).

Ostrea sublamellosa.

The most abundant fossil of the Plistocene terrace here, just as is the following species:

Ostrea taurica.

Together with this marine fauna I found in the same layer also the following fauna of terrestrial Gastropodes:

1. *Hyalinia* (s. l.) sp. 1 shell
2. *Theba* sp. frgm. 2 frgm.
3. *Helicella* sp. aff. *spiruloides* A. J. WAGNER . . . 1 shell
4. *Helicella* sp. cf. *striata* MÜLLER 1 shell
5. *Helicella* sp. cf. *obvia* HARTMANN juv. 22 shells
6. *Chondrula microtragus* PARREYS (Rossm.) 7 shells
7. *Cyclostoma elegans* MÜLLER 6 shells.

In addition still some material of presumably Tertiary conchylia.

Stratigraphico-Chronological Survey of the
Course of the Oscillations of the Sea Level of the
Black Sea.

In his article of 1937 Grahmann gives the following survey, which in my opinion need not apply absolutely to the whole coast of this sea as it is not proved for this area as general. In his bibliography

Marine moluscs of the Plistocene of Bulgaria: Marinní měkkýši bulharského plistocenu:	Terrase Terasa BALČIK- TUZLA	Spraš LOESS
1. <i>Nassa reticulata</i> LINNÉ var <i>marginulata</i> LAMARCK		●
2. <i>Nassa reticulata</i> var <i>mediterranea</i> RISSO	●	
3. <i>Nassa reticulata</i> var <i>modesta</i>	●	
4. <i>Cerithium vulgatum</i> BRUGUIÈRE var		●
5. <i>Cerithium reticulatum</i> BRUGUIÈRE var <i>exile</i>	●	●
6. <i>Gibbula divaricata</i> LINNÉ	●	
7. <i>Cyclonassa nerita</i> LINNÉ	●	●
8. <i>Rissoa</i> sp.		●
9. <i>Pholas dactylus</i> LINNÉ	● 1:	
10. <i>Petricola lithopaga</i> RETZIUS	●	
11. <i>Venus gallina</i> LINNÉ	●	
12. <i>Cardium edule</i> LINNÉ	●	●
13. <i>Mytilus galloprovincialis</i> LAMARCK	●	●
14. <i>Mytilaster linneatus</i>	●	
15. <i>Ostrea sublamellosa</i>	●	
16. <i>Ostrea taurica</i> KRYNICKIJ	●	



The abandoned beaches of the Black-Sea at Kara-Kiöj (Dobrudja).

Orig. Jar. Petrbok

Historical Development of the Black Sea since the Pliocene. (GRAHMANN).

Geological Period	Climate	Period	Sea Level	Salt Content	Important Fossils	State of the Black Sea	
Postglacial	warm	Pontus	high	high ¹⁾	<i>Modiola phaseolina</i>	connected with the	1) bay at Nessebr, Varna Dam
Petering out of the Glacial	growing warmer	ancient Pontus	rises	rises	<i>Cardium edule</i> , <i>Mytilus galloprovincialis</i>	Mediterranean Sea	
Last Glacial (= Würmian)	cool	new Euxinus	low	low	<i>Adacna</i> , <i>Monodacna</i> , <i>Dreissenia</i>	inland sea with outlet	Baba Burun, Galata, Nessebr Ses Sevmes
Last Interglacial (= Riss-Würmian)	warm	Karangat	high	high	Echineidae	connected with the Mediterranean	? Balčik-Tuzla
		middle Euxinus	low	low	?	inland sea with outlet	
		Unsular	high	rises	<i>Cardium edule</i> <i>Mytilaster</i>	connected with the Mediterranean	
Rissian	cool	ancient Euxinus	high	low	<i>Didacna pontica</i> <i>Dreissenia</i>	transgressive inland sea with outlet	
Mindel-Rissian	warm	post-Čauda	low	?	?	regressive inland sea	
Mindelian	cool	Čauda	high	low	<i>Didacna Baeri</i> , <i>crassa</i>	transgressive inland sea with outlet	
Günz-Mindelien	warm	?	?	—	—	areal reduction:	
Günzian	cool	?	?	—	—	? inland sea? ? areal reduction?	
Upper Pliocene	very warm	Kujalnik	?		—	connection with the Mediterranean	

Grahmann has neither Soviet nor earlier Russian authors, who are however indispensable for such general conclusions. Nor does he give in his article lists of the faunas of the different stages. We should certainly need a complete list of all the Bulgarian faunas of the different Quaternary terraces of this sea. It is a pity that only the find of the Plistocene fauna of marine terrace molluscs made me understand also the importance of the Holocene faunas, which I could have studied in my 12 pre-war travels. It is only in the present article that I give at least a first contribution in his respect for Bulgaria.

I proved in my papers by stratigraphical documentation that the Bay of Nesebr and of course its marine terrace fauna belong to the Atlantic Litorinian. I have the same proof for the Varna Dam between the Varna Lake and the Black Sea itself. But the Holocene terrace and its fauna at Balčik I can place only generally in the Litorinian, for I did not find any stratigraphical proof for a more detailed specification.

Conclusion: We came to know the first Plistocene marine mollusc of Bulgaria from their secondary localities in the youngest loess (Ses-Sevmes, Galata and Baba Burun near Varna, Nesebr = Mesemvrie), which correspond in their age to the last—Würmian—glaciation of Europe.

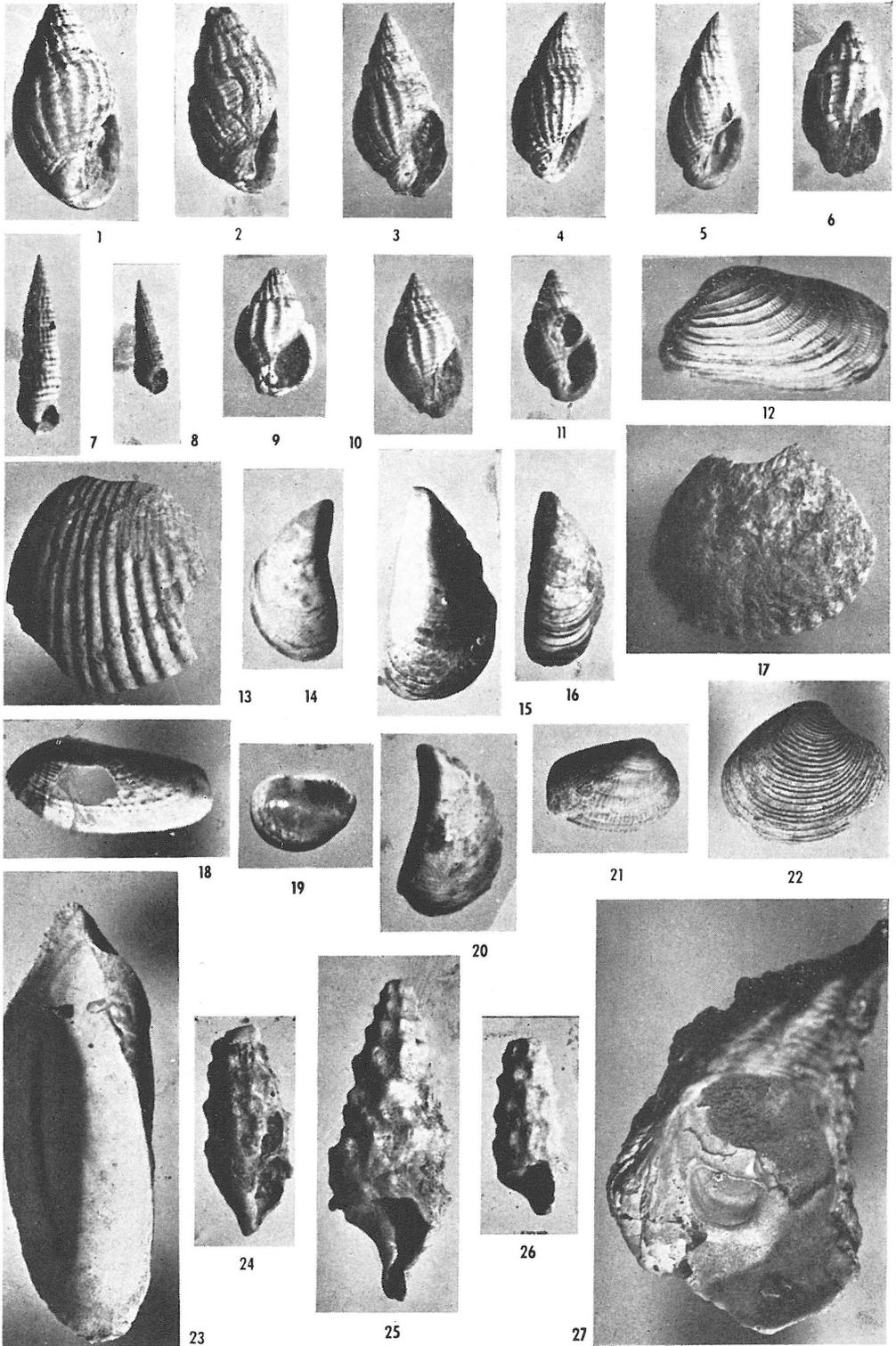
Only later, in June 1949, I found for the first time a Plistocene marine terrace at Tuzla beyond Balčik in northern Bulgaria, which is paleontologically and stratigraphically proved as such. As this terrace is not covered by loess, and as we do not know yet the difference between the mollusc association of this terrace and of any other, accurately horizonted primary deposit of these marine molluscs, we cannot for the present even by such comparative paleontology judge at least per analogiam the accurate phase of the Plistocene period in which this terrace at Tuzla rose above the sea.

N. B. Tuzla is a Turkish word signifying "salt, salt lake". There are several such "Tuzlas" in Bulgaria, and therefore the place has to be designated also by the nearest other place.

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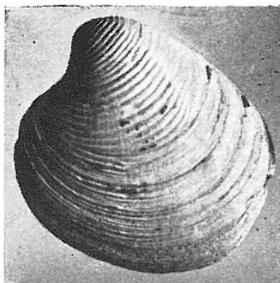
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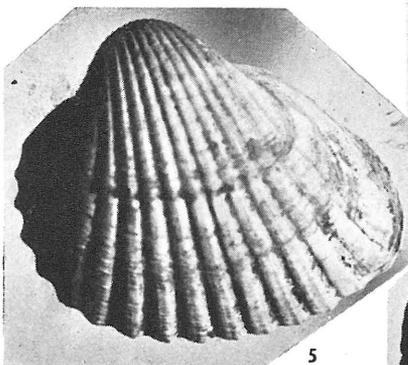
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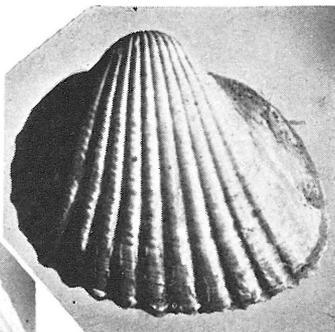
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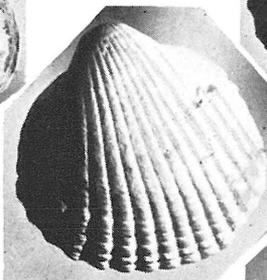
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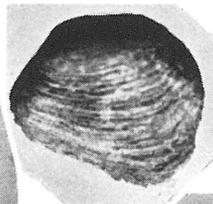
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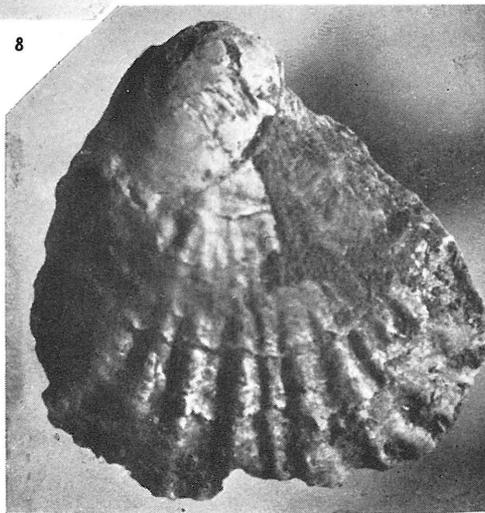
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11

Měkkýši plistocenní marinní terasy. BALČIK.

Tab. I.

- Nassa reticulata* L. var. *mediterranea* Risso 1, 2
Nassa reticulata L. var. *modesta* 3, 4, 5, 11
Nassa reticulata L. var. *marginulata* Lamarck 6, 9
Ceritholium reticulatum Bruguiere? var. *exile* 7
Ceritholium reticulatum Bruguiere? var. *exile* 8
Venerupis irus 12
Cardium sp.? *tercier*? — plistoc. marin. terasa Baba Burun 13, 17
Mytilaster linneatus 14, 15, 16, 20
Petricola lithophaga Retzius 18
Cyclonassa nerita Linné 19
Venus gallina Linné 21, 22
Pholas dactylus Linné 23
Cerithium vulgatum Bruguiere 25 — plistoc. spraš Baba Burun
Cerithium vulgatum var. *ibidem* 24, 26
Ostrea sublamellosa 27

Měkkýši holocenní terasy marinní. BALČIK.

Tab. II.

- Tapes linneatus* 1
Venus gallina Linné 2
Syndesmya ovata 3
Cardium simile 4
Cardium edule Linné 5, 7
Cardium edule var. 6
Venerupis sp. 8
Barnea candica 9
Mytilus galloprovincialis 10
Ostrea taurica Krynickij 11

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REDAKTOR IVAN KLÁŠTERSKÝ

JAR. PETRBOK: MĚKKÝŠI PLISTOCENNÍ A HOLOCENNÍ MARINNÍ TERASY
ČERNÉHO MOŘE U BALČIKU V BULHARSKU A MARINNÍ MĚKKÝŠI BULHAR-
SKÉHO PLISTOCENU. THE MOLLUSCS FROM ONE PLISTOCENE AND ONE
HOLOCENE TERRACE OF THE BLACK-SEA AT BALČIK IN BULGARIA AND
THE MARINNE MOLLUSCS OF THE BULGARIEN PLISTOCENE.

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