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PALEOGEOGRAPHIC RECONSTRUCTIONS AND CONDITIONS OF FORMING NON-TRADITIONAL RESOURCES OF THE BLACK SEA

Modern Mediterranean, Black and the Caspian Sea have been repeatedly geocatastrophic events caused by abrupt climate change or global geological processes. Notable examples in this regard is the Mediterranean Messinian crisis on the border of the Miocene—Pliocene (5.7—5.2 million years ago), when formed evaporite-sulfur-bearing formation. At the same time formed the Azov — Black Sea province of iron ore and Balhan Formation of the Caspian Sea which connected major oil and gas fields. The Black Sea crisis Appearances at about 8—9 thousand Years ago, geocatastrophic event as a result of melting glaciers Wurm glaciation. As a result, the water of the Mediterranean Sea salinity 38 ‰ flooded into the Black Sea lake and eventually formed clusters of giant deep sea organogenic — mineral sediments (DSOMS).

Key words: *Pre-Pleistocene, Lower Pleistocene, Middle, Upper Pleistocene, Holocene, Messinian, Zanclean, Galesian, Piachenzian, biostratigraphy.*

The present-day Mediterranean Sea, Black Sea and Caspian Sea are relics of the basins existed during the Neogene — the Tethys (the Mediterranean Sea) and the Paratethys (the Black Sea and the Caspian Sea). While the Tethys was directly linked to the ocean, the Paratethys was periodically isolated from it that led to sharp changes in its salinity levels. This makes difficult the biostratigraphic correlation between two basins (Semenenko, 1987, 1999), irrespective of their genetic similarity.

The connection between the communicating vessels Atlantic Ocean — the Mediterranean Sea — the Black Sea — the Caspian Sea used to be a subject to disruption and restoration. There were two geocatastrophic events in the geological history of the Tethys known in the Western literature as a stress or a crisis — a sharp negative impact on the ecosystem (Saturani, 1973; Ryan, Cita, 1978; Hsu, 1978; Ryan and Pitman, 1998) that took place during the Serravalian and the Messinian periods. These events were brought about by the northward movement of the African plate and its subducting under the Eurasian plate (Benson, 1986). The following stages are marked off during the Miocene in the Mediterranean region: Aquitanian, Burdigalian, Langhian, Serravalian, Tortonian and Messinian; and during the Pliocene — Zanclean, Galesian and Piachenzian. During the same age in the Ponto-Caspian basins the Miocene covers the Caucasian, Sakaraul, Kosakhkur, Tarchanian, Chokrakian, Karaganian, Concian, Sarmatian, Meotian and Pontian stages; and the Pliocene — the Kimerian and the Akchagil stages.

During the early and middle Miocene the Tethys represented a straight connected the Atlantic Ocean to the Indian-Pacific basins. Indo-Pacific fauna elements were found also in the Paratethys. About 14 million years ago, during the Serravalian crisis (a catastrophe caused by the subducting and the rising of the African and the Arabic plates) the connection between the Mediterranean Sea and the Indian Ocean was sealed off; it led to the formation of the Mediterranean basin peripheral to the Atlantic Ocean. At the same time the vast semi-sea Sarmatian basin was formed in the Paratethys. The Sarmatian, Meotian and Pontian basins were located on the territory of the Black Sea valley and characterized by specific stages in their development. During the drills with the American vessel of *Glomar Challenger* in 1972 was discovered the so called Messinian crisis (catastrophe) in the Mediterranean Sea (Ryan, Hsu, 1973). The drills uncovered 1 km thick evaporates and deposited 5.7—5.2 million years ago (Ryan, Pitman, 1998; Hsu, 1978) which indicates that the Mediterranean Sea dried up for a period of 500 thousand years. The reason for that event was the closing down of the Strait of Gibraltar as a result of the collision between the African and the Eurasian plates in the region of Morocco and Spain. The Mediterranean Sea became a closed salty lake and its bottom was covered by evaporates. At that time Meotian and Pontian sediments subsided as time analogues of the Tortonian and the Messinian. Semenenko (1987) takes also the lower Kimerian to the Messinian period. During the drills of the Nile Delta in 1968 in connection with the construction of the Aswan Dam Chumakov (Chumakov, 1973) described for the first time the Messinian evaporates. After the drying up of the Mediterranean Sea water from the Black Sea flowed into it turning it into a «largo — mare» (sea — lake). After that there existed the dry land of Pontida in the Black Sea (Andrusov, 1961) and separate salty lakes (Hsu, 1978). The discovery of the Messinian catastrophe changed the scientists' approach to the search of similar events in the entire geological history of the Black Sea and the Mediterranean Sea. It helped us immensely to desipher the catastrophic events that took place in the Black Sea aboutn 8 thousand years ago (Dimitrov, 1978; Ryan, Pitman 1998; Dimitrov, Dimitrov, 2004).

It should be noted that the Azov-Black Sea basin appeared 5 million years ago within boundaries close to their present-day outlines on the border between the Pontian and Kimerian age. The modern river network on the continental slope originated as early as that period (Semenenko, 1999). The Black Sea and the Mediterranean Sea appeared almost simultaneously as a result of the Kimerian — Zanclean regression evidenced by Messinian evaporates and the Kimerian iron-ore formation (Ryan, Pitman, 1998; Shnyukov, Ziborov, 2004).

The prototypes of present-day basins appeared on the boder Miocene — Pliocene (Messinian — Zanclean in the Mediterranean Sea, Pontian — Kimerian in the Black Sea). Three productive basins were formed on this border (Miocene — Pliocene): evaporite and sulphur-bearing formation of the Messinian (formazione gessoso—solfifera) in the Mediterranean Sea, Azov-Black Sea ore province in the Kimerian (Shnyukov, 1999) and the Balhanian formation of the Caspian Sea hosting gigantic deposits of petroleum and natural gas.

The Black Sea basin acquired its present-day appearance over the past 1.7 million years — a period during which it has been repeatedly disconnected from and reconnect-

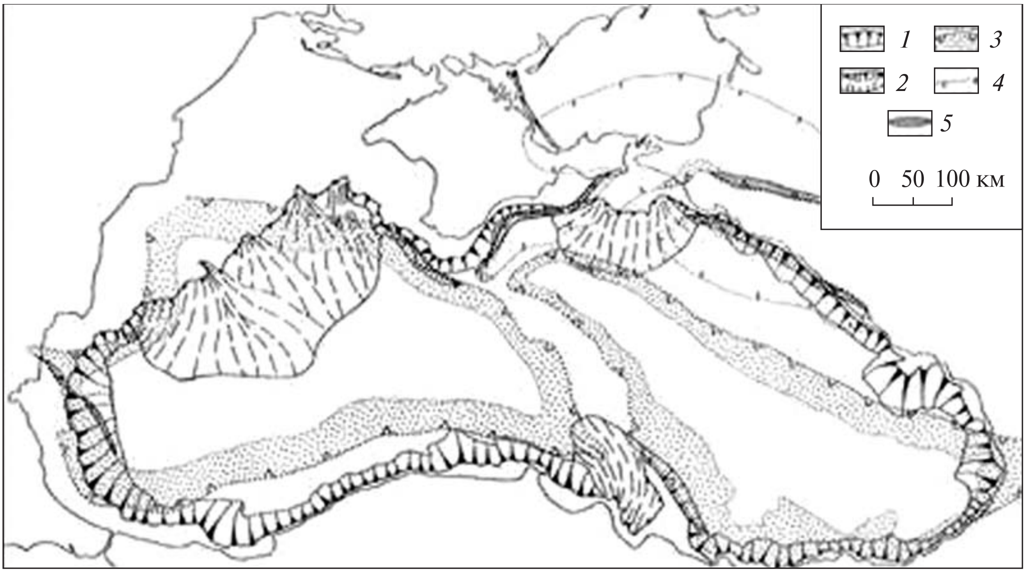


Fig. 1. Situation of the present-day continental slope of the Black Sea and the slopes of Paleogenic depressions (Tugolesov et al., 1985): *1* — denuded sections of the present-day continental slope; *2* — accumulation sections of the present-day continental slope; *3* — steep slopes of Paleogenic depressions; *4* — conditional situation of the borderlines of Paleogenic depressions; *5* — areas of possible development of faults on depression slopes

ed with the Mediterranean Sea. Shows the schema of present-day continental slope and the slopes of the Paleogenic valleys (Fig. 1).

The geocatastrophic event in the Black Sea took place about 8 thousand years ago and led to the formation of unique deposits of deep sea organogenic-mineral sediments regarded as a complex and non-traditional raw material with multi-purpose application (Dimitrov, Velev, 1988; Dimitrov, Vasilev, 1988; Dimitrov, Dimitrov, 2004; Dimitrov et al., 2003, 2005, 2006; Dimitrov et. al., 2003, 2004, 2005, 2007; Dimitrov, 2010).

Pre-Pleistocene stage

According to geological and geophysical data there are three long periods in the development of the Black Sea. The first stage, covering the Mesozoic and Paleogenic era, characterizes a sediment cover of the median mass. The deep sea valley did not exist and its place was occupied by a shallow pool.

The second stage (Oligocene—Miocene) coincides with the Alpine orogenic cycle when the median mass fell apart and separated depressions formed within the boundaries of the modern one (Muratov, 1972; Tugolesov et al., 1985). These depressions had limited area and were the location where substantial sediments from the Maykop series and the Miocene settled down reaching thickness of 3—5 km. Black aleurite clays dating back to the Upper Miocene were uncovered in the foundation of the cross-section of C-380 and 381 (Geological history..., 1980). Here can be found dolomite beds which were formed in shallow waters and went through substantial diagenetic changes in the subaerial conditions. The Bosphorus area was also a shallow basin during the late Miocene as evidenced by the data of the diatom analysis and the benthic foraminifera in C-381 (Geological history..., 1980). At beginning the basin was freshwater but later

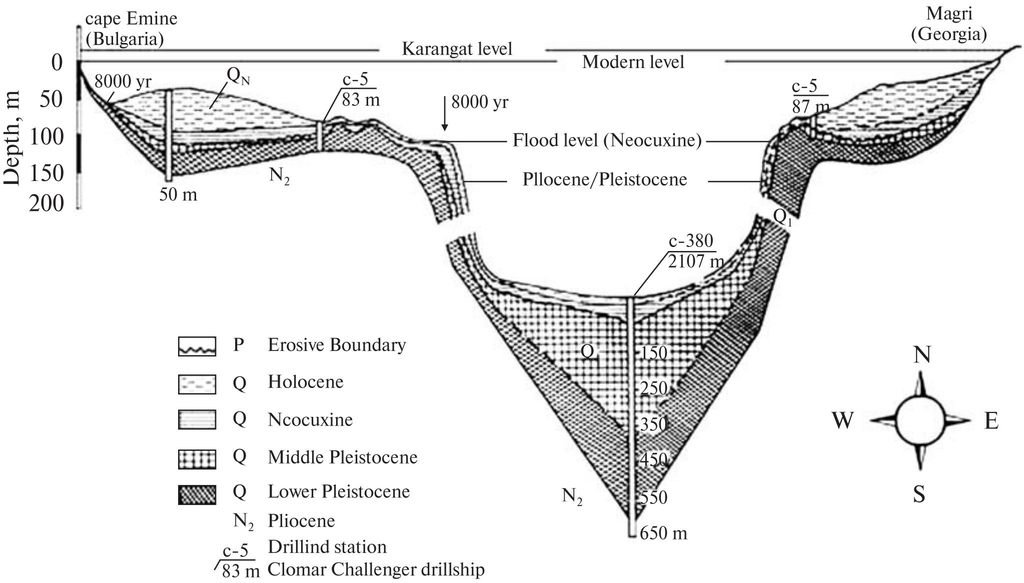


Fig. 2. Schematic geological cross-section and the old shorelines of the Black Sea (Dimitrov, Dimitrov, 2004)

the conditions changed and it became marine. The climate was warm. The sediments are mainly black, there are carbonate and zeolite beds, pyrite and organic matter. Everying points to the fact that the reduction processes were predominant at that time in the basin. The discovered brecciated layers indicate that there was a sudden inflow of Mediterranean water which explains the rising level of the basin and its becoming saline. During the Miocene the basins bottom gradually sank.

The third stage in the development of the basin (Geological history..., 1980) corresponds to the formation of Pliocene — Pleistocene sediments. The sinking of the bottom continued during the Pliocene accompanied by accumulation of sappropel-diatom and carbonate sediments. At the beginning (the Pontian) the basin was a typical marine basin as evidenced by the coccolithophorids *Braurudosphaera bigelowi*. According to the spore-pollen analysis the climate was still warm. There is no evidence of marine sediments from the Pont or the whole Pliocene along the Bulgarian coast and in the shallow areas of the basins. Lithified littoral sediments with thick-walled *Didacna* were dragged on the continental slope at depths of 150—170 m and dated by E. Kuyumdzhieva (Dimitrov, 1990) as belonging to the Upper Pliocene. The terrace situated within 150—170 m was marked by Parlichev (Parlichev, 1984). During the Bulgarian-American research expedition with R/V Akademik in 2002 the author studied the Upper Pliocene coastline along 1 km at depths within 165—172 m with the submersible PC-8. This line was found to be a well formed terrace with lithified littoral sediments (Fig. 2).

During the second half of the Pontian the transgression of the Mediterranean water stopped and the basin became again freshwater area as established by the replacement of the typically marine stenohaline diatoms with euryhaline ones (Geological history..., 1980). The connection between the Black Sea and the Caspian Sea was sealed off at that time (Milanovskiy, 1968). According to Chumakov (1973) and Semenenko (1987) this happened because the water from the Black Sea was flowing into the dried out Eastern Mediterranean basin during that period. That was the time when the sea-lake stage in the development of the Black Sea began turning it into a closed basin with intermittent reconnection to the Mediterranean Sea. The in the western of the Black Sea shelf became a vast alluvial plain.

It is supposed that during the Kimerian the Black Sea was connected to the Dacian basin through the River Danube (Semenenko, 1999). The formation of the sandy-clayey ferruginized sediments in the northwestern Black Sea shelf and in the Sea of Azov took place exactly during the Kimerian. The Krivoy Rog ferrian quartzite were intensively eroded in the warm and humid climate and in the places with a well developed river network and decreasing levels of erosion while the colloidal iron imported by water led to the formation of oolitic iron deposits. Ferrous compouts settle down together with clayey and carbonate particles in the open sea areas thus forming siderite concretions fixed in C-380/380 A (Geological history..., 1980).

The oldest Lower Pleistocene sediments, discovered in the water area of the Bulgarian shelf, were found according to Kuprin et al. (1984) in C-114 made in the periphery of the southern Bulgarian shelf at a depth of 100 m and in C-2b on the territory of Samotino Sea — at a depth of 53.3 m (Stoyanova, 1990). In C-114 (in the interval from 2.00 to 2.60 m) under the Neoeuxinian littoral sediments with redeposited Chaudian fauna there are also clays without macrofauna. The diatoms are represented by the species *Melosira prae* while the spore-pollen analysis indicates there were marine conditions and a sporadic connection to the Mediterranean Sea. The sediments in the basis of the cross-section S-2b are analogical where the Kujalnik clays lie under clay with Chaudian fauna (Kuprin et al., 1984). The Kimerian and Kujalnik sediments in the deep sea valley (C-380/380 A) cannot be distinguished — they are diatom clays with interbeds of chalky clay, siderites and sappropels containing euryhaline forms of diatoms and dinoflagellates serving as prof of the bilateral connection with the Mediterranean Sea (Geological history..., 1980).

The sediments formed within the interval of 1.8—0.7 million of years correspond to the Gurian layers which some researchers refer to the so called Eopleistocene (Kuprin et al., 1984; Fedorov, 1978), and others — to the Upper Pliocene (Geological history..., 1980). As most Bulgarian researchers were refered the Gurian to the Upper Pliocene (Shopov, 1993).

The Gurian horizon covers dark green clays discovered in Varna Bay — C-33, drilled by drill vessel *Geohimik* in 1982. Their upper part reaches absolute depth of 70 m. We will provide their description in accordance with the data given by Grigoryev, Shevchenko, Shopov (1985).

There are dense, dark green carbonate clays without macrofauna under the thick cover of Holocene and Neoeuxinian muddy and sandy-muddy clays at a depth of 48.5 m under the sea level. According to the mentioned researchers the microfauna is typical of the marine sediments of the Miocene however the content of Ostracoda excludes ages older than the end of the Pliocene and the beginning of the Pleistocene. The Gurian horizon is described (Kuprin et al., 1984) in C-2b of Eastern Samotino where it is represented by dense dark gray clays whose upper part lies at an absolute depth of 98 m. A formation 38 m thick in the deep sea valley is refered to the Gurian (C-380/380 A). With duration of 1.1 million years the rate of sedimentation in the deep sea is estimated at 3.5—4 cm/1000 years. The marine sediments of the Gurian are widespread along the coast of Western Georgia and the Rion Depression where their capacity exceeds 1000 m. The Gurian basin in the western part most probably reached absolute depths of 70 m on the side of the mainland, however such assumption is conditional as far as the sediments are dated on the basis of the microfauna that may have been redeposited from older layers.

Currently no Pliocene marine sediments with confirmed dating in the western part of the basin have been published and therefore the paleogeographic reconstructions for that period are mainly speculative.

It would be very difficult to forecast any accumulation of placer mineral deposits at this stage on the basis of the possible feeding provinces of Pliocene sediments in the aquatic area even more that currently the River Danube does not feed the shelf with terrigenous material. During that period the material from the Danube was deposited in the Eastern Carpathian Lake. More optimistic is the situation in the northwestern part where the deposits of Kimerian oolitic iron ores are formed.

Pleistocene stage

Lower Pleistocene. The obtained data of the geological structure and geomorphology of the relief in the western area of the Black Sea allowed the reconstruction and definition of the individual stages in its development. Use of broad spectrum of stratigraphic methods and absolute datings as well as the comparison of the data from the deep drills made possible the development of a relatively streamlined plan of the basin's evolution through the course of the Pleistocene and the Holocene. It should be taken into account however that the individual stages are sometimes related to considerable transitions and that the alternation of warm periods and salinization of the basin with cold periods and desalination in combination with tectonic movements is blurred and can be truthfully tracked when compared with the mollusc fauna, the nanoplankton and the spore-pollen spectra. The shelf, where the glacial eustatic oscillations are the best expressed, is characterized by frequent and sometimes considerable stratigraphic interruptions yielding only relic forms and sediments.

The end of the Pliocene and the onset of the Pleistocene is marked by a deep regression and an overall transformation of the river valley network. The basin's boundaries were substantially compacted and vast shelf areas dried out.

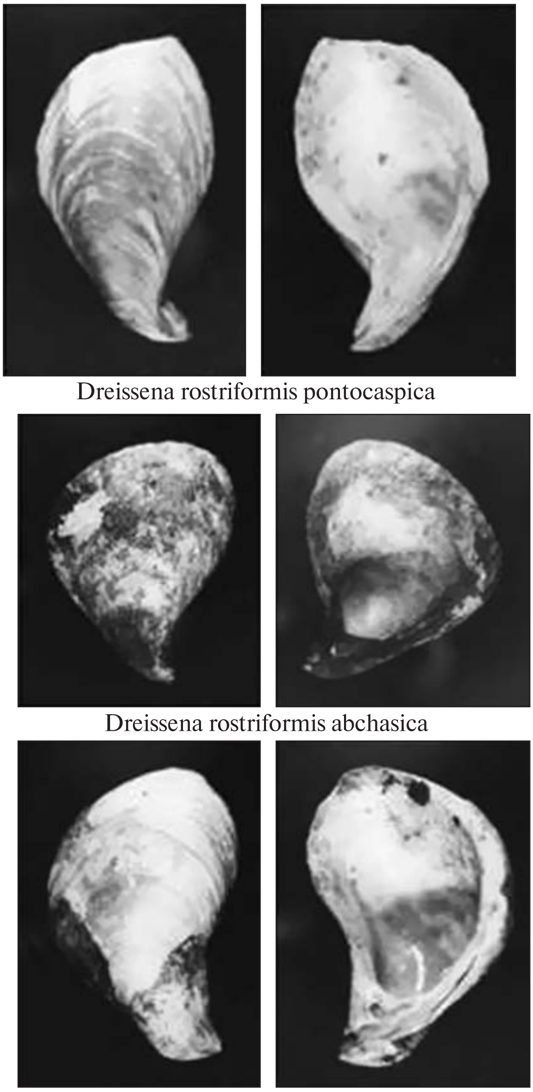
The development of mollusc fauna of Pontian type (Kimerian, Kujalnik) came to an end during the Gurian. A complex of forms with modern appearance developed on a large scale through the course of the Lower Pleistocene while relics of some Pontian forms preserved during the Chaudian.

The Chaudian sediments found both in the coastal terraces and in the water area of the Black Sea are referred to the Lower Pleistocene. They are represented by very large spectrum of sediments and can be found at different hypsometric levels. Marine Chaudian sediments are deposited on the terraces of the Taman Peninsula (35—40 m), the Caucasion coast (55—60 and 100 m — Fedorov, 1978), and in the water area. Complex terrigenous sediments up to 1500 m thick were formed in the southern area (Rion Valley) during the early Pleistocene. Sediments analogous to the Chaudian sediments are also found in the coastal areas of Northern Turkey. The discovered sediments containing Chaudian fauna on the shelf are dated as Upper Chaudian (Dimitrov, Govberg, 1979; Khristchev, Shopov, 1979).

Chaudian sediments from the Lower Pleistocene, rich in fossil mollusc fauna, typical of the Chaudian, lie on the erosion border of sea and continental sediments from the Pliocene in the aquatic area. They are characterized by a wide area of occupation and facial diversity. Initially, they were found in the periphery of the shelf, in the bar area, at depths from 80 m to 140 m, as lithificates of littoral origin and clays (Dimitrov, Govberg, 1979), however, at a later stage, almost all of their facial types were established

(Dimitrov, 1990). Sediments of the same type with Chaudian fauna were found in parallel almost everywhere along the periphery of the Black Sea shelf in the bar area as well as in the central part of the shelf up to absolute depths of 80 m (Fig. 3, *a, b*).

In the area of the Caucasian shelf (Magri, Georgia) (Fig. 2) at a depth of 100 m in a drill column with length of 210 cm were found Chaudian littoral sediments (Dimitrov, 1990). Phaseoline and mytilus aleuro-pelitic ooze typical of the Holocene were found within 0 to 175 cm on the shelf. Littoral shelly sediments from the Neoeuxine with fragments of redeposited Chaudian fauna were found under them from 175 to 195 cm. The interval 195—210 cm disclosed sediments with typically Chaudian fauna similar to the fauna described above (Fig. 2). A drill column with length of 100 cm was taken during the oceanological studies in the area of the Bosphorus at a depth of 96 m. Holocene aleurite-pelitic mud was established in the interval from 0 to 40 cm. It was followed by a narrow strip (within the interval 40—45 cm) of shelly terrigenous sediments from the Neoeuxine under which there were beach-like light yellow quartz sands with detritus and whole shells with Chaudian mollusc fauna (Dimitrov, 1990). In that way it was established that what is referred to as the «Bulgarian Chaudian» by some researchers (Fedorov, 1978; Kuprin et al., 1984) is not represented only locally but is widespread along the whole Black Sea shelf. The analysis of the spore-pollen spectra (Filipova et al., 1987) of the discovered cross-sections of Lower Pleisto-

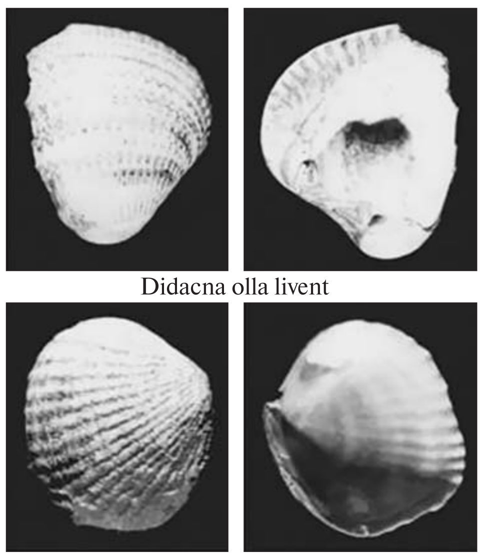


Dreissena rostriformis pontocaspica

Dreissena rostriformis abchasica

Dreissena rostriformis tschaudae

a



Didacna olla livent

Didacna tschaudia guriana

в

Fig. 3. Lower Pleistocene fauna: *a — genus Dreissena*; *b — genus Didacna*

cene support the thesis that they were formed under the conditions of a deep regression of the basin (Fig. 2). Most probably the sediment complex was formed during the Mindel Glacial Stage.

The schematic geological cross-section (Fig. 2) illustrates the situation of the Chaudian layers pointing to a single regional stage in the development of the basin during the Lower Pleistocene. The discovered sections from the Bulgarian, the Turkish and the Caucasian shelf contain the same Chaudian fauna and similar spore-pollen spectra. They are attached to the peripheral area of the shelf in the bar zone.

Many researchers distinguish two phases in the development of the Chaudian basin within the boundaries of the Black Sea basin — an early regressive phase and a late transgressive phase (Kuprin et al., 1984; Kuprin et al., 1985; Fedorov, 1978). Only regressive Chaudian layers, formed in a cold climate and hosting identical Chaudian fauna, have been established so far on the basis of the rich factual material we have with respect to the water area of the Black Sea. It should be noted that the same conclusions were drawn on the basis of study of the diatoms and the spore-pollen analysis using the data from the deep sea drills (Geological history..., 1980).

The Bulgarian researchers (Dimitrov, 1978; Khristchev, Schopov, 1978) defend the Upper Chaudian age of the discovered shelf sediments with Chaudian fauna and its regressive nature. The Chaudian layers on the continental slope and the abyssal bottom are from 200 to 300 m thick and are differentiated by seismoacoustic profiling data (Fig. 2.). The gravelly and the sandy fluvial riverbed sediments on the coast formed around the mouths of big rivers, may be related to the Lower Pleistocene (villafrank). Their configuration, morphometry and the contained mammal fauna allow us to accept them as continental analogues of the Chaudian from the aquatic area. For example *Archidiskodon meridionalis Nesti* remnants were found in the cross-section of the cross-bedded alluvial formations in the area of Novoseltzi — Sredetz during excavations for construction materials which confirmed its Lower Pleistocene age (Popov, Savov, Yordanov 1964). It is a just assumption (Khristchev, Schopov, 1979) that the continental sands in the foundation of C-8 are analogous to the Chaudian layers. The paleogeogrpahic reconstructions of the Chaudian layers indicate that the basin's boundary in its west area reached a 70-meter isobath. Further data of the wide area occupied by the Chaudian sediments were obtained during the engineering and geological studies of the shelf (Kuprin et al., 1984; Stoyanova, 1990). It is assumed that the inner boundary of the basin was limited by the same depths in the other areas of the Black Sea as well.

The analysis of the elemental and mineralogical composition of sediments does not support any forecasts of placer deposits of mineral resources or anomalous concentrations of some useful components.

Middle Pleistocene. Presently we have little data about the evolution of the Old Euxinian basin in its western area to be able to create a more truthful picture of its boundaries. Apart from the classical cross-section of the Old Euxinian basin uncovered in Burgas Bay (Khristchev, Schopov, 1978) Old Euxinian sediments were found to the north of the cross-section in the region of the East Samotino structure, the structures of Samotino Sea, Stefan Bogdanov, Elizavetian and Nanevska (Stoyanova, 1990). In some case the Old Euxine lies on continental analogues of the Chaudian and in others — on marine Chaudian sediments. The thickness of the Old Euxine on the shelf ranges from 0.2 to 27.2 m (C-3 Aprilska Area) and the absolute depths of its upper part — from 71.5 to 91.8 m (Kuprin et al., 1984; Stoyanova, 1990). Obviously the Old Euxinian basin overlapped with the Chaudian and extended closer to the beach. There are Old Euxinian sands, aleurites and clayey mud separated by an erosion area from the underlying littoral sediments in C-3 located on the April area 10 km to the east of Shabla's parallel (Bozilova et al., 1989). Based on spore-pollen spectra the interval in question was related to the «glacial age of the late Old Euxine» (Bozilova et al., 1989). The full cross-section of the Middle Pleistocene (C-380/380 A) is developed in the deep water area where Jose, Koreneva, Muhina (Geological history..., 1980) distinguish Paleouzunlar, early Old Euxinian, late Old Euxine and Uzunlar layers.

The Paleouzunlar sediments settled on the complex of diatoms in a saline sea basin which points to the existence of links to the Mediterranean Sea. According to Fedorov (1978) this was the first transgressive phase after the Mindel (Chaudian) regression. Typically the Old Euxinian layers are characterized by relative cooling of the climate as evidenced by the appearance of cold-loving diatoms. This is proof of the Riss Glaciation dated by the corresponding sediments found in C-3 of the April area (Bozilova et al., 1989). During the Uzunlar period the climate warmed up and the connection to the Mediterranean was restored.

Upper Pleistocene. The Middle Pleistocene cross-section on the Bulgarian shelf is gradually passes into Karangatian sediments characterized well by the fauna without traces of erosion or discontinuation (Khristchev, Schopov, 1979). It is an interesting fact that a magnetic inversion correlated with the Blake magnetic polarity episode (110 thousand years ago) was established in C-3 by Bozilova et al. (1989) on the basis of the paleomagnetic data (interval 34.5—55.2 m). Unfortunately this interesting fact was not confirmed by the fauna or the spore-pollen analysis which makes it doubtful. The Karangatian sediments are widespread on coastal terraces making it possible to follow the boundary of the Karangatian basin on the side of the dry land with a high degree of truthfulness.

The height of the Würm glaciation took place about 18 thousand years ago and caused a deep eustatic regression of the World Ocean whose level was 130 m below its present-day level (Dimitrov et al., 1986). At that time the Black Sea basin was going through the so called Post-Karangatian or Pre-Surozh regression. The obtained vast materials of the pre-deepened paleovalleys of the coast and the shelf (Ostrovskiy, 1967; Ostrovskiy, 1969; Popov, 1973) allowed the quoted researchers to distinguish two regressive phases — Pre-Surozh (Post-Karangatian) and «Predchernomorski» (Pre-Black Sea) (Pre-Holocene). The so called Pre-Surozh sediments in the valley of the River Bzivi are found at a depth of 140 m while the Pre-Holocene sediments are at a depth of 120 m (Ostrovskiy, 1967). Such results confirming the considerable decrease of the sea level during the Post-Karangatian (about 18 thousand years ago) and the Pre-Holocene (about 8 thousand years ago) regressions were produced during geological studies of the shelf (Shterbakov et al., 1978; Dimitrov, Govberg 1979; Khristchev, Shopov, 1979; Dimitrov, 1982). Most Russian researchers (Shterbakov et al., 1978; Kuprin et al., 1984; Vozovik, 1982) defend the gradual salinization of the Pre-Holocene basin while the author believes that the event was of catastrophic nature and supports his thesis by convincing arguments.

Holocene and modern stage in the development of the basin

Holoene stage covers the sediments formed over the past 8 thousand years; its most upper part which comprises the last 3—3.1 thousand years (the Djemetinian period) is called a modern stage.

As a result of the deep regression of the basin the pouring of freshwater from the Black Sea into the Mediterranean stopped about 9500 years ago (Jones and Gagnon, 1994; Ryan et al., 1997; Cagatay et al, 1999, 2000; Aksu et. al., 1999; Demirbağ et. al., 1999; Hiscott et. al, 2002) and the level of the freshwater Black Sea lake settled within depths of 90—120 m (Dimitrov, Dimitrov, 2004). About 8000 thousand years ago the level of the World Ocean, respectively of the Sea of Marmara, was higher than the level of the Black Sea by about 80 m. The catastrophic rush of oceanic water with salinity of 38 ‰ into the freshwater Black Sea lake led to dramatic consequences for the natural flora and fauna. An area of 50 000 km^2 was swept. The disruption of the Bosphorus barrier was caused either by the high hydrostatic pressure by the Sea of Marmara or by the frequent earthquakes in the region or by their accumulated effect (Dimitrov, 1990; Dimitrov, Dimitrov, 2003) (Fig. 4).

The beginning of the Holocene stage is marked by a catastrophic rise of the sea level when sediments of mixed origin — freshwater and marine — of molluscan communities settled down on the shelf. It should be noted once again that the absolute datings of the lower part of the Holocene based on the radiocarbon analysis of *Monodacna caspia* shells, *Mytilus galloprovincialis* shells and other shells indicate an age around 7.5—8 thousand years (Fig. 5).

There is no disagreement between Bulgarian researchers studying the Black Sea regarding the location of the Holocene-Pleistocene boundary. Some researchers suggest that the lower Holocene boundary to be placed on the upper part of the Neoeuxine. The arguments in that respect are loosely founded (Grigoryev et al., 1985). The absolute datings 14C of the lower part of the Holocene using Mediterranean type of fauna represented by Mytilus galloprovincialis, Cherastoderma glaucum, Monodacna caspia and the lower part of the sapropels according to Corg., indicate an age of 7500—8000 calendar years and fix the time of the catastrophe (Slavova, 2002).

The transitional Bugazian layers on the shelf are fragmented and are lodged within the range of 7.5—8 thousand years. Their situation on the continental slope and the abyssal bottom is quite contested. What we called earlier «a transitional formation» lying under the sapropelic oozes had to be referred to the Neoeuxine according to the the spore-pollen spectra (Filipova et al., 1989). Leaving aside the exact location of the Bugas layers in the deep areas of the basin we should note that their distribution on the shelf is irregular reaching a depth of 30 m. Leaving aside for a while the exact location

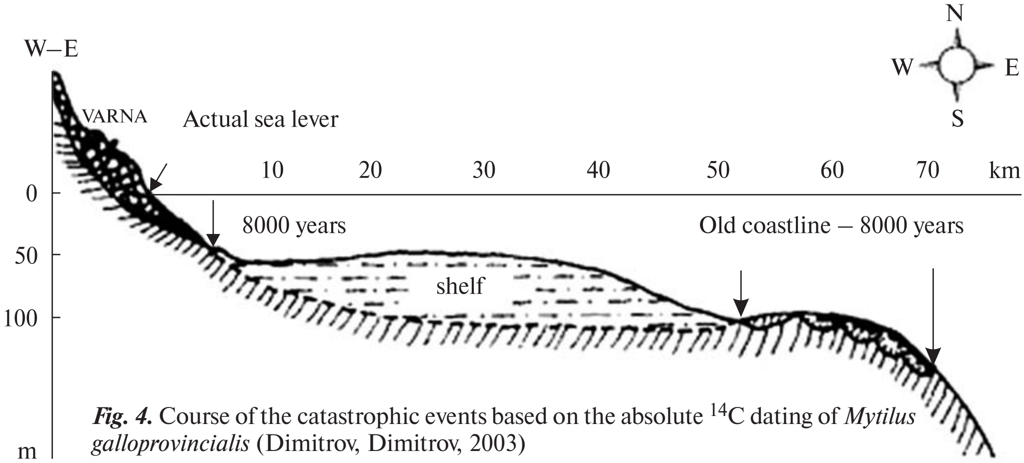


Fig. 4. Course of the catastrophic events based on the absolute ^{14}C dating of *Mytilus galloprovincialis* (Dimitrov, Dimitrov, 2003)

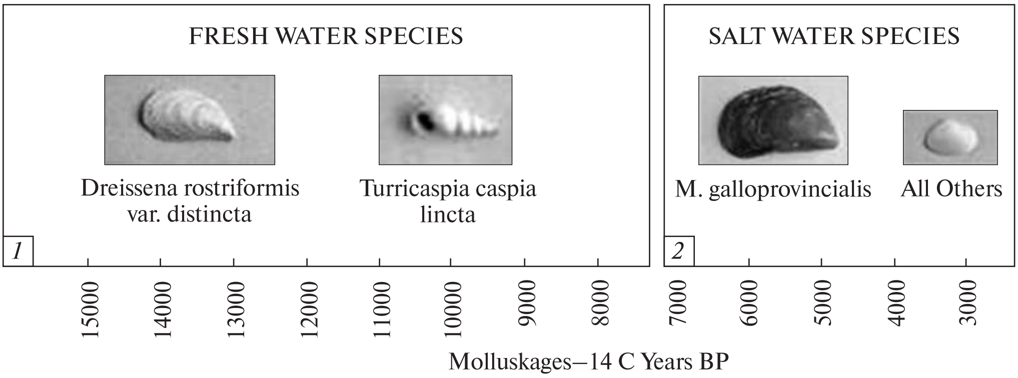


Fig. 5. Change of mollusk fauna: Types of fauna: *1* — freshwater and brackish; *2* — salt water (Ballard et al., 2000)

of Bugazian layers in the deep water area of the basin we should note that their distribution on the shelf is fragmented and reaches an absolute depth of 30 m. The established stable connection between the Black Sea and the Mediterranean Sea marked off the settlement of the Kalamitian — Vityazevian layers (Oldchernomorian layers according to Fedorov, 1978), standing out with considerable thickness and substantial distribution. The sapropelic sediments are traced by a facial transition from the upper part of the continental slope towards the deep areas. The modern stage is characterized by sedimentation of deposits of various composition and features on the shelf reflecting the characteristic features of present-day feeding provinces. The coccolithophorid sedimentation is prevalent in the deep water areas.

During the modern Djementian stage in the development of the Black Sea the formation of organogenic mineral sediments takes place in the so called halistases, i. e. the areas below the centres of the main cyclonic vortices. The latter have most probably preserved the nature of their circulation throught the Holocene. A unique separation of plankton biomass with predominant carbonate components (coccolithophorids) is performed in these areas under the conditions of relatively high productivity of phytoplankton (dinoflagellates and coccolithophorids) and poor feeding with terrigenous material. Carbonated (50—70 %) to highly carbonated (>70 %) muds are formed. Similarly to modern Coccolith oozes, the Kalamitian — Vityazevian sapropels were also formed within the cyclonal circulations however they were slightly carbonated due to the low development of the coccolithophorids. Their content of OM may be as high as 22 %. The palynological studies (Filipova et al., 1989) indicate that through the Kalamitian — Vityazevian period the sedimentation took place in a warm and humid climate (more humid than the modern climate) and the aquatic area was supplied with a larger amount of nutritious salts. The main inflow of nutrients came from the Mediterranean leading to wild «blooming» of diatoms, dinoflagellates, crustaceous plankton and copepods. The organogenic matter is preserved from complete decomposition under the conditions of hydrogen sulfide contamination. The areas where the sapropelic oozes settled down changed with the alternation of the hydrodynamic regime and especially in the regions where the underwater valleys are unloaded on the continental slope. For that reason interbeds of terrigenous and terrigenous-sapropelic oozes occur frequently and in various combinations in the sapropels.

The Holocene transgression evolved quite irregularly. Nevesskiy (1967) distinguishes 6 transgression phases over the past 9 thousand years, each of which was preceded by a short-lived but sufficiently deep regression. Analyzing the late Pleistocene history of the Black Sea over the past 15 thousand years Fedorov (1978) distinguishes 7 intermediate regressions followed by periods of fast elevation of the sea level. Popov and Mishev (1974) separate 4 submarine terraces on the shelf in the western part of the Black Sea, located respectively at depths of 35—40, 20—25, 8—12 and 4—5 m and reflecting the stages of stabilization of the sea level during the Holocene.

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Received 01.04.2015

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ПАЛЕОГЕОГРАФИЧЕСКИЕ РЕКОНСТРУКЦИИ И УСЛОВИЯ ФОРМИРОВАНИЯ НЕТРАДИЦИОННЫХ РЕСУРСОВ ЧЕРНОГО МОРЯ

Современные Средиземное, Черное и Каспийское моря неоднократно подвергались геокатастрофическим событиям, вызванным резкими изменениями климата или глобальными геологическими процессами. Ярким примером этого служит мессинский кризис в Средиземном море на границе миоцен — плиоцен (5,7—5,2 млн лет тому назад), когда сформировалась эвапоритово-сероносная формация. В это же время формируется Азово-Черноморская железорудная провинция и балханская свита Каспийского моря, с которой связаны крупные месторождения нефти и газа. Черноморский кризис около 8—9 тыс. лет тому назад связан с геокатастрофическим событием в результате таяния ледников вюрмского оледенения: воды Средиземного моря соленостью 38 ‰ хлынули в Черноморский пресноводный бассейн, что привело к формированию гигантских скоплений органо-минеральных осадков (сапропелей).

Ключевые слова: *ранний плейстоцен, нижний, средний, верхний плейстоцен, голоцен, мессиний, занклий, галесий, биостратиграфия.*

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ПАЛЕОГЕОГРАФІЧНІ РЕКОНСТРУКЦІЇ
ТА УМОВИ ФОРМУВАННЯ НЕТРАДИЦІЙНИХ
РЕСУРСІВ ЧОРНОГО МОРЯ

Сучасні Середземне, Чорне та Каспійське моря неодноразово піддавалися геокатастрофічним подіям, викликаним різкими змінами клімату або глобальними геологічними процесами. Яскравим прикладом у цьому плані є месинська криза в Середземному морі на межі міоцен-пліоцен (5,7—5,2 млн років тому), коли сформувалась евапоритово-сірконосна формація. У цей же час формується Азово-Чорноморська залізорудна провінція і балханськая світа Каспійського моря, з якою пов'язані великі родовища нафти й газу. Чорноморська криза близько 8—9 тис. років тому пов'язана з геокатастрофічною подією в результаті танення льодовиків вюрмського зледеніння: води Середземного моря солоністю 38 ‰ ринули в Чорноморський прісноводний басейн, що призвело до формування гігантських скупчень органомінеральних осадів (сапропелів).

Ключові слова: *ранній плейстоцен, нижній, середній, верхній плейстоцен, голоцен, месиній, занклій, галесій, біостратиграфія.*