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WHERE EAST MEETS WEST: Pontocaspia, the historical dimension of the evolution of a unique biodiversity

Abstracts
of the International youth school-conference

Rostov-on-Don / Kagal’nik, Astrakhan’, Russia
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W62 **(2017) Where East meets West: Pontocaspia, the historical dimension of the evolution of a unique biodiversity.** Abstracts of the International youth school-conference (Rostov-on-Don / Kagal'nik, Astrakhan', Russia, August 21 – September 02, 2017). Rostov-on-Don: SSC RAS Publishers. 128 p. (In English). ISBN 978-5-4358-0155-2.

The book presents the materials of the International Conference held in Rostov-on-Don / Kagal'nik, and Astrakhan' (Russia). Reports concern a wide spectrum of issues connected to the study of the current state of marine ecosystems, climatic and ecosystem transformations in the Black Sea – Caspian region, the geology of Quaternary marine and continental deposits of the Black Sea, the Sea of Azov, and the Caspian Sea. Also presented the newest data on the study of the influence of anthropogenic factors on the development and state of biocenoses. The special attention is given to the questions of history and conditions of the biological diversity of these inland seas forming.

Addressed to biologists, ecologists, geologists, stratigraphers, paleontologists, and paleogeographers.

Abstracts are published with the maximal preservation of the authors' texts

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ТАМ, ГДЕ ВОСТОК ВСТРЕЧАЕТСЯ С ЗАПАДОМ: Понто-Каспий, исторический аспект эволюции уникального биоразнообразия

Тезисы докладов
Международной молодежной школы-конференции

Ростов-на-Дону / Кагальник, Астрахань, Россия
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Т17

При поддержке исследовательской и инновационной программы Horizon 2020 Европейского Союза в рамках гранта Марии Склодовской-Кюри № 642973

Т17 **Там, где Восток встречается с Западом: Понто-Каспий, исторический аспект эволюции уникального биоразнообразия:** тезисы докладов Международной молодежной школы-конференции (Ростов-на-Дону/ Кагальник, Астрахань, Россия, 21 августа – 2 сентября 2017 г.). – Ростов н/Д: Изд-во ЮНЦ РАН, 2017. – 128 с. – ISBN 978-5-4358-0155-2.

Книга содержит тезисы докладов Международной конференции, проведенной в г. Ростове-на-Дону, пос. Кагальнике и г. Астрахани. Сообщения касаются широкого спектра проблем, связанных с изучением современного состояния морских экосистем, климатических и экосистемных трансформаций в Черноморско-Каспийском регионе, геологии четвертичных морских и континентальных отложений Причерноморья, Приазовья и Прикаспия. Также представлены новые данные по изучению влияния антропогенных факторов на развитие и состояние биоценозов. Особое внимание уделено вопросам истории и условиям формирования биологического разнообразия этих внутренних морей.

Издание предназначено для биологов, экологов, геологов-стратиграфов, палеонтологов и палеогеографов.

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TESTING THE CONNECTIVITY HISTORY OF THE BLACK SEA AND THE CASPIAN SEA DURING THE PLEISTOCENE, USING STRONTIUM ISOTOPES

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ИССЛЕДОВАНИЕ ИСТОРИИ СВЯЗИ ЧЕРНОГО И КАСПИЙСКОГО МОРЕЙ В ПЛЕЙСТОЦЕНЕ С ИСПОЛЬЗОВАНИЕМ ИЗОТОПОВ СТРОНЦИЯ

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Over the last few million years, the Black Sea and the Caspian Sea have experienced multiple transgression and regression events, mainly driven by changes in fresh water hydrologic budgets caused by regional and global climate change and active tectonics. As a consequence, these basins have at times been connected to each other and to the global ocean via the Mediterranean, while at other times they have been three isolated systems. The periods of connectivity facilitate faunal exchange between the basins, whereas, the periodic isolation of the basins promotes the evolution of endemic fauna. Identification of faunal biodiversity in the geological record has been used to reconstruct connectivity and isolation between these three marine systems. We use strontium isotopes analysis to test this connectivity history over the last 2.5 Million years.

Strontium isotope ratios ($^{87}Sr/^{86}Sr$) in marginal marine and lacustrine systems are a function of the balance between the freshwater and oceanic input to the basin. This ratio is captured and preserved by organisms that precipitate low Mg-calcite shells. The $^{87}Sr/^{86}Sr$ record of the two basins will show similar values during periods of connectivity whereas, the $^{87}Sr/^{86}Sr$ record will diverge from each other during periods of isolation if the fluvial inputs to each basin are different. $^{87}Sr/^{86}Sr$ was measured on fossil ostracods, micro-crustaceans with calcitic exoskeleton, obtained from the Pleistocene sediment of the Black and the Caspian seas to investigate the coeval water geochemistry of the two basins over the last 2.5 Ma.

The combined strontium isotopic ratio of these basins broadly supports the paleontological data but provides more details in terms of timing and nature of the connectivity between the basins. Water samples from the Black Sea, the Caspian Sea, and various rivers draining into them were also measured for $^{87}Sr/^{86}Sr$ to examine the present day strontium isotopic signal across the region.

THE ROLE OF SATELLITE REGIONS IN THE EVOLUTION OF PONTOCASPIAN BIOTA

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РОЛЬ ВОДОЕМОВ-СПУТНИКОВ В ЭВОЛЮЦИИ ПОНТО-КАСПИЙСКОЙ БИОТЫ

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Basins in Turkey have played various roles in the evolution of Pontocaspian biota despite their ephemeral location in the Pontocaspian area (Fig. 1). In this contribution we will review the current geological and paleontological knowledge of these basins and their role in the evolution of Pontocaspian biota.

Within the Pliocene and early Pleistocene two adjacent basins in western Anatolia contained species of Pontocaspian genera or their immediate predecessors. In the Denizli Basin a Late Miocene – Pliocene Paratethian assemblage was reported by Taner [1974a, b; 1975]. Then, a Late Miocene Pontocaspian fauna was recorded by Wesselingh et al. [2008] containing four species of *Didacna*. The age of the fauna is likely to be revised to Early Pliocene. Further *Didacna* species are to be reported. Within the Denizli Basin a late Pliocene-Early Pleistocene lake succession exists where only a single *Didacna* species remained. The attribution of the Denizli material to *Didacna* will need confirmation as part of a wider appreciation of the definition of the genus.

In the adjacent Baklan Basin a species of the genus *Monodacna* is found in Pliocene deposits. This attribution is uncontested and appears the oldest record of true *Monodacna*. Furthermore a gastropod species attributed to “*Euxinipyrgula*” is found. These Anatolian species most likely derived from the Paratethys or even Mediterranean Lagomare faunas (with a specific *Pontalmyra* species as possible ancestor for *Monodacna*). The exact role of the Anatolian Basins in the origin of Pontocaspian biota remains to be further clarified.

Molecular evidence has shown that a radiation of hydrobiid species of the genus *Falsipyrgula* in southern Anatolian lakes in the Eğirdir-Beyşehir region possibly derives from a Pontocaspian pyrguline ancestor whose introduction can be dated to approximately the Middle Pleistocene [Wilke et al., 2008]. A relative recent finding in the adjacent Karapınar Basin (Konya) of three lymnocardiine species in ca. 40 kyr (Late Pleistocene) has furthermore shown the potential role of these basins as "sinks" for long-distance dispersal of Pontocaspian taxa from the core Black Sea – Caspian region in the past.

Finally, Pontocaspian conditions and faunas have been established and disappeared during the Middle and Late Pleistocene in the Marmara region and adjacent basins. It concerns a succession of faunas that derive from overflow events of the Black Sea Basin. A Middle Pleistocene Chaudian fauna is reported from the Gelibolu peninsula [Andrussov, 1898; Taner, 1983; Tchepalyga, 1995]. A Middle Pleistocene *Didacna* bearing terraces are also found in Lake Iznik dated to 'early Khazarian' [İslamoğlu, 2008]. Furthermore a complete Late Pleistocene (Neoeuxinian) fauna is found in deposits underlying the Marmara Sea [İslamoğlu & Tchepalyga, 1998; Büyükmeriç, 2016] and also in the samples obtained between the 26-28 m levels of the drilling cores [Meriç et al., in press]. The latter fauna is identical to Neoeuxinian faunas in the Black Sea and shows direct connections between the two basins. Within the Iznik fauna the species identifications are problematic and local species may have developed.

Anatolian basins have played various roles in the evolution of Pontocaspian biota. They were possibly involved in the origin of some genera and were also "sinks" and subsequent centers of radiations.

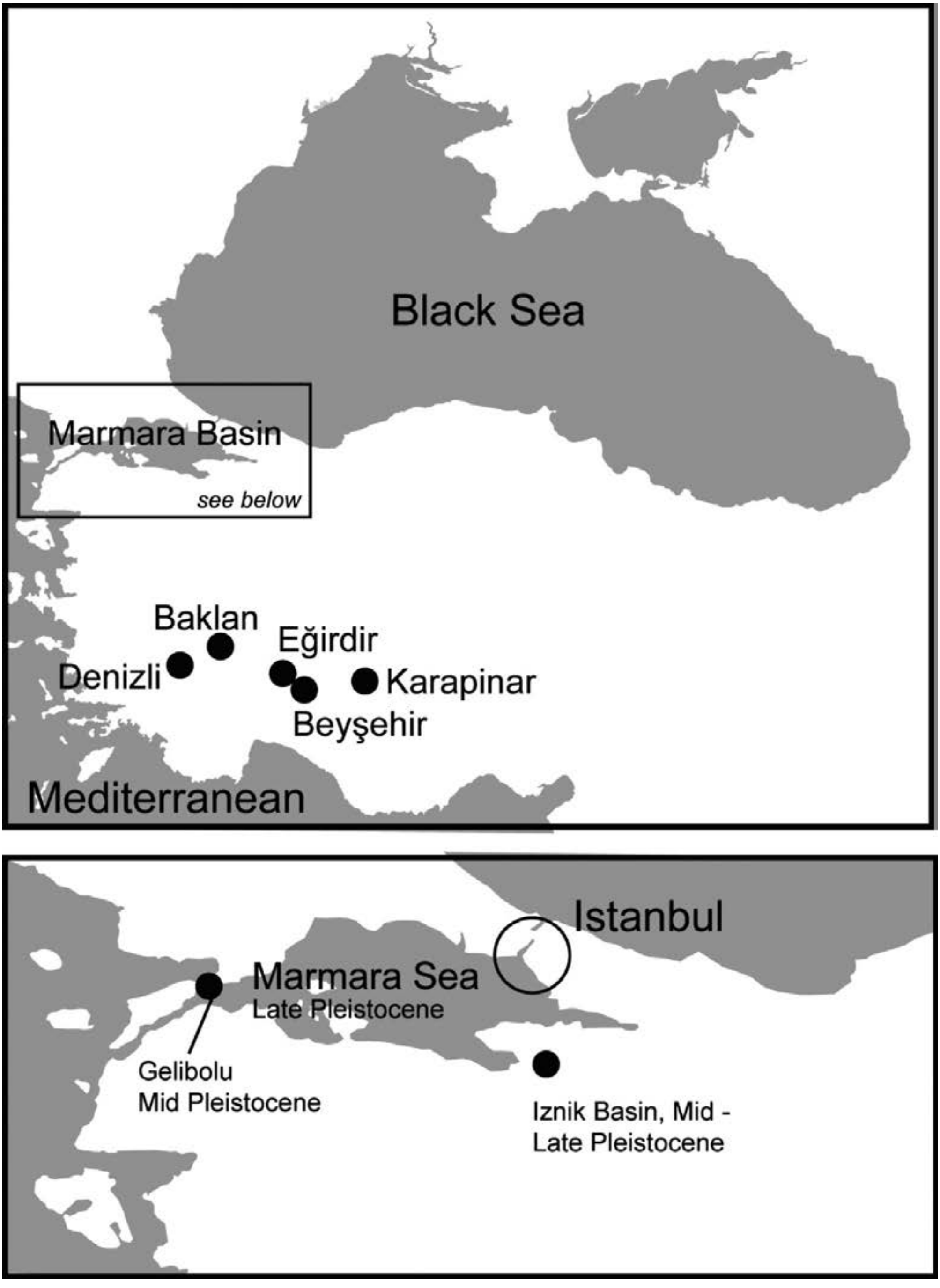

Fig. 1. Map of the satellite Pontocaspian basins in Turkey

DO ECOLOGICAL INTERACTIONS EXPLAIN DOMINANCE SHIFT BETWEEN PONTO-CASPIAN BIVALVES *DREISSENA POLYMORPHA* AND *DREISSENA ROSTRIFORMIS BUGENSIS* IN THEIR INTRODUCED RANGE?

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ОБЪЯСНЯЮТ ЛИ ЭКОЛОГИЧЕСКИЕ ВЗАИМОДЕЙСТВИЯ СМЕНУ ДОМИНИРОВАНИЯ ПОНТО-КАСПИЙСКИХ МОЛЛЮСКОВ *DREISSENA POLYMORPHA* И *DREISSENA ROSTRIFORMIS BUGENSIS* В ОБЛАСТИ ИХ ИНВАЗИОННОГО АРЕАЛА?

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The invasive bivalve species *Dreissena polymorpha* and *Dreissena rostriformis bugensis* are native to the Ponto-Caspian area (i.e., rivers basins northern of the Black Sea, Caspian Sea and Azov Sea). In the 19th century *D. polymorpha* started extending its geographical range. Nowadays this species can be found throughout Europe, Eurasia and North America on hard substrates in fresh to oligohaline rivers, lakes and canals. However, since circa 20 years ago the closely related *D. r. bugensis* too started showing invasive behavior, causing a dominance shift from *D. polymorpha* to *D. r. bugensis*. Although, this is a widely observed phenomenon, mechanistic understanding of displacement of *D. polymorpha* by *D. r. bugensis* is still limited. Therefore, we focused on two sites in the Rhine-Meuse river delta where both species co-occurred since 2006. We assessed the ecological interactions within these mixed populations on fouling plates 3 to 48 months after settlement (Fig. 1). This may shed more light on the mechanistic understanding of the displacement of *D. polymorpha* by *D. r. bugensis* at other sites.

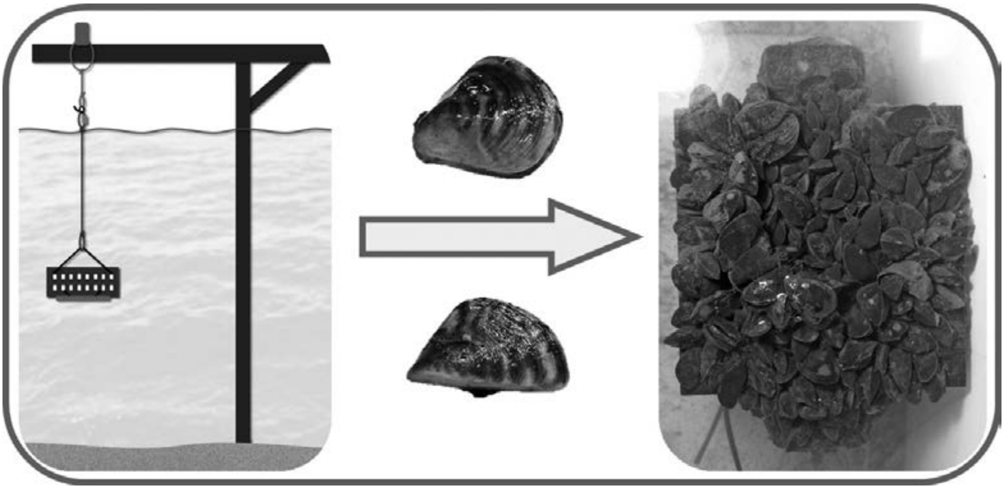

Fig. 1. Setup of field experiment in the Rhine-Meuse river delta for assessment of the ecological interactions between the invasive bivalve species *Dreissena polymorpha* and *Dreissena rostriformis bugensis*

PLEISTOCENE MOLLUSCAN FAUNAS FROM NORTH-EAST OF AZOV SEA AND LOWER DON RIVER REGION

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ПЛЕЙСТОЦЕНОВЫЕ ФАУНЫ МОЛЛЮСКОВ СЕВЕРО-ВОСТОЧНОГО ПРИАЗОВЬЯ И НИЖНЕГО ДОНА

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The Pleistocene deposits of the Azov Sea region and the Lower Don region are traditionally divided into terrace levels. For Early Pleistocene to Early Middle Pleistocene deposits of the Northern Azov Sea region, three main stratigraphic levels are distinguished: the beginning of the Early Pleistocene (Gelasian) (40-45 m), the Khapry (VII) terrace, the late Early Pleistocene (30 m above sea level) Margaritovo (VI) (southern shore) and Nagaysk (northern shore) terraces, early Middle Pleistocene (20-25 m asl) Gerasimovka and Platovo (V) terrace (northern shore) and the Semibalki terrace (southern shore), and a younger Rozhok (IV) terrace.

The Quaternary molluscan fauna from the North-East Azov Sea region were studied based on material of 15 localities (Nesmeyanovka, Sarkel, Semibalki 1, 2, Margaritovo 1, 2, Port-Katon 3, 4, Platovo, Zeleniy, Kagalnik, Mikhailovskiy, Beglitsa, Lebyazhiy and Siniy Yar).

Late Early Pleistocene (late “Levantine”) in the North-East Azov Sea region is known from Nesmeyanovka location. According to the data from the literature the assemblage includes *Bogatschevia scutum*, *Pseudosturia caudata*, *Pseudosturia brusinaiformis*, *Potamoscapha tanaica* and different species of the genus *Unio* [Stratigraphy of the USSR, 1982]. The fauna of small mammals correlates to the upper part of the regional zones MQR9 [Tesakov, 2010].

The freshwater fauna of the late Early Pleistocene reflects climatic conditions from the subtropical to more temperate (Mediterranean) climate and is characterized by the gradual loss of subtropical elements and increasing role of boreal ones, and the appearance of the new genus of Unionidae (*Pseudosturia*).

Late Early Pleistocene in our material was collected from sites of Sarkel, Semibalki 1, Port-Katon 3 and Margaritovo 1. In all of these localities large mammals belonging to the Taman faunal complex and the association of small mammals are correlated to the regional zone MQR8 [Tesakov et al., 2007].

The following molluscs are determinated in this complex: *Viviparus pseudoturritus*, *Viviparus* spp., *Lithoglyphus* cf. *naticoides*, *Lithoglyphus pyramidatus*, *Fagotia esperi*, *Bithynia tentaculata*, *Bithynia* sp. (opercula), *Parafossarulus* sp. (opercula), *Valvata piscinalis*, *Lymnaea* spp., Planorbidae spp. *Unio* sp., *Pisidium sulcatum*, *Pisidium* sp. and others. This association is characterized by a large number of extinct species that originated in Pliocene, but are closely related to the modern fauna. *Viviparus pseudoturritus* is probably close to modern Italian species [Section of the newest deposits... 1976].

Late Early Pleistocene molluscan associations are characterized by boreal limnophilic and stagnopilic forms belonging to the modern species that still alive in this area (except extinct *Parafossarulus* and *Pisidium sulcatum*). The malacofauna indicates a lacustrine water body with an oozy bottom and thickets of riparian vegetation. Southern boreal molluscs *Fagotia* and *Lithoglyphus* are thermophiles for this region. The presence of fragments of thick-walled shells of Unionidae and Viviparidae provide an indication of a warm climate.

The fauna of the terminal Early Pleistocene was studied in the Margaritovo 2 locality. The stage of evolution of the *Stenocranius* voles from this site correlates to the first half of the MQR7 regional zone. According to the paleomagnetic data, these deposits are reversely magnetized, and correspond to the inverse polarity interval between the Jaramillo Subchron and the Brunhes-Matuyama reversal.

Bithynia leachi, *Bithynia* sp. (opercula), *Parafossarulus* sp. (opercula), *Valvata pulchella*, *Valvata piscinalis*, *Borysthenia naticina*, *Lymnaea* sp., Planorbidae spp., Succineidae indet, *Limax* sp., Euglesidae spp., Pisidiidae spp., *Dreissena* sp. and others were determinated in this section. Most of this association is represented by modern boreal species inhabiting water bodies with a weak current. Many of the recorded molluscs prefer sandy-clay bottom habitats. Compared with the late Early Pleistocene, the climate has become colder: southern boreal genera are missing in this assemblage.

The freshwater fauna of the end of late Early Pleistocene reflects the gradual cooling of the climate and the restructuring of the fauna from the subtropical through the southern boreal to the modern boreal type.

Early Middle Pleistocene molluscan fauna were found in Platovo, Zeleniy, Kagalnik and Simebilki 2 localities. According to A.S. Tesakov, small mammal associations from these sections are typical for the Tiraspol faunal complex and belongs to the regional zone MQR 5 with an age range of ~550-700 thousand years old.

46 taxa of molluscs were identified here. A significant part of the fauna is modern (89.1%). The extinct forms include *Parafossorulus* sp., *Borysthenia* cf. *goldfussiana*, *Unio rumanoides*, *Unio* cf. *chozaricus,* and *Pisidium sulcatum*. Most species of this complex are living now in the middle latitudes, there are also southern boreal species that now inhabit southern rivers of Eastern and Central Europe. *Lithoglyphus pyramidatus* occurs in the north of the Balkan Peninsula and in North-Western Anatolia [Gloer, 2002]. From the ecological point of view, limnophiles are dominated. They prefer shallow coastal, overgrowing parts of large rivers.

The fauna of molluscs from Port-Katon 4 locality is younger in comparison to other early Middle Pleistocene sites. It contains modern boreal species. The extinct snail *Parafossorulus crassitesta* is the exception. It worth noting that complete shells of this species are collected in this location, although only opercula attributed to this genus are usually preserved. This finding is one of the youngest in Eastern Europe. The absence of any thermophilic elements makes it possible to assume a cold climatic interval and correlate the locality to the end of the early Middle Pleistocene.

Late Middle – Late Pleistocene. This stage includes molluscan faunas from the Mikhailovskoe, Beglitsa, Lebyazhiy, and Siniy Yar sites.

Association of this time are characterized by extant species currently living in this region, except several species living in more southern areas. The warm interval at the beginning of late Middle Pleistocene affected the composition of the mollusc association, including an extensive northward migration of the genus *Corbicula* from the south. It is characteristic of the optimum of the Likhvin (Holsteinian) interglacial and is a distinctive feature of this period.

Beglitsa and Lebyazhiy faunas are geologically younger and are dated to late Middle Pleistocene. These associations characterize the modern stagnophilous boreal fauna, without any warm elements. All freshwater species here are modern and live in the temperate zone. The ecological range of terrestrial mollusks includes moderately moist forest, shrub, meadow and less often steppe habitats.

The youngest fauna was studied from the Siniy Yar location. It was correlated to post Eemian part of Late Plesitocene. Association of molluscs without thermophilic species is similar to the modern one. According to the data [Tesakov et al., 2012], the faunistically characterized middle part of the section probably formed in the second half of the Middle Valday megainterstadial (Bryansk time).

INVESTIGATION OF PHYTOPLANKTON OF DIFFERENT SIZE FRACTIONS ON THE EXAMPLE OF THE TAGANROG BAY

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ИССЛЕДОВАНИЕ ФИТОПЛАНКТОНА РАЗНЫХ РАЗМЕРНЫХ ФРАКЦИЙ НА ПРИМЕРЕ ТАГАНРОГСКОГО ЗАЛИВА

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The phytoplankton of the Taganrog Bay of the Sea of Azov is one of the most studied components of the Azov Sea ecosystem. Hydrobiological studies however, were mainly confined to the study of algae with a size of more than 20 µm [Studenikina et al., 1999; Makarevich, 2007]. For methodological reasons scientists have rarely considered the algae, with sizes ⩽20 µm: pico- (0,2-2 µm) and nanoplankton (from 2–10 to 20 µm), although these organisms can form to 59-69% of primary production and the total biomass of phytoplankton [Mikheeva, 1988; Vedernikov, Mikaelyan, 1989; Makarevich, Druzhkova, 2010]. In our studies we used the method of luminescence microscopy, which extends our possibilities of studying small-scale objects (fractions from 0.2 to 20 µm).

The aim of the study was to determine the role of algae of different size fractions in the functioning of the modern phytoplankton community, to evaluate their contribution to the general biomass of phytoplankton on the example of the summer phytoplankton community of the Taganrog Bay (June 2016).

Analysis of the summer phytoplankton community of Taganrog Bay revealed characteristic processes for the period under study: the dominants were representatives of the phylum Cyanobacteria, their biomass and abundance was 3996 mg/m^3 and $36 \cdot 10^9$ cells/m^3 respectively; subdominants were diatoms (Bacillariophyta: up to 2806 mg/m^3 and $19 \cdot 10^9$ cells/m^3) and green (Chlorophyta: up to 2008 mg/m^3 and $31 \cdot 10^9$ cells/m^3) algae; the total biomass of the community was low in the Taganrog Bay, except for the eastern part of the Bay. The mass development of predominantly small-cell (⩽20 µm) fast growing algae was noted there.

According to the obtained data, algae of nanofraction size predominated almost everywhere in the studied basin – they accounted for 67 to 85% of the total biomass of phytoplankton.

Contribution of large-cell algae (>20 μm) differed in regions from 13 to 41%, and only in the Eastern part of the Taganrog Bay it reached 72%. Algae of picofraction size did not make a significant contribution to the biomass of phytoplankton in the eastern and centralparts of the Bay (2-10%), but significantly contributed to it (from 13 to 17%) in the western part of the investigated area.

Cluster analysis of the spatial structure of phytoplankton showed the differentiation of the algocoenosis to communities of oligogalobic (saline waters ⩽5‰) and mesogalobic (from 5 to 20‰) algae. Algae reached the greatest quantitative development with water salinity from 0.7-1.5 to 3.8‰, which was recorded in the eastern part of Taganrog Bay. Probably, this distribution was caused not only by the salinity of water, but also by the content of nutrients in the Don River water. Thus, mineral nutrients that came with the inflow of the Don River have been consumed almost completely in the eastern part of the Bay (the content of nitrites decreased from 0.081 to 0.001 mgN/l, nitrates – from 0.082 to 0.001 mgN/l, phosphates – from 0.054 to 0.011 mgP/l). This stimulated the simultaneous development of cyanobacteria, green and diatom algae (this is further confirmed by the high concentration of chlorophyll-a – from 49 to 131 μg/l) and led to supersaturation of water with oxygen in this part of Bay (from 9.0 to 16.1 mgO_2/l). The concentration of mineral nutrients began to increase again in the central and western parts of the gulf – nitrite content increased to 0.018 mgN/l, nitrates – to 0.002 mgN/l, phosphates – to 0.013 mgP/l (personal communication of V.S. Gerasyuk). Probably, this was due to a decrease in the intensity of development of oligogalobic phytoplankton and a reduction in its consumption of these elements.

In summary we can state that in June 2016 the phytoplankton community of Taganrog Bay was in the appropriate succession stage. The prevalence of algae of nanofraction in the investigated basin was noted, and as we used the method of luminescent microscopy, the proportion of algae of nanofraction in the total biomass of phytoplankton was determined, reaching 67-85%.

The work was carried out within the framework of the research topic “Modern condition and inter-annual variability of the coastal ecosystems of Russian Southern seas”, State reg. № 01201363187.

OUTREACH IN THE HEART OF THE PONTOCASPIAN REGION

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СОЦИАЛЬНО-ОРИЕНТИРОВАННАЯ ПРОГРАММА В ЦЕНТРЕ ПОНТО-КАСПИЙСКОГО РЕГИОНА

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Stakeholder engagement and provision of knowledge products to end-users is critically important in science. Effective frameworks to reach out to stakeholders and end-users, however, are generally lacking. The PRIDE (Pontocaspian biodiversity RIse and DEmise) project, an EU Horizon 2020 project that studies the evolution of the unique Pontocaspian fauna in the Caspian Sea-Black Sea region, is one of the pioneering programs that incorporates outreach as integral part of its program. One of the target stakeholder groups of PRIDE's Outreach Plan is: "Citizens in coastal areas of the Danube Delta in Ukraine and Romania". The goal of engagement is to raise awareness on the demise of Pontocaspian biota and to create conditions that support future conservation in the region. Both Romania and Ukraine are parties of the Convention on Biological Diversity (CBD) and have national targets to raise awareness on biodiversity (Aichi Biodiversity Target 1). Both countries share responsibility of Danube Delta Biosphere Reserve and Black Sea coastal area. Furthermore, Danube Delta is an international UNESCO world heritage site that harbours a diverse Pontocaspian fauna that remains largely unappreciated until today. Apart from raising the awareness and understanding the social context of the Pontocaspian biodiversity related problems, PRIDE intends to inform policy makers on different scenarios of anthropogenic influence and come up with well-argued, science-based suggestions for improvement. To address the abovementioned issues together we are studying: (1) Differences in the stakeholder social network structures in Ukraine vs Romania in order to understand how stakeholder organizations' social dynamics drive the outcomes for Pontocaspian biodiversity. (2) Pontocaspian biodiversity related environmental policy, particularly related to Danube Delta and Black Sea coastal area in Romania as an EU vs Ukraine as a non-EU country. (3) Current public biodiversity awareness and attitudes as a baseline study in the Danube Delta region. Here we present the preliminary results from our studies.

BASIN CONNECTION AFFECTS CASPIAN SEA ENVIRONMENTS AND BIOTA AT 2.73 MA

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СВЯЗЬ МЕЖДУ БАССЕЙНАМИ ВЛИЯЛА НА СРЕДУ И БИОТУ КАСПИЙСКОГО МОРЯ 2,73 МЛН ЛЕТ НАЗАД

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The Caspian Sea is the largest isolated water body in the world and both its hydrology and biota are highly sensitive to changes in water conditions driven by climate and basin connectivity. During most of the Pliocene, the Caspian Sea was disconnected from the global oceans and a thick sequence of fluvio-deltaic and lacustrine sediments was deposited in the South Caspian Basin (the Productive Series). Overlying this sequence, the Akchagylian mudrocks were formed in relatively deeper water settings following a large-scale transgressive event that caused the Caspian Lake to expand over vast areas that had previously been sub-aerial; including parts of Azerbaijan, Georgia, Iran, Turkmenistan, Kazakhstan and South-western Russia. Although the occurrence of this transgressive event is well noted, the exact nature and timing are not completely constrained.

Here, we present new radiometric dating ($^{40}Ar/^{39}Ar$ on volcanic ashes) as well as palynological, sedimentological and geochemical evidence for the connection at the Lokbatan section, Azerbaijan. Proxy data demonstrate clear effects of the basin connection on biota and chemistry in the South Caspian Basin, including evidence of complete overturn in phytoplankton communities as well as changes in sediment chemistry across the transition interval. The new age data place the transgression at the Lokbatan section at ~2.73 Ma, which is broadly concordant with other new data from elsewhere in Azerbaijan [Van Baak et al., in prep.]. This date suggests that the event was more or less contemporaneous with the intensification of northern hemisphere glaciations at, or immediately preceding the Pliocene-Pleistocene boundary at 2.58 Ma.

Paradoxically, the base of the Akchagylian as encountered north of the Caucasus appears to be somewhat older than in the south (time equivalent of the Surakhany Suite in Azerbaijan). New dating of the Plio-Pleistocene deposits in the South Caspian Basin may warrant a renewed look at the north-south correlation of the Akchagylian, which is far from straightforward and has often relied on magnetostratigraphic zonations. Reassessment of the available data may help to reconcile apparent differences in timing and to improve understanding of the transgression at a basin scale.

PROBLEMS OF GEOLOGY AND DEVELOPMENT HISTORY OF THE KERCH STRAIT

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ПРОБЛЕМЫ ГЕОЛОГИИ И ИСТОРИИ РАЗВИТИЯ КЕРЧЕНСКОГО ПРОЛИВА

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The zone of the Kerch Strait refers to the relatively young Kerch-Taman folded region. A feature of this area is the intersection of folds of two directions: Crimean – latitudinal, and Caucasian – northwest. With the interference of the uplifts of these two directions, numerous manifestations of diapirism and mud volcanism can be associated. A fairly simple folding, represented by a successive alternation of anticlines and synclines, is quite confidently traced through the water area of the strait from the Kerch Peninsula to the Taman Peninsula. This was already evidenced by the researchers of the first half of the twentieth century. Gradual rejuvenation of folding from west to east was noted. In the zone of the strait – the Crimean orientation of the folds (latitudinal or even northeastern) prevails. The pre-Pleistocene deposits that appear here on the surface are represented by a significant set of sedimentary formations of the Oligocene, Miocene, and Pliocene, typical of the eastern Paratatis region. Various dense layered clays, formed in conditions of marginal shallow, mostly desalinated seas, predominate in them lithologically. The subordinate development includes sandstones, siltstones, limestones, and also sands, which are particularly noticeable in the Upper Pliocene part of the section.

The study of the Neopleistocene deposits of the bottom of the Kerch Strait has a century-old history, the beginning of which is associated with the work of N.I. Andrusov (1918 and others) according to the results of drilling operations in 1916-1918. It must be said that the study of bottom sediments was always confined to drilling. In connection with attempts to build bridges, several of drilling campaigns were performed. A significant amount of drilling was performed in 1945. Large and detailed survey work was carried out by the Moscow Institute “Hydroproject” in 1972-1975 in connection with the design of the bridge in the narrowest northern part of the water area. Almost simultaneously with this North Caucasian geological department, drilling operations were carried out on the east coast of the strait, including the Chushka Spit and other accumulative forms. The last two organizations produced a coordinated, massive study of biostratigraphic material from the cores. At the same time, the processing of materials was carried out by G.I. Goretsky (1982), P.V. Fedorov (1978), G.I. Popov (1983), A.B. Ostrovsky, Ya.A. Izmailov (1977), etc. Beginning in the 70-s of the last century, large-scale drilling campaigns was carried out by the Institute of Geological Sciences of the Academy of Sciences of the Ukrainian SSR and other organizations of Ukraine [Shnyukov et al., 1981]. In the following years, many publications appeared on the geochronology and biostratigraphy of the sediments of the Neo-Pleistocene terraces located on the eastern and western shores of the Strait [Arslanov et al., 1983; Izmailov, Arslanov, 2007; and others]. Currently, the next cycle of works related to the construction of a new bridge is being conducted, but these materials are not considered here. Many of the discussion problems on the geology and history of the development of the Strait, which were revealed during the 20th century, are still relevant at present.

The first cores drilled in the northern part of the strait showed that the basis of the strait, composed of Neogene deposits, is located substantially below the modern bottom, at absolute elevations of about -60 m. At one core, the mark was even -70 m. This figure requires confirmation by additional materials. In general, the deepening of the strait has a trough-like shape with a flat bottom and rather steep sides. Talveg depression has a slight slope in the south direction [Shnyukov et al., 1981]. In the thick layer of sediments filling this depression, at least three uneven-aged complexes, corresponding in our opinion to MIS 2-1, MIS 4-3 and MIS 6-5 and to the last glacial cycles, can be distinguished. The structure of these complexes is similar: they begin with a deep erosion cut and coarse alluvial deposits, passing higher into the sediments of the gradually mineralized lagoons and seas (Fig. 1). Their brief description is given below.

1. Sediments of the last glacial cycle – Neoeuxine-Black Sea (IIA 2-1). They fill the maximum deepening of the strait and are distributed in the central-most part of the strait. The bottom of this depression deposits (Chushka layers) up to 15 m thick is represented by sands with gravel, alternating upwards in the section with light gray aleurites, which, in turn, are crowned by a layer of peat bogs. Paleontological remains in them (mainly associated with sands), are presented everywhere as a mixture of marine, brackish and freshwater elements. Despite of this, there is reason to believe that their genesis is alluvial, with an age oflate Pleistocene (pre-Holocene). Remains of fauna, in addition to freshwater ones, are redeposited from older layers in our opinion. The frequently occurring re-depositing of paleontological material in the region is worth noting here. The view about the more ancient mid-Pleistocene age of Chushka layers and their marine genesis has been expressed [Goretsky, 1982; Popov, 1983]. The lagoon clay deposits with a thickness of up to 30-35 m lie above

the alluvium, the orectocoenoses of which indicate a successive change in the salinity of the basin from freshwater conditions (the Yenikalian layers) to the conditions of the sea lagoon (Neoeuxinian, Bugazian, Vityazevian and Kalamitian layers according to [Neveskaya, 1965]). At the same time, in the coastal part of the Strait, the facies of the lagoon beaches, inter-bedded with peat bogs, indicate the reciprocal development of the transgressive basin. Finally, this complex ends with shell sands (up to 20 m) containing marine fauna of the modern type (the Dzhemetinian and Nymphaean layers). Thus, in the development of the Strait in this cycle of sedimentation, three stages were distinguished: a) the stage of the river valley, b) the stage of the lagoon, the salinity of which increases with sea level rise, and c) the stage of the marine strait.

2. Sediments of the Tuzla-Surozh cycle (MIS 4-3). Within the eastern side of the depression when drilling on the Chushka spit, a separate valley-like depression to a -45 m mark, filled with a 30-m thickness of precipitation was found. The section repeated the late Pleistocene-Holocene section of the near-strait part of the Strait, but was a reflection of the earlier, older regressive-transgressive cycle. Alluvial sands and sandy loam lying at the base, upwards along the section, pass here into the liman-sea clays. The change in the orientocoenoses in the latter also resembles the younger complex, with the only difference being that the beds of the Neoeuxinian layers with Monodacna are occupied by layers with very small and sharply keeled trigonoid Didacna, very reminiscent of those described by N.I. Andrusov (1918) as *Didacna moribunda* (the Tuzla layers). The upper part of the section is characterized by a Mediterranean fauna, more halophylic than the Holocene fauna, with large *Paphia senescens* and others (the Surozh layers). Uranium-ionium datings in the interval 40.7-41.25 kyr (LU-449, 488), as well as radiocarbon dating of more than 30.5 kyr (LU-366V) were obtained in the laboratory of the St. Petersburg University.

3. Sediments of the Chokrak-Karangat cycle (MIS 6-5). On the eastern side of the depression, sand-clay sediments, representing the ancient-most sedimentation cycle, constructed similarly to the previous ones, were encountered in cores up to –23 m. The upper part of them is blurred. The final stages of this cycle seem to be met by sediments of the Karangat terraces with characteristic fauna, described both on the western and eastern shores of the Strait, in particular at the base of the Chushka spit. It is not completely clear whether the deposits, which are described in detail within the western side of the depression at elevations from -15 to -42 m, should be attributed to the Karangat or Surozh cycle. According to the hypsometric position, they are closer to the Surozhian, and according to the fauna of mollusks – to the Karangat. This does not limit the list of discussion problems of the geology of the Neopleistocene and the history of the development of the Strait [Izmailov, 2015].

In conclusion, we note that in general the zone of the Strait is closer to the eastern part of the Kerch-Taman folded region, where folded deformations in the

Neopleistocene were replaced by common tectonic uplifts [Milanovsky, 1968]. In this regard, it seems quite logical that the deepest part of it is composed precisely of the young sediments of the last glacial cycles, i.e. there is an embedded, and not superimposed, character of the structure of sedimentary complexes. The older Pleistocene deposits were preserved mainly above sea level, both on the western and eastern shores of the strait.

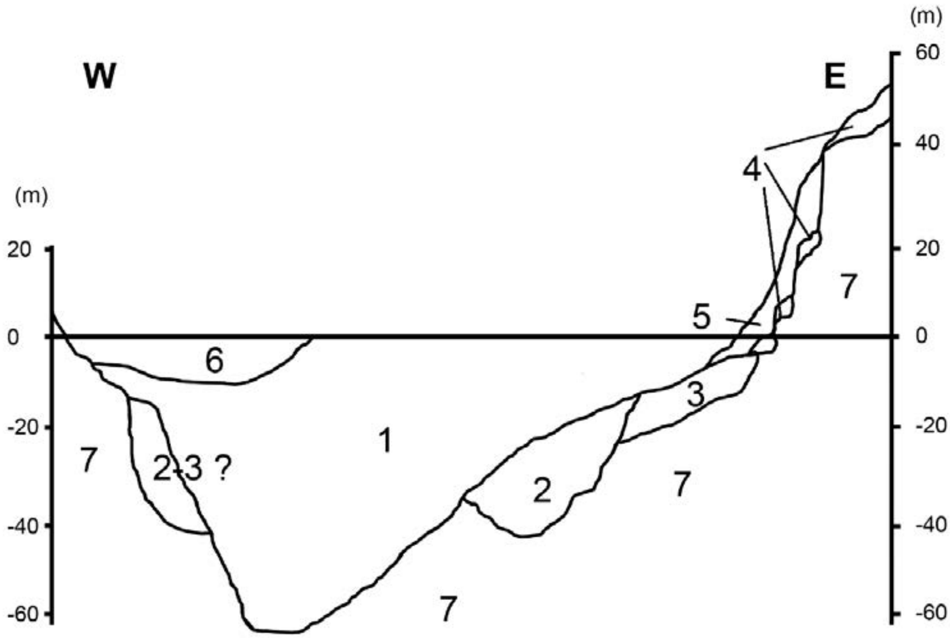

Fig. 1. Schematic diagram of the relationship of sedimentary complexes in the northern part of the Kerch Strait (Spit Chushka – the water area of the Strait): 1 – Neoeuxine-Black Sea complex, 2 – Tuzla-Surozh complex, 3 – Chokrak-karangat complex, 4 – Neoplestocene marine terraces, 5 – subaerial deposits, 6 – water, 7 – pre-Pleistocene deposits

PECULIARITY OF MOLLUSKS COMMUNITIES DISTRIBUTION OF THE MIDDLE CASPIAN BASED ON BIOMASS INDICATORS AND THEIR SPATIAL STRUCTURE

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ОСОБЕННОСТИ РАСПРЕДЕЛЕНИЯ СООБЩЕСТВ МОЛЛЮСКОВ СРЕДНЕГО КАСПИЯ ПО ПОКАЗАТЕЛЯМ БИОМАССЫ И ИХ ПРОСТРАНСТВЕННАЯ СТРУКТУРА

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The methodology for communities identification by dominat species was used first by V.P. Vorobev (1949) in the Sea of Azov. For the Black Sea this method was applied by M.I. Kiseleva (1981). This method was used in the Caspian Sea by G.A. Aligadjiyev (1965) for the Middle Caspian, M.G. Kaspinskiy (2003) for the Middle and Southern Caspian, M.K. Guseinov (2005) for Dagestan part of the Caspian Sea, I.A. Suleymanova (2007) for Apsheron Bay.

The previous research showed that the majority of communities in the Azerbaijan territorial waters of the Middle Caspian are characterized by distinct domination in terms of biomass, but also sometimes by size of one or few species, called dominants. The dominant species are unevenly distributed vertically: in some depths they form big clusters, but in others they can be observed in small number.

As a result, the research of benthic fauna done in the Azerbaijan territorial waters of the Middle Caspian found out three distinct mollusk communities (*Cerastoderma lamarcki, Dreissena rostriformis distincta*, *Mytilaster lineatus*), two of them are invasive. It is important to emphasize that communities of mollusks identified by M.G. Karpinski (2002) based on dominant species, were also found by us, with the exception of *Didacna* sp., *Hypanis* sp. and *Abra ovata*.

The community of *Cerastoderma lamarcki* was found at depths of 10-25 meter. Oligochaetas were observed almost in all benthic samples. In the community, in addition to the oligochaetas we recorded 27 species of benthic organisms: Polychaeta – 3, Crustacea – 21, Mollusca – 3. The calculations showed that diversity index at 10 meter depth was 1.22 and at 25 meter depth was 1.87, however the ratio of similarity between these depth was obviously less – 29.0.

Analysis of food chain in the community, showed that filter feeders (bivalvia mollusks, balanus and corophiidae), which constituted 48% of whole community biomass were dominating here. The detritivores group, constituted the 27% of total biomass. The stratified distribution of the food web was also observed in the studied communities. Cerastoderma, having semi-diving form of life in the upper layers of the sediment feeds on plankton and detritus from the water. Cerastoderma seems to tolerate the influence of inhabitants of adjacent ecological niches of its own community – the mytilaster, the balanus and the abra, who consume the same food, without much harm, since one of the subdominants of the community is abra, and the secondary is balanus. These species are segregated by the use of food resources in their own level of the biotope.

The community of the mytilaster was detected only in one transsect at a depth of 10 meters. The community structure was rather poor, except for the oligochaetes; only 8 species of macrozoobenthos were recorded: Polychaeta – 1, Mollusca – 3, Crustacea – 4. The first 4 positions in the density index were occupied by the invasive species of Mediterranean origin.

The community of *Dreissena rostriformis* was also detected only at one site in the transsect at a depth of 50 meters. Oligochaetes and 15 species of macrozoobenthos (Polychaeta – 2, Crustacea – 12, Mollusca – 1) were found. In this community, mainly Caspian autochthonous organisms predominated, balanus was the only representative of the Mediterranean complex, and the only competitor for the resources. Oligochaetes and corophiidae were found en masse.

A detailed study of the communities of mollusks in the Azerbaijan coast of the Middle Caspian reveals similarities and differences in their structure. By studying the distribution of species in biotopes occupied by the respective communities, it can be seen that moving from the shallow waters to the deeper ones, not only the number of species, but also their composition change. Calculation of the similarity ratio of species in different zones of biotopes showed that the species composition of macrozoobenthos at the upper and lower boundaries differs to a greater extent than in adjacent areas. This difference in the ratio of common species was observed by M.I. Kiseleva in her work on benthic communities in the Black Sea [Kiseleva, 1981]. Differences in the coefficients of similarity of species in different zones of the biotope indicate that the species composition of macrozoobenthos differs at different depths, which may be due to heterogeneity of the sediment at the studied depths. Back in 60-s, L.G. Vinogradov drew attention to the fact that the species diversity of communities dependes on the diversity of biotopes [Vinogradov, 1963]. A similar difference in the ratio of common species in different biotopes of the corresponding biocenoses was observed earlier by other authors on the Black Sea [Kiseleva, 1981]. It is interesting to note that the distribution of communities is also affected by the surface shape of the bottom sediments, formed by the wave action. It is known that the temperature, salinity, oxygen content, etc. are important for the formation of the spatial structure of benthic communities, but even with identical values of these factors, the structuring of both communities and individual species of benthic fauna due to the peculiarities of the microrelief is sometimes observed [Vodovskii, 2012].

In the process of life the bottom population is in constant contact with thepelagic zone, which is a reserve of food particles used by filter feeders and detritophages, and serves as a medium for the development of pelagic larvae of benthic animals. When analyzing the trophic structure of communities in the studied section of the sea, it can be seen that the sestonophages is a dominant group in almost all of communities (Tabl. 1), therefore almost the entire shelf of the western coast of the Middle Caspian can be considered as a biofilter zone.

Tabl. 1.

Characteristics of the communities of the western coast of the Middle Caspian

Dominant species	Bilmass, g/m^2	Shennon index	Share of the dominant species, %	Depth, m	Number of species	Trophic groupings, %				
						Collecting	Swallowing	Gnawing	Sestonophages	Predators
Cerastoderma lamarcki	26.0	2.1	41	10-25	28	39	13	–	48	–
Mytilaster lineatus	230.0	0.9	67	10	8	1	8	–	91	–
Dreissena rostriformis	26.7	2.2	44	50	16	5	2	8	85	–

After analyzing the obtained data it can be concluded that the taxonomic composition in the biotopes of mollusks occupied by the relevant communities varies qualitatively and quantitatively. It should also be noted that there are differences in the qualitative and quantitative characteristics of communities also in different regions of the sea.

DRIVERS OF THE PROGRADATION OF A RIVER-DOMINATED DELTA IN THE SEMI-ISOLATED BASIN: EXAMPLE OF THE DACIAN BASIN (ROMANIA)

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ФАКТОРЫ РАЗВИТИЯ РЕЧНОЙ ДЕЛЬТЫ В ПОЛУИЗОЛИРОВАННОМ БАССЕЙНЕ НА ПРИМЕРЕ ДАКИЙСКОГО БАССЕЙНА (РУМЫНИЯ)

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Facies models of lacustrine deltas commonly differ from facies models of deltas evolving in the open ocean. Deltaic processes are controlled by different drivers in (semi-)isolated basins and are therefore differently registered, building peculiar sedimentary architectures. During the Pliocene, the Dacian Basin constituted an embayment of the Black Sea. This brackish semi-isolated basin was filled in by a delta flowing southwards along the uplifting Eastern Carpathians. The deltaic sediments currently crop out along the continuous, well-exposed and fossil-rich Slănicul de Buzău section in Romania.

The studied 835 m thick Pliocene deltaic interval marks the transition from distal shelf sediments with brackish-water fauna up to shallow fluvial sediments with fresh-water fauna. The interval exposes 64, clearly-expressed, decimeter-scale, regressive parasequences. The parasequences regress from distal pro-delta clays to proximal delta-front or delta-top sands, which commonly register small-scale cross stratifications (3-50 cm sets) and an enrichment in organic material, bioturbation, endemic brackish and fresh-water mollusk faunas. The parasequences are typically topped by sharp-based, fossil-rich sand bodies with small-scale cross stratifications (5-20 cm sets). These high frequency parasequences combine into 3,315 meters thick, regressive sequences. The sequences are composed of thick clay-dominated parasequences at the base, which progressively become thin sand-dominated towards the tops of the larger-scale sequences, illustrating the general shallowing-up of the delta progradation.

The section has a robust magnetostratigraphic time frame, which provides the opportunity to compare the observed sedimentary cyclicity with the amplitude and the frequency of various climatic cycles. The preliminary results suggest an independent behavior of the regressive parasequences, whose frequency outnumbers the precession cycles. This suggests that climate forcing had a limited influence at the timescale of delta-lobes switching. On the larger scale, the system recorded regressive sequences, separated by long periods of decrease in sand input. These relative water-level increases could imply longer period astronomical forcing through eccentricity cycles.

The deltaic system was interpreted as an autogenic river-dominated delta. Because of the strong river influence of this delta prograding on a protected coast, sediments experienced minor sediment redistribution, resulting in an enrichment in organic material, bioturbation and fossils. Sediments were transported towards the basin by gravity currents on a low-gradient slope, causing a multiplication of terminal distributary channels, covering a wide depositional area. Due to the low salinity of the basin, sediments were also frequently transported by hyperpycnal plumes. The deltaic succession, being deposited in a shallow basin with restricted accommodation space, formed numerous thin parasequences, regressing up to sharp-based delta-front and delta-top sands.

The semi-isolated Pliocene Dacian Basin provided an unusual geomorphological setting. The studied delta prograded on a shallow, low-gradient and protected slope, into the brackish-water semi-isolated Dacian Basin. Consequently, the delta shaped a peculiar sedimentary architecture co-pared to open ocean deltas. This study constitutes an ideal example to apprehend the drivers of deltaic progradation in semi-isolated basins and represents therefore a perfect point of comparison with the other Pontocaspian deltas.

UNDERSTANDING THE DRIVERS OF HISTORICAL CASPIAN SEA LEVEL VARIATION USING OBSERVATIONS AND HYDROLOGICAL MODELLING

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ПОНИМАНИЕ ФАКТОРОВ, ОБЕСПЕЧИВАВШИХ КОЛЕБАНИЯ УРОВНЯ КАСПИЙСКОГО МОРЯ В ИСТОРИЧЕСКОЕ ВРЕМЯ, С ИСПОЛЬЗОВАНИЕМ ДАННЫХ НАБЛЮДЕНИЙ И ГИДРОЛОГИЧЕСКОГО МОДЕЛИРОВАНИЯ

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The Caspian Sea is by far the largest body of inland water in the world. Over a hundred rivers flow into the sea, with the Volga contributing 80% of total inflow. Currently, the only outflow from the Caspian is evaporation at the surface, although it has formerly been connected to the global ocean via connection through the Black Sea and Sea of Azov at various times in prehistory. The Caspian basin integrates the hydrological budget over a vast area of around 3×106 km^2, from high northern latitudes to the Middle East encompassing semi-arid and hot arid, and humid mountains climatic zones (Caucasus). Over the historical time period (1850 – present) Caspian Sea levels have varied between -25 and -29 m bsl, resulting in considerable changes to the area of the lake (currently 371,000 km^2). The Basin delivers considerable ecosystem services to the majority of inhabitants from most part of Europe, Russia and Middle East. Given the importance of the Caspian Sea for fisheries, agriculture, and industry, it is vital to understand how sea levels varied over the historical period to infer for the future developments in the region.

In this study, the Terrestrial Hydrological Model (THMB) is applied and evaluated to investigate the hydrological processes of the basin for the historical period

1900 to 2000. The model has been forced using observational reanalysis datasets (ERA-20) and historical climate model data outputs (from CESM) to investigate the variability in the Caspian Sea level and the major river discharges. We examine the differences produced by driving the hydrological model with reanalysis data and climate models, and the effects of human intervention (irrigation water withdrawal). Secondly, we investigated the sensitivity of Caspian Sea level variations to different aspects of climate changes to examine the most important processes involved over this time period.

MICROPALEONTOLOGYCAL STUDIES AND BIOSTRATIGRAPHY OF THE ANCIENT AZOV AND THE NEW AZOV DEPOSITS (THE SEA OF AZOV)

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МИКРОПАЛЕОНТОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ И БИОСТРАТИГРАФИЯ ДРЕВНЕ- И НОВОАЗОВСКИХ ОТЛОЖЕНИЙ (АЗОВСКОЕ МОРЕ)

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The Azov Sea was formed as separate water basin at the beginning of the Middle Holocene (ca. 7.8-7.5 ka BP). Significant climate changes frequently took place during the period of the water basin existence. As the result, they caused the pronounced changes in hydrological and biogeochemical features of the environment (mainly water level fluctuations).

The biostratigraphy of marine quaternary sediments was based on the fossil mollusks' studies [Nevesskaya, 1965; Stratigraphy... 1984] and pollen analysis [Vronskiy, 1976; Isagulova, 1978]. Biostratigraphic studies of Late Quaternary sediments of the Sea of Azov have included the results of diatom analysis for only the last decade [Matishov et al., 2007; Matishov at al., 2013; Kovaleva, Zolotareva, 2013; Kovaleva et al., 2015].

The present study was based on the sediment cores from the Western part (St-97), Northern part (St-1) and South-Eastern part (St-86, St-79) of the Sea of Azov. St-1 core had the maximum length (220 cm), and the bottom layers had the maximum age of 6480 cal. (calendar years) BP. The dating of the absolute age of the sediments was used as well. The dating was performed by the radiocarbon analysis of mollusk shells; all of the data were calibrated. The "CalPal-2007" software [Weninger et al., 2007] was used for the calibration. The data allowed for characterization of the variations in the species composition of the dominant taxa of the diatom algae and pollen from the Ancient Azov and New Azov sediments.

The ***Ancient Azov layers*** (7500-3100 cal. BP) were characterized by the large species diversity of marine genius *Thalassiosira* (Bacillariophyta) and layers with extremely high concentration of spores from Dinophyta species of marine origin (*Protoperidinium* sp., *Gonyaulax* sp., *Echinidinium* sp. and al.). The spores of *Chaetoceros* genus also predominated in certain layers which we considered to be correlated with transgression periods.

The other specific feature of the Ancient Azov sediments was the presence of layers with a high abundance of cysts (resting stages) of golden algae (Chrysophyta). These algae were recorded both from freshwater and marine environments which makes it difficult to determine their ecological preferences. Taking into account that the *Actinocyclus octonarius* Ehr. valves increased in number in those layers as well, they were attributed to regressive stages of sea with brackish shallow conditions.

The shift from *Actinocyclus octonarius* domination layers to intervals with *Chaetoceros* sp. spores predominant was recorded for the ***New Azov layers*** (3100 cal. BP – now). The layers with *Actinocyclus octonarius* and *Actinoptychus senarius* (Ehr) Ehr. predomination were described earlier [Kovaleva 2007; Kovaleva, Zolotareva, 2013; Kovaleva et al., 2015]. As the mentioned species was recorded for shelf brackish waters of mild climate seas, we have correlated its predominance in sediments with lower sea level (regressive stages). The *Chaetoceros* species are typically registered in deep-water marine environments. We have correlated the layers with increased number of *Chaetoceros* spores with the sea level rise and salinity increase [Kovaleva et al., 2015].

The amount of *Actinocyclus octonarius* cells increased up to 80% (from the total amount of cells) in the layers correlated with Phanagorian regression. Moreover, these layers were characterized by the significant increase in the number of this species' varieties (*Actinocyclus octonarius* var. *ralfsii* had dominated quantitatively).

The pollen analysis of the cores, together with diatom analysis, allowed for stratigraphic zonation of the layers and reconstruction of the climatic and landscape features in the shore area. Chenopodiaceae (ca. 30-40%) and *Artemisia* sp. (ca. 20-30%) pollen predominated in the pollen spectra. The Poaceae pollen content was also high and reached 15-20% in certain samples. The pollen of other herbs (Apiaceae, Fabaceae, Lamiaceae, Brassicaceae) was widely presented at all layers of the cores. The *Alnus* and *Betula* tree pollen predominated among the arboreal group. The pollen of *Quercus* and *Carpinus* significantly influenced the pollen spectra as well. The pollen of *Picea, Pinus*, *Corylus*, *Fagus*, *Tilia* and *Ulmus* were recorded as constant components of the arboreal group (from 1 to 10%). The aquatic plant pollen was recorded in all of the cores, including *Sparganium* (abundant), *Typha latifolia* and *Potamogeton* (single specimens). The spores were rare and were represented mainly by Polypodiaceae, *Sphagnum* and *Lycopodium*.

The landscape and climatic conditions of the Sea of Azov shores were characterized by the southern migration of arboreal plants at about 6000-5700 cal. BP (1b zone) and 4500-4000 cal. BP (2a pollen zone) because of humidification and climate cooling in the region. Those climate changes also affected the hydrological conditions in the Sea. The marine diatom taxa predominated in the sediments of that early period, marking the transgression stage (Aa3 and Aa5 diatoms zone) (Fig. 1). We tend to correlate such layers with New-Black Sea transgression stage [Fedorov, 1977]. This stage was heterogeneous as the diatom composition from Aa4a and Aa4b diatoms zones also indicated some regression stages of the Sea. The pollen analysis data showed that the steppe advection with aridification preceded to the regression process of the Sea (1a and 1c pollen zones).

As the New-Black Sea transgression stage was over, the change in dominant diatom taxa took place. We correlate the change with the Phanagorian regressive stage (3100-1800 cal. BP). The *Actinocyclus octonarius* valves increased in number in the sediments of that period indicating the shallow-water conditions (Na1a and Na1b diatoms zone) (Fig. 1).

The comparison of the transgressive-regressive stages of the Azov Sea from the diatom analysis and the sea level curves showed the good correlation of the results obtained by the alternative methods (Fig. 2). The zones, revealed by the diatom analysis correlate well with sea level change.

The pollen analysis data showed the several stages of landscape and climatic change during the Phanagorian stage. The composition of pollen spectra and interrelation of their major components around ca. 3100-2500 cal. BP denotes more humid climate conditions when the interzone arboreal communities were restored and the arid steppe biocenoses experienced the humidification.

The sea level fall was not constant during the Phanagorian regressive stage. A layer with increased *Chaetoceros* spores was characterized together with the decreased *Actinocyclus octonarius* numbers and was distinguished within 2500-2000 cal. BP interval. This change could indicate a short-period sea level rise. The interval followed the humidification stage, distinguished from 3100-2500 cal. BP. The period of climate humidification was recorded for the Eastern part of the Sea of Azov from 3100-2500 cal. BP and the transgression stage took place a few centuries later. The environmental conditions of the shores during the shift from the Phanagorian to the Nymphean stage and the sea level rise indicate a new humidification stage, based on pollen analysis and dated as (2000-1500 cal. BP).

The Nymphean transgression stage (Na2 diatom zone) was distinguished in sediments by the increase of *Chaetoceros* spores which was not recorded at such an extent during the Phanagorian regression (Fig. 1). The abundance increase of *Actinocyclus octonarius* valves was recorded in Na2 zone of St. 86 core, together with the simultaneous decrease of *Chaetoceros* spores, indicating the short sea level fall ca. 1500 cal. BP (Na2b diatom zone).

During the period of ca. 800-100 cal. BP a short sea level fall was recorded. It was linked with the Korsun regression. The zone was clearly recorded in the cores of St. 79. The considerable changes of the vegetation (pollen zone 6 at St. 97) were registered for the areas close to the Sea of Azov for the period ca 650-150 cal. BP according to pollen data. The changes were correlated with increased flood plain forest in the Don valley and its tributaries. The events were accompanied by climate cooling. This stage could be a sign of general cooling during the Little Ice Age. A sea level rise is recorded for the past 100 years.

The correlation of diatom and pollen analysis results showed the interrelation between sea level fluctuations and climate change. According to the diatom analysis, the sea level changed with a certain time lag after the climate-landscape phases' changes took place, according to pollen analysis.

The analysis of Holocene cores showed the unstable sea level during its formation. The data showed the relation between marine and land processes in the Sea of Azov. The transgressive phases were preceded by general humidification and regressive phases were preceded by total aridification.

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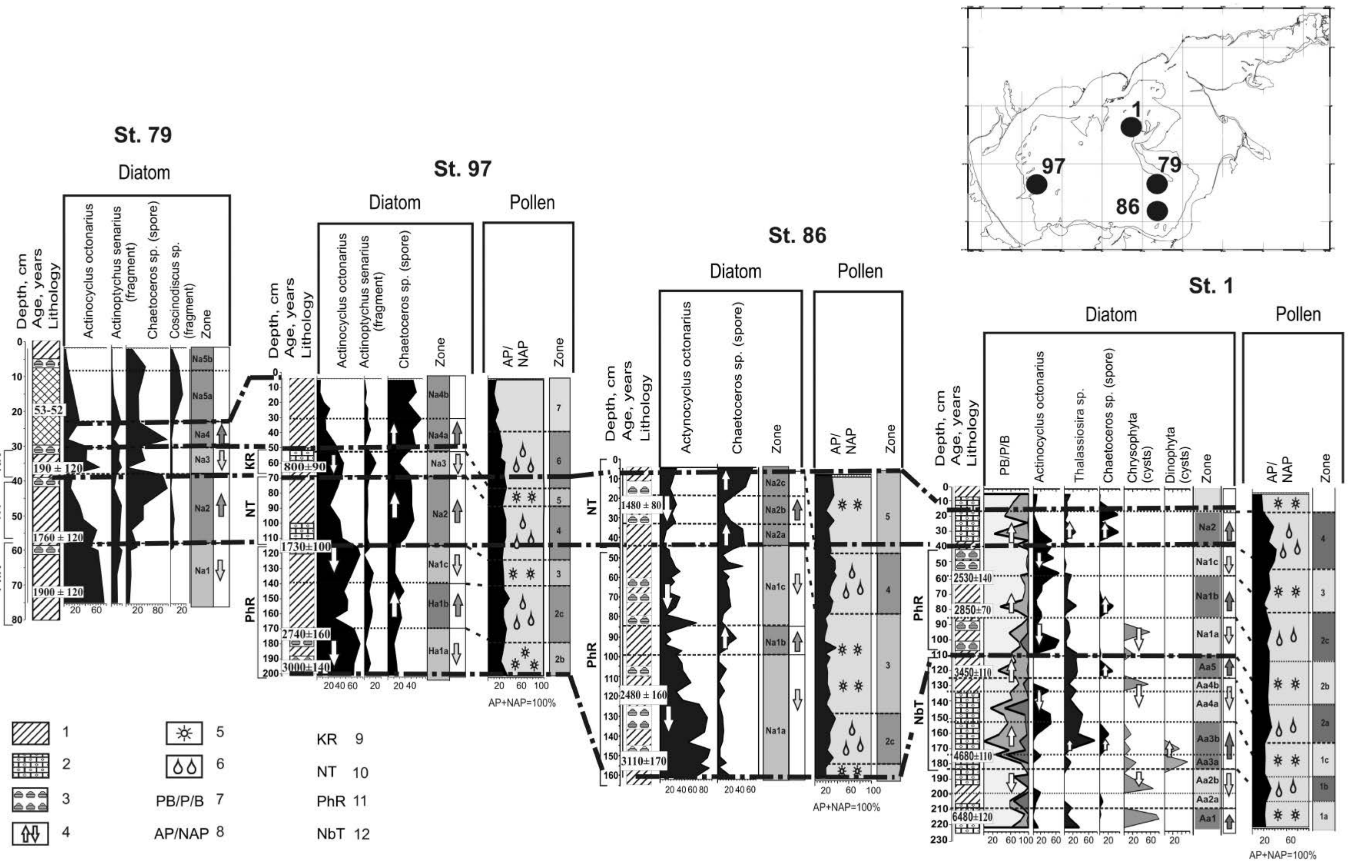

Fig. 1. Correlation of results of diatom and pollen analysis. Legend: 1 – clayey mud; 2 – silty shelly ground; 3 – shelly ground; 4 – the transgressive and regressive phases; 5 – aridization phases; 6 – humidification phases; 7 – PB – plankto-benthic diatoms, P – plankton diatoms, B – benthic diatoms; 8 – AP – arboreal pollen, NAP – non-arboreal pollen; 9 – the Korsun regression; 10 – the Nymphean transgression; 11 – the Phanagorian regression; 12 – the New-Black Sea transgression

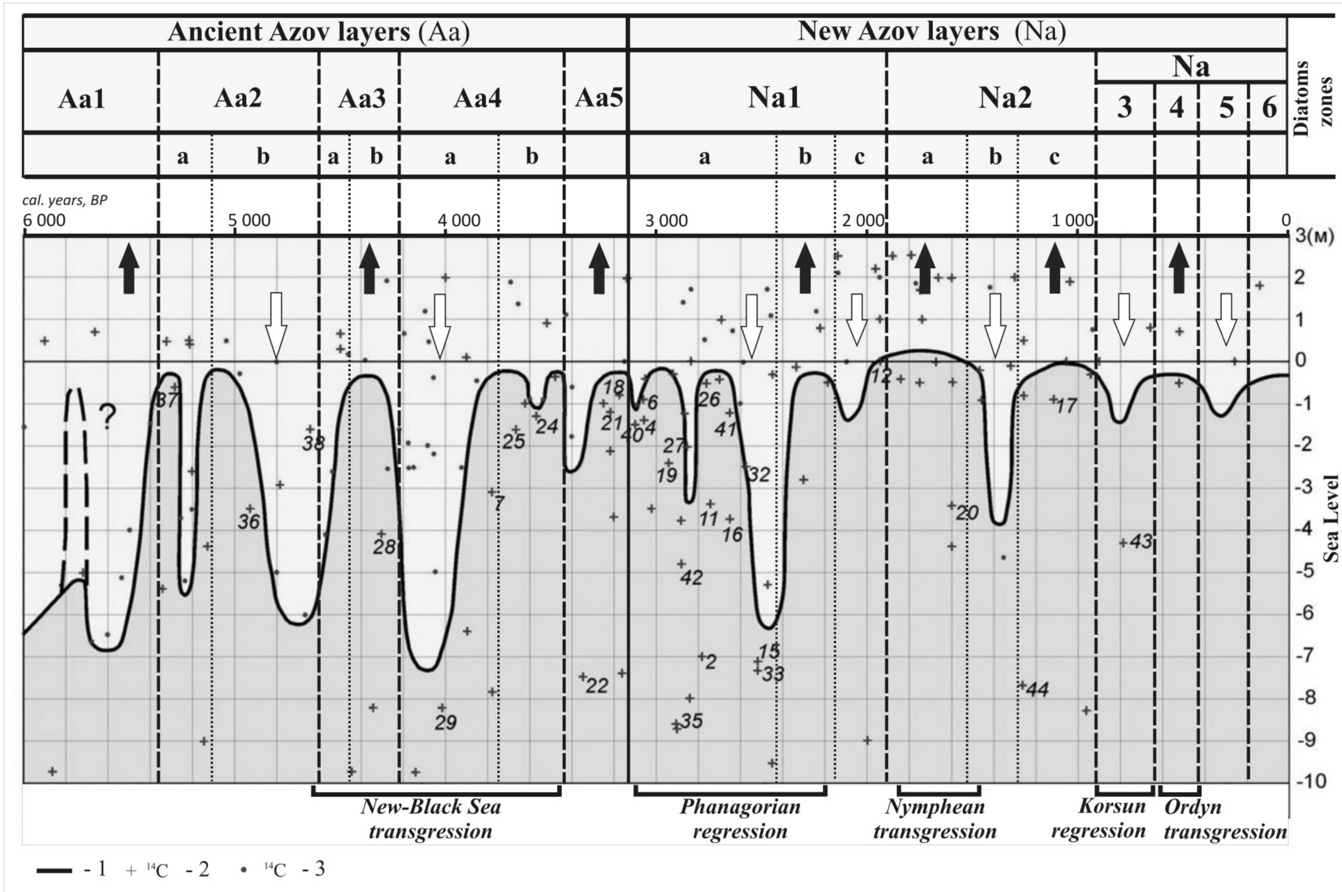

Fig. 2. Correlation of the transgressive-regressive stages of the Azov Sea development in the Middle and Late Holocene with the diatom analysis results and absolute geochronology. Legend: 1 – sea level; 2 – radiocarbon dates (mollusks shells); 3 – Radiocarbon dates (peat) *(Fig. 2 based on [Kovaleva et al., 2015] with additional data)*

PLIO-PLEISTOCENE STRATIGRAPHY AND ENVIRONMENTAL EVOLUTION OF THE PONTOCASPIAN

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ПЛИО-ПЛЕЙСТОЦЕНОВАЯ СТРАТИГРАФИЯ И ИЗМЕНЕНИЕ ЭКОЛОГИЧЕСКИХ УСЛОВИЙ В ПОНТО-КАСПИЙСКОМ РЕГИОНЕ

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Semi-enclosed basins like the Black Sea and Caspian Sea are exceptionally suitable to study (paleo)environmental changes as a function of relative sea level fluctuations. A precise and accurate absolute chronology for the sedimentary successions is a crucial prerequisite to establish basin-wide correlations and to identify driving mechanisms. We use high-resolution geochronology ($^{40}Ar/^{39}Ar$ on volcanic ash layers) together with integrated stratigraphy (magnetostratigraphy, cyclostratigraphy, biostratigraphy, marine palynology and geochemistry) to unravel the tectonic and climatic forcing factors to resolve the effects of progressive isolation. Such a multidisciplinary approach is the only way to attain a comprehensive system view on lake system evolution.

As a result of our ongoing work to provide high-resolution age constraints for sedimentary sections, we have encountered apparent inconsistencies in the Plio-Pleistocene (chrono) stratigraphic scheme. Here we will highlight the problems encountered and propose a solution. We will furthermore go into detail on the paleoenvironmental changes as recorded in the outcrop record.

Our main focus will be on the early time period of Pontocaspian evolution and the age and events surrounding the first introduction of the Pontocaspians into the Caspian Sea. For this, we will have a closer look at the Akchagyl and early Apsheron interval to understand the environmental conditions in which the first Caspian Pontocaspian introduction occurred.

25 YEARS OF CASPIAN SEA RESEARCH

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25 ЛЕТ ИССЛЕДОВАНИЙ КАСПИЙСКОГО МОРЯ

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In 1991 Prof. Nikolay Sergeevich Kasimov, Dean of the Faculty of Geography of Moscow State University and I were discussing future joint research themes, after one year of successful educational cooperation. ‘The Caspian Sea Level is rising fast, a hundred times as fast as sea-level rise at the Dutch coast. It is a major environmental disaster for Russia and the other Caspian countries, and we don’t understand why this is happening’, he said.

That sounded like a good idea. We were impressed by the drowning villages on Chechen Island, houses invaded and destroyed by encroaching beach sand, we saw how abandoned oil wells in Izberbash, once constructed kilometres inland, were now attacked by stormy waves, spilling pollutants all over the place. We saw how inhabitants of the town of Kaspiisk defended themselves by makeshift concrete sandcatchers along the coast – until, suddenly, something happened in 1995 that nobody had predicted: sealevel started to fall again, and since then up to the present day it has already fallen by two metres. That was the state of affairs at that time: nobody predicted sudden 3 metres sea-level fall from 1929-1977, nobody predicted that after the 1977 lowstand sea-level would rise almost 3 metres, and in 1995 we were again taken by surprise. We are not used to trend breaks and tipping points. We really needed a better understanding of Caspian Sea level change.

We expected not only to clarify the causes and consequences of CSL for the Caspian countries, but also to get a better understanding of the *general* mechanisms of sea-level rise. Half of the Netherlands is situated a few metres below sea level, and studying accelerated sea-level rise in the Caspian would help us also to better understand the impact of global sea-level rise on the Dutch coasts.

We started with a remote sensing and field study of historic changes in sedimentation, vegetation and geochemistry as a result of CSL in the Astrakhan

Biospheric Nature Reserve in the Volga Delta. Soon this was extended to study also the Kalmykian and Dagestani coast, and in later years also to Azerbaijan, Iran and Kazakhstan. Since then we have carried out 11 joint projects, funded by the Dutch Organisation for Scientific Research (NWO), by RFFI, INTAS-EU, IGCP-UNESCO, BP, Shell and all participating institutes. At least 60 Russian and over 20 Dutch scientists and students participated in the joint projects, as well as scientists from Belgium, France, Italy, the UK, Canada and all Caspian states. Over 60 joint scientific papers have been published, over 60 abstracts in international and joint conferences, at least 9 PhD theses and over 20 MSc theses were presented. Moreover, a comprehensive International Conference *The Caspian Region – Environmental consequences of the Climate Change* was held in Moscow in 2010 in which all major actors in the Caspian participated, and which produced a special proceedings volume with 93 papers on the Caspian.

Among the major achievements of our projects is an updated Holocene Caspian Sea-level (Fig. 1) curve for the last 5000 years, based on extensive drilling campaigns onshore in the Volga delta, Russia, onshore and offshore drilling in the Kura delta, Azerbaijan, outcrop and augering data from the Turali barrier coast in Dagestan, and outcrop and drilling data from the southeastern corner of the Caspian in Iran. Most data points were obtained by first selecting suitable sites using seismic, parametric echosounder or GPR surveys, followed by drilling or augering, sampling and analysis using AMS 14-C dating of molluscs or organic matter, palynology, mollusc paleo-ecology, sedimentology, mineralogy and geochemistry.

The obtained curve shows a good correspondence with major global climatic cycles, including highstands in the Little Ice Age and the Late Bronze Age cold periods, and a deep lowstand during the Mediaeval Warm Period. The period between 5000 and 2500 BP is characterised by a gradual sea-level rise, recorded in great detail in the Volga delta. Data before 5000 BP are still too scarce to construct a reliable curve. The Late Glacial Khvalyn highstand with overflow to the Black Sea around 13 000 BP dated by other authors also has been recorded in our Caspian cores, and the characteristic red clay horizon found in the Black Sea marking this transgression has also been found back in the Kura delta and along the Iranian Caspian coast with similar ages.

It is clear that further progress in coupling of Caspian Sea Level change to climate cycles deeper back in time will come especially by detailed coring campaigns in the lowstand deltas of the major rivers: already now valuable data have been obtained by members of our team on the age and environment of the Eemian Khazarian deposits in the Volga lowstand deltas.

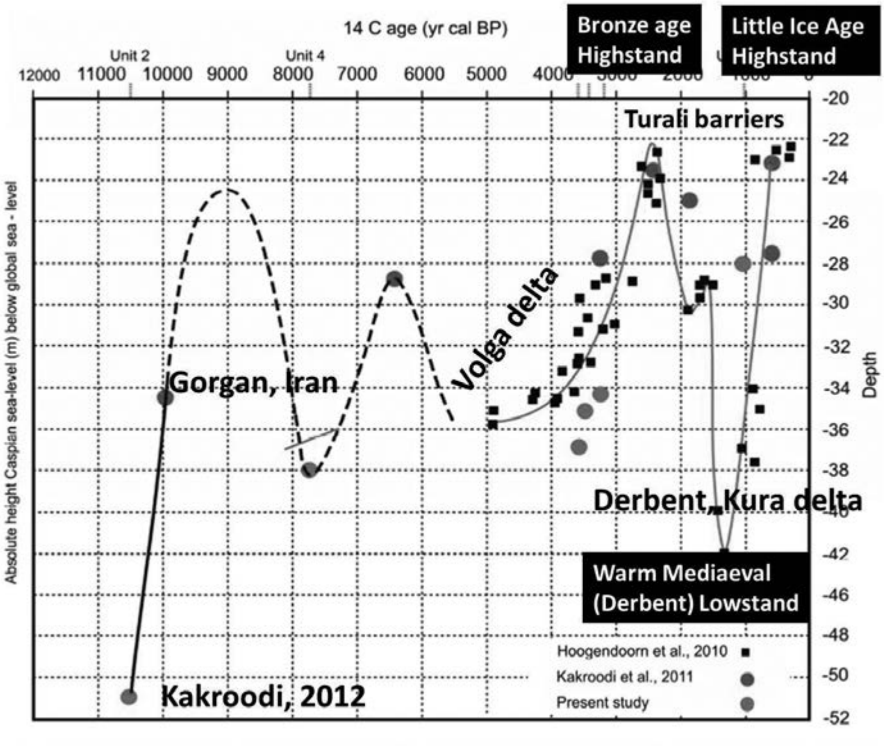

Fig. 1. Caspian Sea level change during the Holocene

DIFFERENTIAL IMPACT OF ANTHROPOGENIC PRESSURES ON CASPIAN SEA ECOREGIONS

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ДИФФЕРЕНЦИРОВАННОЕ АНТРОПОГЕННОЕ ВОЗДЕЙСТВИЕ НА ЭКОРЕГИОНЫ КАСПИЙСКОГО МОРЯ

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In the Caspian Sea, a renowned endemic rich ecosystem, species likely diversified in space along various abiotic parameters such as temperature, salinity and depth. In a previous study, these parameters were used to infer 10 ecoregions, which are nested into three physico-geographically defined sea areas: i) North Caspian ii) Middle Caspian, and iii) South Caspian. Recently, a biodiversity decline probably caused by a combination of natural and anthropogenic pressures, was reported from all the three sea areas. In this study, we analyzed the anthropogenic impact of 9 human-derived pressures in the 10 ecoregions by the use of Cumulative Effect Assessment (CEA) methods. Aggregating the results in the sea areas, we found that the North Caspian shows higher average CEA scores compared to the Middle Caspian and the South Caspian. Furthermore, we detected differences in the anthropogenic pressure contribution to the CEA score among the sea areas: the North Caspian is mostly affected by poaching (46% of the CEA score), whereas the Middle and South Caspian by pollution (45% and 51%). This was further supported by the average ecoregion CEA scores, where the highest impact appears in the transitional ecoregion between the North and the Middle Caspian. This can pose a risk for the survival of the endemic species with the distribution limited only to the North Caspian. We propose that the potential explanation for the spatial pattern of the CEA score may be the pollution removal by water currents flowing south and the concentration of anthropogenic activities near river mouths. Finally, our study can be used as baseline for spatially explicit future monitoring of the environmental situation to implement ecosystem management plans focused on biodiversity conservation.

THE EARLY PLEISTOCENE AGE MODEL OF THE KURA BASIN ALONG THE GOYCHAY AND HAJIGABUL SECTIONS: PALEOMAGNETIC APPROACH FOR DATING AND CORRELATION

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РАННЕПЛЕЙСТОЦЕНОВАЯ ВОЗРАСТНАЯ МОДЕЛЬ КУРИНСКОЙ ВПАДИНЫ ВДОЛЬ РАЗРЕЗОВ ГОЙЧАЙ И ХАДЖИГАБУЛ: ПАЛЕОМАГНИТНЫЙ ПОДХОД К ДАТИРОВАНИЮ И КОРРЕЛЯЦИИ

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The Early Pleistocene development of the Pontocaspian region is strongly depended on climatic oscillations, which are characterised by alternations of glacial and interglacial intervals. These regular alternations are expressed as changes in a water budget of basins, which in turn resulted in fluctuations of the Black Sea and the Caspian Sea water level and connection/disconnection between them. This is registered in the outcrop record, and our best option to understand past paleoenvironmental changes. For the Caspian Sea, the most representative record is provided by marginal basins like the Kura Basin in Azerbaijan.

At the same time, strong tectonic activity along the Caucasian orogeny system caused regional landscape restructuring and acts as another active control on depositional environments. As a result, it creates preconditions for diachroneity of regional transgression/regression events, which together with fauna content define the boundaries of regional stages.

To identify synchronous base level changes, we conducted paleomagnetic research on two continuous sections – Goychay and Hajigabul, that approximately cover a time interval 2,5-1 My (Akchagylian – Bakunian). These sections are situated in the northern, north-eastern interior of the Kura Basin (Azerbaijan) and represent a wide range of coastal environments. At the Goychay 140 levels are drilled in around 2000 m section, of which 85 samples are thermally demagnetized. In the Hajigabul section, we sampled 160 levels within 2100 m section thickness, among which 75 samples are thermally demagnetized.

This work provides the age constraints, which will be the basis for further paleoenvironmental studies.

PALAEOENVIRONMENTAL CHANGES IN THE LATE PLEISTOCENE – EARLY HOLOCENE IN THE SOUTH CASPIAN COAST

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ИЗМЕНЕНИЯ ОКРУЖАЮЩЕЙ СРЕДЫ В ПОЗДНЕМ ПЛЕЙСТОЦЕНЕ – НАЧАЛЕ ГОЛОЦЕНА НА ЮЖНОМ КАСПИЙСКОМ ПОБЕРЕЖЬЕ

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The south Caspian Sea coast not only underwent deep climatic changes at the Late Pleistocene-Holocene transition, but also its narrow coastal plain at the foot of the Elburz Mountains changed its width according to important water level changes. The area is known for its large biodiversity and the occurrence of glacial refugia for plants, which were also used by animals and humans. Mesolithic and early Neolithic populations are known to have lived there and their diet, according to the archaeological investigations of cave infill by McBurney in 1949–50, changed widely according to the availability of resources alternating between more steppe–based animals and more marine-based ones. N Iran with SE Azerbaijan have a diverse environment owing to the Talysh-Elburz Range that is north facing and catches precipitation from air masses coming from the Caspian Sea. The humid area represents a pocket of life in an otherwise dry Middle-East.

This study examines palynological remains in two 17 m long sediment cores (Gharasoo and Shakileh cores) obtained in palaeo-lagoons, located between ancient caves (Hotu and Belt caves) and the coast and dated by radiocarbon. In particular, pollen grains and charcoal provide information on vegetation; parasite eggs and fungal spores on the presence of large herbivores and erosion; and small aquatic organisms (such as dinocysts) on water level and changes in Pontocaspian biodiversity.

Despite problems with radiocarbon dating, preliminary results indicate the continuous presence of diverse woodland over the last 30,000 years, significant changes in the fire regime, in the climate (eg the Last Glacial Maximum and the Younger Dryas) and in water level and quality (eg the early Holocene lowstand of the Mangyshlak). Coprophilous fungal remains indicate the continuous presence of herbivores, except during a very freshwater phase at the end of the Bølling-Allerød.

ROLE OF PERIGLACIAL PROCESSES IN FORMATION OF KHVALYNIAN CLAYS IN THE MIDDLE AND LOWER VOLGA REGIONS

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РОЛЬ ПЕРИГЛЯЦИАЛЬНЫХ ПРОЦЕССОВ В ФОРМИРОВАНИИ ХВАЛЫНСКИХ ГЛИН СРЕДНЕГО И НИЖНЕГО ПОВОЛЖЬЯ

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During Late Pleistocene (15–13 ka) thick mass of clays were deposited on the territory of Middle and Lower Volga River valley region. Potential causes of formation of these so-called "chocolate" clays were periglacial and permafrost processes, which occurred on territory of the East European Plain in the Last Permafrost Maximum (LPM) 25-17 ka on more than 2000 km^2 [Vandenberghe et al., 2014]. After LPM and Last Glacial Maximum (LGM) 15-13 ka permafrost degradation has started in this area so called solifluction processes that provided the enormous number of fine-grained deposits. Glacial melt water discharge with fine grained materials was deposited within an ancient paleodepression in Middle and Lower Volga region. At that time Early Khvalynian transgression, one of the largest in the Pleistocene, began in the Caspian Sea.

The aim of this study was to determine the potential role of periglacial processes in the formation of specific facies of chocolate clays. We analyzed eight samples of chocolate clays and moraine clay loam from river outcrops within Volga River region and separated them to particles of size <2 μm to analyze with X-ray diffraction (XRD). These clays consist of a number of clay minerals associations, which are presented by illite, chlorite, kaolinite and smectite. Clay minerals of the Middle Volga River valley are presented by illite (33%), kaolinite (16%), smectite (28%), chlorite (17%) and mixed layers (6%). In the Lower Volga River valley outcrop profile demonstrates a prevalence of illite (33-48%) and kaolinite (18-33%). Moraine clay loam from Upper Volga region also demonstrates the prevalence of illite (45%) and kaolinite (33%) with concentration of smectite (22%), while chlorite in this sample is not detected.

Illite is a major clay mineral of chocolate clays of Middle and Lower Volga River valley and its maximum can be an indicator of increasing solifluction processes and intensive erosion of north moraine complexes due to large glacial melt water runoff during the degradation of the Late Valdai (the Late Weichselian) ice sheet. Illite is the result of the physical erosion and lower temperatures due to extremely huge amplitude ranges [Chamley, 1989].

Chemical compositions of these clays demonstrate high concentration of iron oxide (Fe_2O_3) ~10% (Fig. 1) which predetermines chocolate (dark brown) color of these clays. Such concentration of iron oxide can be the result of destruction of crystalline grid of illite associated with intensive permafrost processes that formed the iron similar to hematite and goethite [Rekshinskaya, 1966].

These processes can occur in extreme climate conditions similar to those in this area during the last stage of the Late Valdai (the Late Weichselian) glaciations 25-15 ka. Consequently, fine grained material which was modified by periglacial and permafrost processes and transfered by melt water runoff of Late Valdai glacier was deposited within the Volga estuary and northern part of Early Khvalynian basin and formed chocolate clays formation with their specific color.

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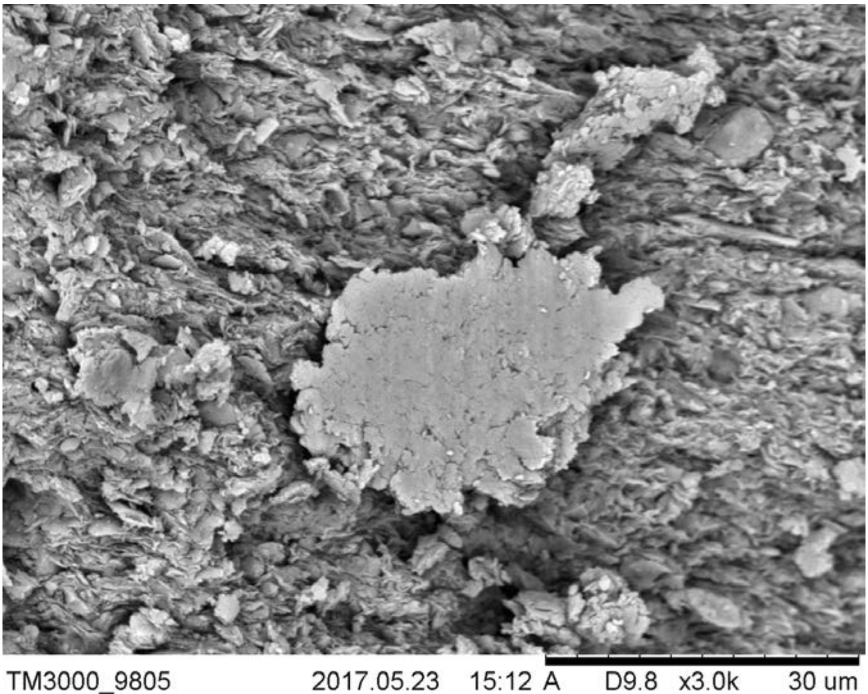

Fig. 1. SEM image of iron oxide in chocolate clays

FRACTAL DIMENSION ANALYSIS AS AN APPROACH TO TACKLE MORPHOLOGICAL VARIABILITY WITHIN THE PONTO-CASPIAN LYMNOCARDIINAE (BIVALVIA: CARDIIDAE)

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ФРАКТАЛЬНЫЙ РАЗМЕРНЫЙ АНАЛИЗ КАК ПОДХОД К ОПРЕДЕЛЕНИЮ МОРФОЛОГИЧЕСКОЙ ИЗМЕНЧИВОСТИ У ПОНТО-КАСПИЙСКИХ LYMNOCARDIINAE (BIVALVIA: CARDIIDAE)

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The Ponto-Caspian basin encompasses the Caspian Sea, Azov Sea, Black Sea and associated lagoons. This area is characterized by the presence of endemic species called “Pontocaspians”, geologically abundant and widespread groups currently restricted to brackish and low salinity areas of the basin. Lymnocardiinae species are burrower bivalves that feed on organic material and plankton present in the water column. In concordance with the rest of the Ponto-Caspian groups, nowadays only a few restricted genera remain. *Monodacna colorata* and *Didacna trigonoides* are relatively common Lymnocardiinae species: while the first one is found in the whole basin, the genus *Didacna* only occurs in the Caspian Sea.

Because of its simplicity, traditional morphometric techniques have been long used for the taxonomical classification of fossil and living bivalve species. Due to subjective or non-accurate measurements, it sometimes leaded to misclassification. In this study, we introduce the fractal dimension analysis as a new and refined technique and compare it with 3D morphometric data. With this tool, and in combination with molecular analysis, we aim to clarify the Lymnocardiinae classification.

Specimens from the Bug-Dnieper Estuary and from the Razim-Sinoe lake were collected by trawling in 2015-2016. Samples from Taganrog Bay were already available at the facilities of the University of Giessen. A number of 3D morphometric variables (Volume; V, Surface; S, and Volume/Surface ratio; V/S) as well as the fractal dimension D were documented by 3D scanning and modelling software. The resulting meshes were exported and computed with MeshLab to determine S, V and V/S. The fractal dimension D was calculated by the Bouligand-Minkowski method. All the variables were analysed using the software Past.

The Mann-Whitney test for the equality of the means between *D. trigonoides* and *M. colorata* was rejected with $p<0.05$ for all the variables. The Kruskal-Wallis test for the equality of the means between the 3 populations of *M. colorata* analysed was only rejected with $p<0.05$ for the dimension D, not being rejected for the variables S, V and V/S ratio.

Regarding to our results, fractal dimension analysis has proved its potential, as it shows differences between *M. colorata* and *D. trigonoides*. It also provides interesting results regarding *M. colorata* populations analysed: while traditional 3D morphometric variables might not be accurate enough to tell between populations/morphotypes, the fractal dimension analysis proved to be useful, which might indicate applications in other cases.

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THE HISTORY OF THE AZOV SEA SHELF IN HOLOCENE, BASED ON MULTIDISCIPLINARY STUDY OF SEDIMENT CORES

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ГОЛОЦЕНОВАЯ ИСТОРИЯ АЗОВСКОГО ШЕЛЬФА (ПО РЕЗУЛЬТАТАМ КОМПЛЕКСНОГО ИЗУЧЕНИЯ КОЛОНОК ДОННЫХ ОТЛОЖЕНИЙ)

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Recently the comprehensive data on morphology, lithology, biostratigraphy and radiometric age of the Azov Sea have been collected and analyzed by the SSC RAS. Interdisciplinary studies on the bottom cores from the different regions of the Sea have been performed. Radiocarbon analysis have been commenced in the different layers of the cores. Peculiarities of the bottom relief and the composition of upper layer of sediments were revealed with seismo-acoustic methods. Numerous archeological data were analyzed as well, keeping in mind the Holocene-long (especially for recent 2,5-3 kyr) record of anthropogenic activity in the Azov Sea region [Matishov, 2006, 2007; Matishov et al., 2007, 2009, 2013, 2016; Polshin, 2009] (Tabl. 1).

Lithological composition of the Ancient Azov sediments differ from the New Azov sediments by the coarser granulometry. This could be due to shallower conditions of their formation [Polshin, 2012]. The layers were formed at the time of deep ingression of the rivers deltas. The process was expressed to greatest extent in the region of modern Kuban delta, together with re-working and flooding of lowland parts of the seashore. The shallow-water marine sediments were deposited in the eastern, western and northern parts of the marine basin. Increased content of mollusks shells, aleurite and sand have been noted at there. Marine sediments (age 6480 ± 120 and 4680 ± 110 years) from the Zshelesinskaya bank consist of silting shells with layers of clayed mud. Sediments formed 5900 ± 140 years ago eastward of Zshelesinskaya bank have silting fine grained sands with shells material and aleurite muds with sand in its composition.

Mytilids (*Mytilus galloprovincialis*) and Mediterranean biotic community (*Chamelea gallina*, *Gastrana fragilis*, *Paphia aurea* etc.) dominated the benthic communities 6000 years ago. These organisms are noted at salinities of 15-18‰ and higher [Nabozhenko, 2013].

Table 1.
Holocene in the Azov Sea region

Time interval (kyr B.P.)	Paleoenvironments
Modern (0-1.5)	– little Ice Age; – Medieval – Tana-Azak (XIII-XIV Century A.D.); – transfer from nomadic to settled cattle breeding; – extinction of tarpans, gabions, European bisons
Nymphean transgression (1.5-2.4)	– formation of sands and spits of the Azov Sea (1.9 kyr); – Tanais city (III century B.P. – V century A.D.)
Fanagorian regression (2.4-3.0)	– airiverine erosion; – Iron Age (early Antiquity); – Elizavetovskoe settlement (V-III century B.P.)
Ancient-Azov transgression (3.0-10.3)	– climatic optimum (5.5-6.7 kyr) – elevated salinity in the Azov Sea; – chernozem soils formation (4.5-3.0 kyr); – Bronze Age, early Iron Age – Kobyakovo, Nizhnegnilovskoe settlements (3.0 kyr); – first record of Cerealia (wheat etc.) (4.0 kyr)

According to composition and pollen spectra ratios in the Ancient Azov deposits, the dynamic changes in the vegetation cover took place in the region. Climatic conditions have been changed from arid (6500-5500 years ago), with the development of steppe communities, to humid (5500-4000 years ago) with an increase of woodland vegetation in the Azov Sea region.

The hydrology of the water basin have started to change gradually about 2500 years ago. This process was termed "Fanagorian regression" in the literature [Fedorov, 1982; Balabanov, Izmaylov, 1988]. The Sea hydrology, depth and shoreline location of that era are the subject of greatest discussion in Russian and foreign scientific communities (geologists, paleogeographers, biologists and archeologists) taking into account the history of Holocene studies in the region. The sea level was lower and the Sea surface was reduced at that period, according to dominating point of view. The extent of the process is a matter of discussion by now [Balabanov, Izmaylov, 1988; Matishov et al., 2007; Maev et al., 2007].

The indirect evidence of sea level fall at Fanagorian phase were obtained in SSC RAS during the seismo-acoustic survey of Taganrog Bay bottom relief [Matishov, 2007; Matishov et al., 2007; Polshin et al., 2013]. The abrasion surface, formed at sub-aereal conditions and buried by younger (New Azov) marine-type sediments, formed at later transgression, was found. The location depth of abrasion surface, the thickness and composition of overlaying marine sediments give evidence for its young (Fanagorian) age. The diversity of stenohaline marine gastropods (*Rissoa, Retusa, Ebala*), occuring mostly at shallow lagoons on macrophytes, is an indirect evidence for sea level decline at that time.

The Azov Sea at the period of Fanagorian regression had the pronounced Black Sea fauna of molluscs and the salinity not less than 8‰ despite the sea surface and depth decline. This is evidenced by rich fauna of Mediterranean origin, found in the central part of the Sea in sediments, formed 2400 years ago, dominated by *Cerastoderma glaucum*, *Abra segmentum, Abra nitida* and *Mytilus galloprovincialis* [Nabozhenko, 2013].

Analysis of pollen spectra from the Sea of Azov bottom sediment showed that 2800 to 2500 years ago, the areas of woodlands were expanded in the coastal areas and in the floodplains of large rivers. The mean annual temperatures also were lower than the present day values by approximately 4-6°C. Annual precipitation was 400-500 mm, which in combination with the substantial cooling led to significant humidification of the territory due to decreased evaporation.

Climate change towards aridification occurred about 2500 years ago. According to pollen analysis warm dry conditions prevailed on the coastal areas in the interval of 2500-2000 years ago. The predominant type of vegetation was mostly herb-grass and wormwood-stubble steppes. Saline communities in combination with halophytic meadows occupied the saline depressions [Matishov et al., 2011, 2012].

The lythodynamics and sedimentation of the Azov Sea in late Holocene were influenced by heterogeneity and partition of bottom relief and took place during the Nimphean transgression [Matishov et al., 2010]. The coquina and organogenic detritic sands were deposited on top of underwater spits and banks at that time. The silty organogenic detritic sands were deposited on their slopes and silty coquina and silts of various granulometry were deposited at the basis of these positive relief blocks. The clay and clay-aleurite sediments with periodic interlayers of thin coquina layers were deposited in the central art of the Sea. The sedimentation process in the Taganrog Bay was dominated at that period by processes in the catchment of Don River and active sea-shore destruction due to sea level rise. The clay-aleurite fine grain sands with shell material inclusions were widely distributed in the Eastern part of the Bay. The grain size of New Azov sediments is reduced westward with the elevated mean depth of the Bay. The clay and clay-aleurites were mainly deposited in the central part of the Bay.

The salinity of the Azov Sea was gradually reduced and stenohaline Bivalvia were repaced with euryhaline species. This process is demonstrated well by species composition of Bivalvia from sediments, formed ca. 1700 years ago [Nabozhenko, 2013].

The shape of Don Delta was also gradually changed at late Holocene. The groundwater level was elevated which could lead to flooding of previously suitable landscapes and migration of people to the higher parts of river plain in III century BP. The Don delta was reduced to its modern size during the peak of Nymphean transgression (around V century AD). Yet the intrusion of the sea to the modern Don delta was short in time and space [Matishov et al., 2013].

Pollen spectra from the bottom sediments formed 1800-1500 years ago indicated the expansion of floodplain forests and pre-Caucasian broad-leaved oak and oak-hornbeam forests in the valleys of large rivers. Paleoclimatic reconstructions demonstrate average January temperatures of -5 to -8°C; those in July from 20 to 22°C [Matishov et al., 2012].

In the period of 650-150 years ago there were significant changes in the vegetation cover. An abrupt increase in the quantity of arboreal pollen in spectra may reflect the expansion of flood-plain forests in the valley of the Don and its tributaries and the appearance of ravine forests in the region adjacent to the Azov Sea. According to modern reconstructions, this time period was substantially colder. January temperatures went down to -11°C, and July temperatures reached the minimal values for the entire studied period (down to 18°C). The mean annual temperatures decreased up to 4-6°C. Precipitation was 500-600 mm per year [Matishov et al., 2011, 2012].

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DEVELOPMENT OF HOLOCENE TRANSGRESSION IN THE NORTH OF THE BLACK SEA

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РАЗВИТИЕ ГОЛОЦЕНОВОЙ ТРАНСГРЕССИИ НА СЕВЕРЕ ЧЕРНОГО МОРЯ

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Three problems are expected to be considered in this communication. The first is the basin level in the time of the last glacial maximum. The second is the age of the modern coastal zone. The third is the problem of Fanagorian regression.

The level of the Black Sea in the time of the last glacial maximum. Evidence on the position of the level, based on the structure of the deeper valleys of the Caucasian coast, is given in the paper [Ostrovsky, 1967]. The deepest post-Karangatian regression is estimated at 112-122 m. In 1975, data were published on the pebble belt on the shelf of the Southern coast of the Crimea at depths of 80 to 90 m [Kuprin et al., 1975]. The echo-survey, conducted by us in the same area showed the presence of a terrace at depths of 90 to 105 m separated from the overlying shelf by a ledge several meters high (up to 10 m). Seismo-acoustic studies revealed its nature: the ledge is the outer edge of the clinoform and its base does not indicate the sea level [Lokhin, Maev, 1989]. The depth of the ancient shore is at 80-90 m. On the outer edge of the northwestern shelf, data have been obtained not only about a drop in the level to 80-100 m, but also about the morphological features (terraces) of the sea regression to -130-140 m [Evsyukov, Rudnev, 2013]. Later, reports of regression signs appeared up to -150 m and even up to -180 m. The time of regression by the researchers is estimated at 19-20 kyr. On the edge of the shelf, cut by the canyon of the Danube, an abrasion terrace [Popescu et al., 2004] is traced at depths of 90 to 98 m at a distance of about 100 km.

On the Romanian shelf at depths of 95 to 100 m, as the researchers believe, the abrasion terraces overlapped with dunes were found. The age of the lake sediments at depths of 70 to 90 m is from 11 to 8.5 thousand years. The region was dominated by the arid climate at that time, and the decrease in the flow of river water caused a level drop to these significant figures [Lericolais et al., 2009]. The dunes on the shelf are divided into two categories: large, up to 10 m high, desert eolian forms with deflation troughs between them at depths of 55 to 80 m, and smaller coastal dunes located at depths of 80 to 90 m [Yanchilina et al., 2017]. The regression was an important stage in the development of the relief of the Black Sea depression. During the regression, the river valleys developed on the north-western shelf and in other regions, and the alluvium carried by the rivers to the continental slope fed turbid streams that descended along numerous canyons. As a result, an extremely dense network of erosion forms have developed on the shelf, continental slope and bottom of the depression: their total length exceeds 50 thousand km, and the length of the most developed (Supsinsko – Chorokhsko – Harshit system) reaches 398 km [Melnik, 1996].

Age of the modern coastal zone. There are two points of view on the nature of changes in the level of the Black Sea in the second half of the Holocene. According to one, the sea have approached the modern level relatively recently, about 1 thousand years ago. Depending on local tectonic conditions (for example, the Anapskaya spit), traces of its position near the modern shore in about 3 thousand years can be fixed. In general, the course of the transgression was of a step nature: the phases of directed ascent were replaced by delay phases, during which the sea managed to create the underwater accumulative forms [Neveskii, 1967]. In the ancient era, the level was lower than today, then it rose. This explains why the lower parts of many ancient cities of the Northern Black Sea Coast are flooded.

According to another point of view, the level approached the modern depths -3, -4 m about 6 thousand years ago and about 5.8-5.5 thousand years B.P. has reached a modern position. Since then, the level has been near modern zero, sometimes dropping and then returning back [Balabanov, Izmailov, 1988; Izmailov, 2005; Balabanov, 2009, etc.]. The datings of the spits of the estuaries of the North-Western Black Sea region give the figure of 5 thousand years [Konikov et al., 2007; Konikov et al., 2010]. In the western Crimea, the formation of barrier spit separating the future lakes Sakskoye and Dzharylgach from the sea and leading to the change in sedimentation in open bays by the formation of estuarine sediments is estimated at 5340-5610 cal. years ago (lake Sakskoye) and 5590-5350 cal. years ago [Dzharylgach; Subetto and others, 2007]. The shell material of the Arabatskaya spit, lying on Novoevksinsky and Bugaz sediments, date from 6.5 to 5 thousands years ago [Balandin, Trashchuk, 1982]. However, the section is located within the Azov tectonic high and the Holocene deposits here are raised by 10-15 m, being above sea level. The depth of accumulation of dated sediments is estimated at 5 m. U.V. Artyukhin gives the earliest dating of sediments accumulative forms of the Azov Sea: 4600 B.P. for a spit Biryuchy Island and 5890 B.P. for the Arabat spit [Artyukhin, 2010]. In the delta of the Kuban river, the age of the most ancient, early-Dzhemete, generation of coastal levees is determined in 5.8-4.5 thousand years ago [Izmailov, 2010]. The earliest datings of the coastal sediments of the Anapa spit from a depth of 0.15 to 1.15 m below the current level lie in the range 5.2 to 5.3 thousand years ago [Izmailov, 2005].

Thus, the age of the modern coastal zone is 5-5,800 years.

The problem of Phanagorian regression. There are evidence according to which in the late Holocene the level experienced small oscillations, dropping by 2-3 m fom the current situation [Shuisky, 2011]. Studies on the shores of the Taman Peninsula led a number of researchers to the idea that the Phanagorian regression, postulated in 1963 by P.V. Fedorov, was not existent or its amplitude was negligible [Porotov et al., 2004; Fouache et al., 2011]. The study of traces of level changes in the Azov delta of the Kuban gave basis for developing a different conclusion. Here the coastal levees of the Dzhemete generation (absolute age 5.8-2.9 thousand years) are separated by regressive deposits from the levees of the Nymphaean stage (2330-510 B.P., Izmailov, 2010). Regression is dated from buried peat sediments; its age lies in the range of 2500-2300 B.P., and the depth is 10-15 m [Izmailov et al., 2001]. Phanagorian regression includes the buried river channel in the Don delta [Zaitsev, Zelenshchikov, 2009], the late Holocene erosion channel of the pra-Don in the Taganrog Bay [Sheikov, 2012]. The seismic profiling carried out by us in the Taganrog Bay revealed the erosional surface at a depth of 1 m under modern sediments, up to water depth of about 8 m, and traces of wave activity at depths of more than 5 m [Maev et al., 2006].

Drilling in the Saki lake in the Crimea found a lens of rock salt with a thickness of 3.5-4 m, accumulated over 150-175 years [Dzens-Litovsky, 1936]. Modern accumulation of table salt in the lake does not occur. According to the calculations of annual (?) layers, the sediments, overlapping the lens, has accumulated over the last 2 thousand years. This indicates the arid conditions and can explain the nature of the Phanagorian regression.

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PAST AND FUTURE IMPACT OF NORTH ATLANTIC TELECONNECTION PATTERNS ON THE HYDROCLIMATE OF THE CASPIAN CATCHMENT AREA IN CESM1.2.2 AND OBSERVATIONS

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ВЛИЯНИЕ КЛИМАТИЧЕСКИХ СВЯЗЕЙ В СЕВЕРО-АТЛАНТИЧЕСКОМ РЕГИОНЕ В ПРОШЛОМ И БУДУЩЕМ НА ГИДРОЛОГИЮ ВОДОСБОРА КАСПИЙСКОГО МОРЯ ПО ДАННЫМ МОДЕЛИ CESM1.2.2 И НАБЛЮДЕНИЙ

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The Caspian Sea level (CSL) has undergone dramatic variations of more than 3 m during the past century with important implications for the life of coastal people, economy and the ecosystem. The origins of these variations, as well as future changes in the Caspian water budget, are still a matter of debate. In this study, we examine the influence of the major seasonal North Atlantic teleconnection patterns, the North Atlantic Oscillation (NAO), the East Atlantic pattern (EA) and the Scandinavian pattern (SCA) on Caspian hydroclimate variability from 1850-2100 CE. Five Numerical experiments at different atmospheric grid resolutions (2° and 1°) and atmospheric model versions (CAM4 and CAM5) are carried out with the coupled Community Earth System Model (CESM1.2.2). We test model skills through validation against observational and reanalysis data by various statistical methods (Empirical Orthogonal Functions, Taylor diagrams, linear regressions and Pearson correlations). Results reveal the strongest simulated signal in winter (DJF) with high explained variances for 1° CESM1.2.2 CAM5 NAO (46.5%) and EA (13.4%), similar to observational data (Fig. 1). The model is unable to reproduce the SCA pattern in the third EOF, which is found in the observations. The DJF NAO has a strong influence on the DJF temperature, rainfall and evaporation minus precipitation (E-P) over the Caspian sub-basins (Volga, Ural, Terek and Kura). Our study suggests that the 1° version of CESM1.2.2 (with CAM5 atmosphere physics) shows adequate performance with respect to teleconnection maps during the historical period (1850-2000). Lastly, 1° model climate projections (2020-2100 CE) are performed with different Representative Concentration Pathways (RCP4.5 and RCP8.5) to examine potential changes in the teleconnection patterns and their influence on the Caspian basin. The NAO under the RCP4.5 and RCP8.5 scenarios remains the leading mode and influences E-P with increased precipitation over the Volga basin and increased evaporation over the Caspian Sea. The NAO and EA cause cancelling effects on the hydroclimate variability in the Caspian sub-basins such that no substantial change is predicted in the CSL by the year 2100.

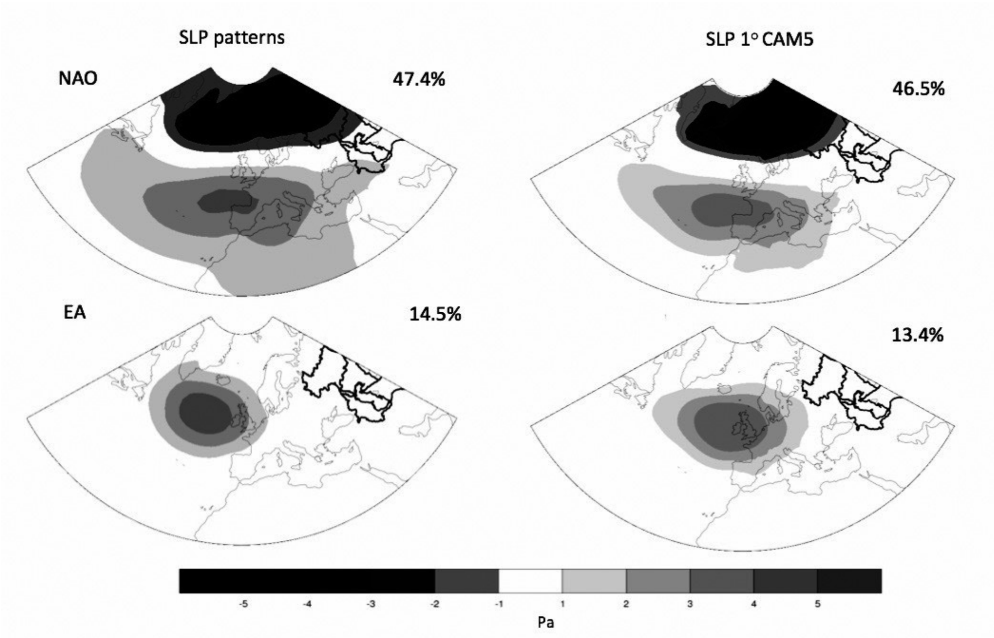

Fig. 1. Leading modes of winter (DJF) SLP variability (1950-2000) from NCEP reanalysis and CESM1.2.2 (1° CAM5). The maps show SLP regressed onto standardized EOF time series

REVISING THE PONTOCASPIAN MOLLUSK FAUNA: PRELIMINARY RESULTS

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РЕВИЗИЯ ПОНТО-КАСПИЙСКОЙ ФАУНЫ МОЛЛЮСКОВ: ПРЕДВАРИТЕЛЬНЫЕ РЕЗУЛЬТАТЫ

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The Caspian Sea has been classified as a major biodiversity hotspot for oligohaline gastropods. About ninety species are listed in latest systematic catalogues, with over 90% of them being endemic. However, little information is available on the evolution of the Caspian hotspot. While published data have suggested a rather species-poor ecosystem during the Pleistocene, several lately uncovered assemblages are unexpectedly diverse. These new data indicate that Pleistocene biodiversity has been so far strongly underestimated. Moreover, they may facilitate investigating the rise and demise of the Caspian biodiversity hotspot during Quaternary climate change. Yet, sound biodiversity reconstructions require a sound taxonomic framework, and the taxonomy of the Pontocaspian faunas is far from being well resolved. The extreme morphological variability of many of the described species complicates taxonomy and, thereby, hampers reliably diversity assessments. Preceding taxonomic studies carried out in the 19th and 20th century have produced a plethora of available species names, partly based on minor morphological deviations. Presently, the statuses of most Caspian endemic gastropods, especially of the numerous representatives of the Pyrgulinae (Hydrobiidae), are poorly resolved.

Here, we present the first results of the beginning taxonomic revision of the Caspian endemic gastropod fauna. As starting point, we chose a species-rich assemblage from Khazarian (middle Pleistocene) deposits of the northwestern Caspian Sea (Selitrennoye, Astrachan, Russia). Preliminary identifications amount to 28 species of which 21 are Pontocaspian elements. Most of the Pontocaspian representatives have been poorly documented in the literature. This first examination has already yielded several taxonomic and nomenclatural rectifications of previous misinterpretations. Above that, genus concepts applied to the Caspian Hydrobiidae hitherto are revised.

ISOTOPE EVOLUTION OF THE PONTOCASPIAN

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ИЗМЕНЕНИЯ В ПОНТО-КАСПИЙСКОМ РЕГИОНЕ ПО ДАННЫМ ИЗОТОПНОГО АНАЛИЗА

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Stable isotope approaches are useful in the study of many aspects of Pontocaspian lake evolution. Stable isotope geochemistry can shed light on climatic aspects, connectivity issues as well as paleo-environmental evolution. In this review we discuss a number of examples where stable isotope geochemistry has been used and is used to shed light on the evolution of Pontocaspian lake basin evolution.

Firstly we will discuss isotope approaches to understand the drainage history of the Aral-Caspian area. The paleo-Amu-Darya and Syr-Darya systems together with other regional rivers in the Uzboi area were a major contributors to the Caspian Sea throughout the Quaternary. Understanding rainfall intensity and origins in the NW Himalayan ranges is of prime importance to understand these paleo-drainage systems. Oxygen isotope signatures suggest a very limited role for Indian monsoons as water source and instead point to Atlantic-derived sources.

In a second example we will show the use of Strontium isotope ratios to reconstruct phases of connectivity and isolation of the Caspian and Black Sea Basin throughout the Quaternary. Initial results show prolonged isolation of both basins with episodic connections. Lately work of Yanchilina et al. [2017] using a combination of Sr and Oxygen isotope ratios from the Late Pleistocene-Holocene transition in the Black Sea has delivered new insights into water sources, connectivity between the Black Sea and the Marmara Sea as well marine reconnection. Another landmark study of Badertscher et al. [2011] using oxygen isotope ratios from the Sofular cave in northern Turkey also shed light on the connectivity histories of the Black Sea (with timing of marine conditions through the Marmara Sea as well as overflows of low saline waters from the Caspian Sea), even though some of the proposed Caspian overflows are disputed. These studies show that geochemical approaches are very important to constrain the regional Ponto-caspian lake basin evolution.

Finally we will present some preliminary stable oxygen data from the Caspian Sea to reconstruct salinity and temperature properties of water masses during the Late Pleistocene and Holocene. Earlier, Vonhof et al. [2003] used sclerochronological analyses from Holocene shells of Turali (Dagestan, Russia) to reconstruct seasonal temperature variation. Currently we are working on establishing water properties during different lake phases in the Caspian Sea since the Early Khazarian using oxygen and carbon ratios.

With our review we aim to advocate more widespread isotope geochemical studies in the Pontocaspian region. Their potential to elucidate the complex regional climate and lake basin evolution is profound.

TAXONOMIC IDENTIFICATION AND DISTRIBUTION OF "SOFT-SHELL MONOTHALAMIDS" FORAMS FIRST SIGNALED ON THE BLACK SEA ROMANIAN SHELF WITHIN THE MAP SHEET PERIMETER FH L35-132

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ОПРЕДЕЛЕНИЕ ТАКСОНОМИЧЕСКОГО СОСТАВА И РАСПРОСТРАНЕНИЯ МЯГКОРАКОВИННЫХ МОНОТАЛАМИД (MONOTHALAMIDAE, FORAMINIFERA), ВПЕРВЫЕ ЗАРЕГИСТРИРОВАННЫХ НА РУМЫНСКОМ ШЕЛЬФЕ ЧЕРНОГО МОРЯ

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Meiobenthos represents a very important segment of benthic diversity, including all organisms with size of less than 1 mm length, which populate the substrate up to 5 to 10 cm in depth (sometimes even more) and the water-sediment interface.

The meiobenthic samples were collected within the habitat of the tubicol polichet *Terrebelides*, located at depths ranging from 50-65 m, characterized by the presence of the biotope consisting of broken shells and mud, which facilitates the penetration of the meiobenthic organisms and their heterogeneous distribution. Only 3% of the analysed area is occupied by the classical habitats of deep mussels in association with tube dwelling *Dipolydora quadrilobata* from the mixed sedimentary and muddy-sand sediments of organogenic origin.

There were 8 samples of meiobenthos collected using a multicorer, each of them being selected from a tube from which 5 cm of sediment was extracted from its surface. The sedimentary material was subsequently washed aboard the ship with a 125 μm mesh size and stored in 10% formalin. In the laboratory, the samples were washed and placed in a solution of Bengal and Alcohol, according to the usual methodology [Giere, 2009] for the detection of organisms.

9 meiobenthic taxonomic groups (Harpacticide, Bivalvia, Gastropoda, Kinorhyncha, Halacarida, Ostracoda, Nematoda, Cercozoa and Foraminifera) were identified.

At the Black Sea level, 23 species of Soft shelled Foraminifera were identified in the field of *Phyllophora* (Zernov): 8 of which were identified at species or genus level, 14 species (9 allogromides and 5 saccammines) at family level. 9 of the those identified at Family level are recorded for the first time in the Black Sea [Anikeeva & Gooday, 2016]. There are 25 species known to date in the Black Sea, out of the 31 known at European level.

The current study reveals for the first time the presence of both the cercozoan (Gromiidae family) and the monotalamid foraminifera from the Astorhizida (Psammophaga sp.) and Allogromiida Orders, identified in 8 stations, collected in the FH L35-132 perimeter.

Thus, 10 forms of monothalamides identified at genus or species level were identified, being significantly more abundant than multicameral calcarous test species, with a mean density of 6533.63 ind./m^2.

Of these, the monothalamides of Fam. Allogromiidae and Fam Gromiidae represented 75.43%, and fam. Saccamminidae, the rest. Monothalamides are known worldwide for their wide tolerance to extreme conditions (high temperatures, oxygen deficiency) in the Black Sea, recent studies [Sergeeva et al., 2010; 2015] bringing incontestable evidence of their presence at the lower limit of the anoxic zone, where they have peak abundances. On the other hand, Saccamminidae in general, and the Psamophaga genus, present in all 8 stations, are well known for their role as indicators of eutrophic conditions and the fact that they can retain mineral particles in their cytoplasm, but the selective mechanism of accumulation is not clear yet.

A single family, the Gromiidae family, single-cell bodies with the stercombase soft test (organic material grains, mostly made of clay minerals being derived from sediment ingestion), were identified from the Cercozoa Phyllum.

This group was proposed in 2002 by Tom Cavalier-Smith. They vary significantly in shape, but are generally amoeba like with pseudopod, filiform, cross-linked or microtubule-supported. Many produce exoskeletons or shells, which can be structurally complex enough, making up much of the protozoan fossils. Almost all of them have tubular mitochondria.

The scientific interest in these foraminifers has increased considerably in recent years. Sergeeva & Anikeeva (2006) and Sergeeva et al. (2010) investigated the composition and taxonomic distribution of monothalamides in deeper areas of the Black Sea, including those subject to hypoxic conditions, while Sergeeva & Anikeeva (2014) studied monothalamides in conditions with or without hypoxia in shallow water deep. Sergeeva & Anikeeva (2004) and Anikeeva (2005) provided the first taxa records for this basin. New species for science have been described by Gooday et al. (2006), Gooday et al. (2011), Sergeeva & Anikeeva (2008) and Anikeeva et al. (2013). Sergeeva & Mazlumian (2006) dealt with meiofauna from Zernov's Phyllophora field (ZPF). Although the first records of monothalamid foraminifera in the Black Sea database only appear in the end of the 20th century [Sergeeva and Kolesnikova, 1996; Golemansky, 1999], these include at least 42 morphocytes [Sergeeva et al., Gooday et al., 2011].

Conclusions:

- Out of the 10 taxa, 3 were identified at genus / species level (*Psammophaga* sp., *Vellaria sacculus, Bathyallogromia* sp.)
- Monothalamides with a density of 4928.37 ind./m^2, as opposed to the calcareous foraminifera, with 1762.25 ind./m^2.
- Multicameral calcarous foraminifera were represented by the species *Ammonia*, *Elphidium*, and agglutinated by *Eggerelloides*.

CASPIAN HYDROCLIMATE AND SEA LEVEL CHANGES DURING THE LAST GLACIAL (MIS2 AND MIS3) AS INFERRED FROM A GENERAL CIRCULATION MODEL

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ИЗМЕНЕНИЯ ГИДРОЛОГИИ И УРОВНЯ КАСПИЙСКОГО МОРЯ ВО ВРЕМЯ ПОСЛЕДНЕГО ЛЕДНИКОВОГО ПЕРИОДА (MIS2 И MIS3) ПО ДАННЫМ ЦИРКУЛЯЦИОННОЙ МОДЕЛИ

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The Caspian Sea Level (CSL) has undergone substantial changes throughout the Quaternary. During the last glacial cycle the total range of CSL change was more than 100 m. However, the exact timing of past transgressions and regressions is often highly uncertain. This also applies to the age of the Early Khvalynian, assumed to be the highest Pleistocene transgression of the Caspian Sea (+75 m relative to the modern stage), which in the literature has been alternatively dated to Marine Isotope Stage (MIS) 2 or 3.

Here we investigate past changes in the hydroclimate of the Caspian catchment area by using the comprehensive fully-coupled general circulation model CESM (Community Earth System Model), which is composed of four components representing the atmosphere, the ocean, the land surface, and sea ice. Besides the modern climate, we simulate climate states of MIS2 and MIS3. To this end, model simulations with boundary conditions for the Last Glacial Maximum (MIS2) and 35 ka before present (MIS3) are set up, taking into account changes in orbital parameters, greenhouse gas concentrations, ice-sheet distributions and global sea level. Two different simulations of the Last Glacial Maximum are performed with different ice-sheet reconstructions in order to take account of the uncertainties in the glacial history of northern Eurasia. Freshwater perturbations are applied to the North Atlantic to simulate millennial-scale climate anomalies associated with Dansgaard-Oeschger and Heinrich events.

The CESM experiments are analyzed with respect to mechanisms of hydroclimatic changes in the Caspian catchment region during the Late Pleistocene. CSL changes are estimated based on simple water balance calculations using CESM output fields, such that hypotheses regarding Late Pleistocene CSL changes can be tested.

LATE MIOCENE – EARLY PLIOCENE OSTRACOD FAUNA FROM THE DENIZLI BASIN (SOUTHWESTERN ANATOLIA): PALEOENVIRONMENTAL ASSESSMENT AND PALEOGEOGRAPHIC IMPLICATION

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ФАУНА ОСТРАКОД ВЕРХНЕГО МИОЦЕНА – НИЖНЕГО ПЛИОЦЕНА БАССЕЙНА ДЕНИЗЛИ (ЮГО-ЗАПАДНАЯ АНАТОЛИЯ): ПАЛЕОЭКОЛОГИЧЕСКИЕ ОЦЕНКИ И ПАЛЕОГЕОГРАФИЧЕСКОЕ ПРИМЕНЕНИЕ

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The Miocene-Pliocene sedimentary succession of the Denizli Basin in Southwestern Anatolia (Turkey) displays a unique record of undisturbed stratigraphy and provides an excellent opportunity to study paleoecological changes in a previously poorly investigated Paratethyan-like ostracod fauna. In this study we further focus on the sedimentary successions of the Basin to elucidate the role of the region as a source/sink-area of Pontocaspian ostracod biota. The so-called Pontocaspian ostracod fauna is characterised by their endemicity, morphological diversity originated from a variety of paleoecological domains inside the Paratethys and a Pannon Lake origin.

The studied ostracods have been recovered from 106 samples collected from two different outcrop localities of Miocene – Early Pliocene age. There have been also taken 240 standard paleomagnetic samples from the upper part of the section with the aim to provide the age constraints.

The lower part of the studied succession (possible Late Miocene) demonstrates a transition from deep water lacustrine environments with sedimentation of laminated clays to a more proximal lacustrine setting with a prevalence of carbonate sedimentation. Widely distributed Pannonian type brackish water ostracods and a presence of dinocysts suggest brackish water environments with a possible connection to the Paratethys.

The ostracod assemblage is dominated by candonids associated with few observations of leptocytherids and loxoconchids. Morphological similarities between the studied fauna and ostracods of Pannon Lake origin are obvious, still the migration patterns are questionable. The existence of an unknown intra-Turkish gateway between the Denizli Basin and the Paratethys is not to be excluded, even if there are no clear evidences found yet. An alternative hypothesis would be the assumption of long distance dispersal (LLD) of ostracods via water birds. Avian dispersal proved to be an important dispersal mechanism for introducing aquatic microorganisms into new habitats [Wesselingh et al., 1999]. Therefore we assume that ostracods might have been transported from the Paratethys (Pannon Lake) to the Denizli Basin, where similar ecological conditions encouraged the spreading of an endemic fauna that is remarkably similar to the one from the Central Paratethys.

The upper part of the section (possible Late Miocene – Early Pliocene) represents alternation of prodeltaic siltstones associated with slumps and turbidites and relatively deep lacustrine lenticular clays. The ostracod fauna suggests a pronounced change of the pre-existing paleoecological conditions. A shift towards a low brackish to a freshwater setting is marked by the evolution of an endemic fauna dominated by candonids. This development can be related to the progressive isolation of the Basin and the formation of a terminal lake, coeval with the restoration of shallow lakes in adjacent Basins of the area [Alçiçek, 2009]. Paleomagnetic investigations established a presence of 2 normal and 1 reversed zones, which creates several options for correlation with GPTS.

BIOSTRATIGRAPHIC AND ENVIRONMENTAL EVOLUTION OF THE NORTH AND CENTRAL CASPIAN: 30 MILLION YEARS OF CHANGE

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ИЗМЕНЕНИЯ ФАКТОРОВ ОКРУЖАЮЩЕЙ СРЕДЫ И БИОСТРАТИГРАФИИ СЕВЕРНОГО И ЦЕНТРАЛЬНОГО КАСПИЯ: 30 МИЛЛИОНОВ ЛЕТ ИЗМЕНЕНИЙ

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The present-day Caspian Sea is like a photograph frozen in time. If you take that photograph today, by tomorrow something, somewhere will have changed. It is only over time that those changes become clearly visible. An example would be the gradual rise in Caspian Sea level of several metres between 1977 and 1995, and the subsequent fall observed over the last 20 or more years. But to understand the origins of the present (and potentially future) Caspian biota, as far as that is possible, we need to look back in time for hundreds, thousands and even millions of years, and to examine the fossil records wherever we can find them. These are the 'photographs of the past'. Palynology is one of the most useful biostratigraphic disciplines that can be used to reconstruct past environments of the Caspian Sea. Palynology uses 'palynomorphs' that are preserved in buried sediments: these include pollen (mainly from land plants), dinoflagellate cysts ('dinocysts', present mainly in marine and low salinity sediments), algae, fungal bodies, acritarchs and others. These fossil assemblages give a unique 'photograph' of the sediments in which they occur. When viewed together with other groups of microfossils, such as ostracods, foraminifera and calcareous nannofossils, a detailed picture starts to emerge.

If we turn back the clock for 30 million years, to the middle of the Oligocene Epoch, the Caspian Sea was fully connected to the world's oceans during the Maykopian regional stage. Open marine conditions deposited organic-rich sediments throughout Paratethys, including the Caspian Sea. These 'oil source muds' are now buried more than 10 000 m below the Caspian Sea bed, so deep that they have not been studied in the offshore region. Maykopian sediments, however, can be studied in outcrop and well sections, for example in onshore Azerbaijan, where they contain rich assemblages of pollen, marine dinocysts, foraminifera and calcareous nannofossils. Maykopian deposition ended at the end of the Early Miocene, around 16 million years ago, but open marine conditions persisted in the Caspian Sea until the Middle Miocene (Sarmatian) more than 12 million years ago, calibrated to world-wide nannofossil zones NN5 and NN6. Subsequently, the Caspian Sea, as part of Paratethys, gradually became disconnected from the world's oceans. This is reflected in the palynofloras that show similar changes from the Pannonian Basin of Eastern Europe, to the Black Sea and the Caspian Sea. Dinocyst assemblages are characterised by the emergence of restricted marine, low-salinity adapted taxa such as *Spiniferites bentorii* (including several sub-species), *Galeacysta etrusca* and various morphotypes of '*Pontiadinium*'. An expansion of the acritarch *Mecsekia*, first described from Hungary [Hajos, 1966], can be tracked eastwards to the Caspian Sea during the Sarmatian and early Pannonian (latest Middle Miocene to basal Late Miocene).

Towards the end of the Miocene, it is well-known that the Mediterranean Sea was desiccated during the Messinian period. At more or less the same time, during the Pontian regional stage, the Caspian Sea supported mainly brackish water ostracod faunas and dinocysts, for example at the Ajiveli locality in Azerbaijan [Grothe, 2016; Van Baak et al., 2016]. In Pontian-aged sediments at Kirmaky Valley, Azerbaijan, the dinocysts include frequent *Caspidinium rugosum* and *Spiniferites cruciformis* which indicate a low salinity regime. Occasional peaks of the dinocyst *Lingulodinium machaerophorum* (long-spined forms) point to periods of increased salinity, although the absence of associated in-situ foraminifera and nannofossils suggests that an open marine connection did not occur at this time. Throughout most of the Pliocene (ca. 5.3 Ma to ca. 2.6 Ma), the Caspian Sea was an isolated fluvio-lacustrine basin, present only in the deeper water central and southern regions. Pollen assemblages are rich and diverse and often include reworked taxa from the Paleozoic, Mesozoic and Paleogene. The non-pollen components include various algae (e.g. *Pediastrum* and *Botryococcus*), fungal bodies and dinocysts (e.g. *Caspidinium rugosum* and *Spiniferites cruciformis*).

Renewed marine influences are evident in the Caspian Sea more or less coincident with the onset of northern hemisphere glaciations at the end of the Pliocene (Piacenzian) and beginning of the Pleistocene (Gelasian) during the Achkagylian regional stage. Limited open marine influence is confirmed by the presence of a rich, but very low diversity, foraminiferal assemblage characterised by calcareous benthonics *Cassidulina reniforme*, *C. obtusa* and *Cibicides lobatulus*. This association is well-known in the northern (i.e. Arctic) oceans and strongly suggests that the dominant marine influence during the Achkagylian was from the north, and not from the Black Sea or Mediterranean [Richards et al., in review].

During the remainder of the Pleistocene, the Caspian Sea has undergone several major (and many more minor) phases of transgression and regression. Each of the major transgressions is associated with a distinct ostracod and palynological signal. The Early Pleistocene, early Apsheronian transgression is characterised by dinocysts of 'Pannonian' affinity, with varied morphotypes of '*Pontiadinium*', *Impagidinium* and *Chytroeisphaeridia* present. The late Apsheronian typically contains increased numbers of *Caspidinium rugosum*. In the Middle Pleistocene, the Bakunian regional stage is marked by a major increase in frequency and morphological variety of *Spiniferites cruciformis*. The 'cross-shaped' morphology and varied ornament are probably adaptations to allow buoyancy at differing water depths and salinities [Mudie et al., in press]. The Khazarian regional stage (Middle to Late Pleistocene) sees the first significant presence of *Pterocysta cruciformis*, a dinocyst that was until recently only known from the Black Sea [Rochon et al., 2002]. It occurs frequently in the Late Pleistocene and Holocene of the northern Caspian Sea. Assemblages of this age further south tend to contain varied representations of *Impagidinium caspienense* among others.

Details of two case studies from the north Caspian region will be presented. The first is of the last ~45,000 ka in the offshore Emba Delta region of Kazakhstan [Richards et al., 2016]. Four distinct lithological units are recognisable from shallow seismic profiles and sedimentology. Each unit has a distinct palynological and ostracod signature. Unit 4 is interpreted as a sub-aerial dune association (similar to the early Holocene 'Baery knolls') linked to the Atelian drawdown of the Caspian Sea during MIS4. Overlying Unit 3 is a lagoonal deposit dated by radiocarbon to MIS3 and contains a unique pollen flora including 'thermophilous and hygrophilous relicts' most notably Taxodiaceae. Unit 2 consists of early Khvalynian transgressive barrier sands and Unit 1 is a thin Holocene brackish water deposit. All of the unit boundaries are unconformable, with the late Khvalynian and LGM (Last Glacial Maximum) sediments eroded between Unit 2 and Unit 1.

The second case study is based on a series of cores of Holocene age from the Damchik region of the lower Volga Delta, studied for palynology and ostracods [Richards et al., 2014]. The study recognises four principal stages of delta development, beginning with the 'Baery knolls' linked to the early Holocene Mangyshlak lowstand event. Pollen associations indicate successive expansions of steppe, forest and aquatic vegetation within the delta and lower Volga catchment in response to changing climatic regimes and delta progradation/aggradation.

DINOFLAGELLATES FROM THE PONTOCASPIAN REGION: FROM BIODIVERSITY TO PHYLOGENY

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ПОНТО-КАСПИЙСКИЕ ДИНОФЛАГЕЛЛЯТЫ: ОТ БИОРАЗНООБРАЗИЯ К ФИЛОГЕНИИ

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The Pontocaspian region (Black Sea, Caspian Sea, Anatolia and surroundings) has experienced highly dynamic changes in geology and climate that have induced abrupt changes in lake levels and environmental parameters, particularly salinity. As a result, over the last two million years, this area has developed a unique and diverse endemic biota adapted towards low salinity. Numerous palynological studies have described endemic species assemblages dominating the dinoflagellate community in this area. However, the complete life cycle and ecology of most of these endemic species as well as their speciation events are still unknown. An extensive sampling strategy across the Pontocaspian region has been designed to infer dinoflagellate biodiversity and the biogeography of these brackish species. By applying palynological methods to surface sediments, microalgae cultures from environmental samples and molecular techniques using dinoflagellates-specific primers (COI and ITS), this project aims to examine the extent to which dinoflagellate phylogeny, current taxon biodiversity and species ecology from the Pontocaspian region have been influenced by the history of natural events during the Quaternary period. Moreover, using dated molecular phylogenies, we aim to reconstruct the evolution and to infer endemic dinoflagellate biodiversity. We present preliminary species assemblages inferred from the identification of dinocyst (taxonomy) and planktonic cells (eDNA) from phytoplankton samples along salinity gradients from three brackish environments along the Black Sea coast linked to their environmental setting.

A PHYLOGEOGRAPHIC PERSPECTIVE ON PONTOCASPIAN BIOGEOGRAPHY BASED ON A GASTROPOD SPECIES COMPLEX (NERITIDAE: *THEODOXUS*)

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ФИЛОГЕОГРАФИЧЕСКИЕ ВОЗМОЖНОСТИ ПОНТО-КАСПИЙСКОЙ БИОГЕОГРАФИИ ПО МАТЕРИАЛАМ ИЗУЧЕНИЯ КОМПЛЕКСА ВИДОВ ГАСТРОПОД РОДА *THEODOXUS* (NERITIDAE)

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The evolutionary relationships between species can often tell biologists and geologists much about the environmental history of a region. Species complexes (a group of closely related species where the systematic relationships between species is unresolved) are particularly useful. These often help to illustrate more recent evolutionary events. Unlike many biodiversity hotspots for aquatic taxa, one region remains poorly understood, the Pontocaspian. This region has gone through immense geological and climatic shifts which are believed to have driven speciation, yet the exact mechanisms are not well known. One species complex that could help revealing its environmental past, belongs to the aquatic snail genus *Theodoxus*, and includes *T. lituratus, T. pallidus, T. euphraticus, T. pallasi,* and *T. astrachanicus*. These species occur across the eastern Pontocaspian. The phylogeographic signatures of this group within and around the Caspian Sea can thus help us to understand more about the historical biogeography and evolution of aquatic species in this part of the world. Here we construct comprehensive phylogenies, and haplotype networks based on mtDNA and nDNA with which to observe the phylogenetic and geographic signatures of this species complex. Additionally Isolation by Distance was also tested. Preliminary results indicate that species, living in the Caspian Sea, show lower levels of genetic differentiation in comparison to populations living in isolated inland drainages. These results are discussed in the context of Pontocaspian aquatic biogeography and suggest fluctuations in Caspian Sea level may have aided in the repeated dispersal and isolation of inland populations (particularly in the south), while fluctuations in Caspian Sea salinity may have caused sufficient bottlenecks to reduce diversity in the main sea body.

MALACOFAUNA OF THE SOUTHWESTERN PART OF THE SEA OF AZOV ACCORDING TO LITHOLOGICAL CORES

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МАЛАКОФАУНА ЮГО-ЗАПАДНОЙ ЧАСТИ АЗОВСКОГО МОРЯ ПО ДАННЫМ ЛИТОЛОГИЧЕСКИХ КОЛОНОК

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The study of shell material of molluscs allows us to conclude on some environmental conditions of the Azov Sea. In layers with a high content of shells, the species composition and quantitative content of species were determined. The lithological cores taken in the southwestern part of the Azov Sea were used as a material for the study (Fig. 1).

At station 14 a poor species diversity of molluscs is recorded, with predominance of euryhaline Black Sea species, such as *Cerastoderma glaucum* and *Hydrobia acuta*. In the lower horizon, the species composition is represented by a depleted series of the Black Sea fauna. In later horizons, the disappearance of psammophilous species of gastropods is observed. In the intervals from 1330 ± 40 to 1170 ± 80 BP *Hydrobia acuta* prevails, being the most resistant mollusc to the conditions of the environment and the indicator of extinction phenomena. In the rest horizons of this core *Cerastoderma glaucum* is the absolute dominant. In the horizons 1430 ± 90 and 1170 ± 80 BP no specimens of *Abra ovata* were recorded, which was observed in the later and earlier series. This may indicate the lower salinity of the water area at this time.

At stations 23, 16 and 18 in the period from 2230 ± 130 to 480 ± 100 BP the malacofauna did not undergo any significant changes. During the study of the shell material throughout all horizons, a depleted Black Sea fauna with insignificant alterations was observed. In all layers, the dominant species were *Cerastoderma glaucum* and *Hydrobia acuta*. In general, comparing with the column selected at station 14, we observed a higher species diversity. Apparently, in this area the hydrological regime did not undergo significant changes during this time. Almost in all series *Abra ovata* was recorded, which is a sign of salinity not less than 14‰.

Fig. 1. Schematic map of the lithological cores sampling point

NEW RESULTS ON PALEOGEOGRAPHY OF THE KERCH STRAIT DURING LATE PLEISTOCENE-HOLOCENE

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НОВЫЕ РЕЗУЛЬТАТЫ ПО ПАЛЕОГЕОГРАФИИ КЕРЧЕНСКОГО ПРОЛИВА В ПОЗДНЕМ ПЛЕЙСТОЦЕНЕ-ГОЛОЦЕНЕ

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The aim of this work is the paleogeographic reconstructions of the Kerch Strait's evolution during Late Pleistocene-Holocene based on malacofaunistic analysis of four boreholes' cores that were drilled on the Tuzla Split.

The structure of core (№№ 93, 95, K4-53, K3-14) in general is similar in facial-lithological and malacofaunistic composition.

At the core bottoms (45-40 m) sediments include representatives of freshwater (*Viviparus* sp., *Valvata* sp., *Unio* sp.) and slightly brackish (*Dreissena polymorpha, Monodacna caspia*) malacofauna.

The complex indicates a significant influence of freshwater inflow to the modern Kerch Strait and rare presence of *Monodacna caspia* – existence of Caspian Sea water supply.

Sediments correspond with the New Euxinian stage in history of the Black Sea, when estuary of the Don river advanced in the area of the modern Kerch Strait and the last gradually turned into a basin of the lagoon type as a result of the New Euxinian transgression development and discharge of the Caspian Sea through the Manych-Kerch Strait. This stage of the Kerch Strait development corresponds to the beginning of the epoch of degradation of the Late Valday glaciation on the East European Plain (MIS 2).

There are alternation of freshwater (*Viviparus* sp., *Valvata* sp., *Unio* sp.), slightly brackish (*Dreissena polymorpha, Monodacna caspia*) and Mediterranean-type euryhaline (*Cerastoderma glaucum, Cerastoderma exiguum, Chione gallina, Mytilater* *lineatus, Ostrea edulis etc.*) mollusks in the next interval of the core. This indicates the first achievement the Kerch Strait modern area by the Black Sea transgression water, which started with discharge of Mediterranean Sea water throw the Bosporus and unstable level of the Black Sea transgression mode with increasing or decreasing influence of freshwater inflow from the Don.

Calibrated radiocarbon dates, obtained from the shells of freshwater and Caspian slightly brackish mollusks at the depth 47.5-47.8 m from the core of borehole №K4-53, demonstrate that before 10 110 ± 330 (ЛУ-8430) the area of the Kerch Strait was influenced only by fresh water of the Don river and waters of Khvalynian transgression of the Caspian Sea.

The degree of increase in Mediterranean-type euryhaline species in the composition of the faunal complex is an indicator of a gradual transgression increase and filling in the area of the strait by sea waters with the displacement by slightly brackish species of mollusks in freshened areas of the basin.

From a depth of the core above 33.0 m in the borehole №K3-14; 35.4 m in the borehole №K4-53; 23.1 m in the borehole №95 and 20.2 m in the borehole №93 as part of the faunal communities have already received widespread euryhaline and moderately euryhaline Mediterranean-type species. Species composition of mollusks indicates spreading of marine waters in the strait. Obviously, it shows clear connection with the Kalamit stage in the development of the Black Sea Holocene transgression, first established by L.A. Nevesskaya [1963], or Novochernomorskaya (New Black Sea) transgression which was highlighted in the Black Sea history by P.V. Fedorov [1963].

This transgression, according to the conclusion of P.V. Fedorov, was the stage with the highest sea level (2-3 m above the present) in the Holocene and the highest salinity for the Holocene epoch and florishing of Mediterranean-type species development there. According to Nevesskaya's ideas [1963], the increase in sea level, salinity level, and growing mollusk's species diversity in the Holocene was gradual. Our research supports Fedorov's conclusion about the Novochernomorskaya (New Black Sea) Holocene transgression.

From intervals which include the largest number of marine stenohaline species in the core №93 at the depth 15.0-15.1 m and the core №95 20.0-20.1, were obtained calibrated radiocarbon dates. Ages of shells are 5530 ± 120 (ЛУ-8108) and 6020 ± 140 (ЛУ-8110). This corresponds to New Black Sea transgression time according to P.V. Fedorov. The age of interval at the depth 12.3-13.0 m in the core №K3-14 with inclusions of euryhaline mollucks shells is 2570 ± 140 (ЛУ-8428). This correspond to the Phanagorian regression phase, during this phase there was a decrease in sea level [Fedorov, 1978], with some desalination of the Kerch Strait water area due to the increased influence of the Don river water.

Thus, according to malacofaunistic analysis of Late Pleistocene-Holocene sediments of the Kerch Strait the stages were identified, representing the major paleogeographic events in the history of the strait. (1). The New Euxinian regression, which correspond to the Late Valday glacial period. The Azov Sea was a lowland, estuary of the river Don, situated in the area of the modern Black Sea shelf zone. In the Kerch Strait the freshwater fauna lived. (2). The New Euxinian transgression, which corresponds to the beginning of the epoch of degradation of the Late Valday glaciation. The Kerch Strait was basin of the lagoon type with freshwater and slightly brackish mollusks. (3). The New Euxinian basin level decreased as a result of discharge of its water to the Mediterranean Sea when it reached the Bosphorus threshold. The area of the Kerch Strait was influenced only by fresh water of the river Don and Khvalynian water of the Caspian Sea before 10 110 ± 330. (4). The New Black Sea transgression, which started with the beginning of the Holocene interglacial transgression of the Ocean. The first Mediterranean-type species appeared in the fauna. Gradual entrance of Mediterranean waters and salinization led to gradual invasion of marine mollusks from euryhaline to stenohaline. The New Black Sea stage was highlighted here. This stage correspond to stage of increased salinity and the richest biodiversity of Mediterranean-type mollusks, age of which is determined as 5530 ± 120 and 6020 ± 140 years ago in the core. The stage of the Phanagorian regression was about 2570 ± 140 years ago, reflected in the composition of the fauna by the increased influence of the river Don.

HOLOCENE SEDIMENTATION ENVIRONMENTS OF THE VOLGA RIVER DELTA: INFERRED FROM DIATOM ASSEMBLAGES FROM SEDIMENTS OF THE RICHA RIVER CHANNEL

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УСЛОВИЯ ОСАДКОНАКОПЛЕНИЯ В ДЕЛЬТЕ ВОЛГИ В ГОЛОЦЕНЕ: НА ОСНОВЕ ДИАТОМОВЫХ АССОЦИАЦИЙ ИЗ ОСАДКОВ ПРОТОКИ РЫЧА

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The Volga River delta has been gently reacting to the Caspian Sea level changes during the Holocene. The sedimentation area is of key importance for paleo-geographical reconstructions for the Caspian Depression. Numerous data concerning the environmental changes in the avan-delta region had been accumulated by now [Overeem et al., 2003; Bolikhovskaya, 2010; Richards et al., 2014]. Nevertheless, the diatomic flora of the region is still poorly understood. This paper describes the morphological, pH, salinity and trophic development of part of the central delta during the time interval in the Holocene, obtained by diatom analysis.

The Core Poy-2016 was obtained from the high floodplain of the River Rycha in the central part of the Volga delta, near the Poymenniy settlement. It is 15 meters deep and consists of four main lithological layers. The upper part (1-1.2 m) is represented by modern soils, extending downwards to 2.7 m depth into the silt. The lower parts of the core up to 15.0 m depth consist of the uniform sand layers. Samples from the intervals 3.2-3.7; 4.65-7.5 and 13.6-14.5 m were not selected due to the high water content.

Diatom samples were taken from all lithological layers in every 5 cm from silt and in 50 cm from sand. After freeze-drying, bulk sediments were prepared for diatomic analysis by 10% H_2O_2 solution treatment for 1.5 hours. Permanent microscopic preparations were made with the NAPHRAX resin, later examined with the JENAVAL (Carl Zeiss) light microscope with ×1000 magnification. Approximately 200-300 specimens were counted and identified in each sample. Results were presented in percentages and concentrations (number of valves per gram of dry matter).

Diatomic assemblages in general were taxonomically diverse, 93 species and varieties were recorded. The diatomic analysis have identified five diatomic complexes (DC), which characterize several lithological and facial conditions of sedimentation (Fig. 1).

V DC (12.0-15.0 m) was distinguished by the monotonous layer of sand with detritus in the upper part. It contained valves of riverine planktonic (*Aulacoseira granulata, Aulaciseira islandica*) and brackish taxa (*Stephanodiscus astraea var. intermedia, Aulacoseira nummodes*). Low concentration of valves (26.9×10^3/g of dry matter) was probably the result of the extremely high sedimentation rates. According to these facts, the sediments were likely to be formed in the channel of the delta stream.

IV DC (8.0-11.5 m) differs by rather high concentration of valves (250×10^3/g dry matter in the lower part of the interval to 773×10^3/g in the upper part). The planktonic cosmopolitan species of *Aulacoseira* predominate in the complex (more than 85% of the total number of valves). Mesogalobic species *Stephanodiscus astraea var. intermedia,* prefering salinity of 0.5‰, is the subdominant in the IV DC. Absolute domination of planktonic diatoms (98%) in the complex is the result of low hydrodynamics, which was higher at the beginning of the sedimentation process (due to the higher (approximately 12%) content of the benthic species in the sample from 11.0 m). Probably the sediments were formed in the water body with low hydrodynamics, and mineralization (0.4-0.5‰) and with pH not higher than 8. Due to the sand grain size of sediments and diatom-based characteristics of aquatic environment, the sediments were likely formed in shallow delta bay (kultuk). Higher salinity could be the result of intensive evaporation.

III DC (1.5-3.2 m) was distinguished in the sand layer by extremely small concentration of diatoms – 18×10^3/g dry matter, which apparently took place under the change of environment: increase of the water turbidity or the extremely high sedimentation rate, preventing the formation of taphocoenoses. The freshwater planktonic taxa *Aulacoseira granulata, Aulacoseira italica, Stephanodiscus astraea var. intermedia* and *Aulacoseira islandica,* typical for the quaternary sediments of the Lower Volga [Genkal, 1992] prevailed in the species composition. Single valves of brackish diatoms *Navicula gastrum* and fragments of re-deposited marine diatoms, probably of Cretaceous age, were also identified. According to the presence of the re-deposited marine diatoms and sand grain size of the sediments, they were formed in a stream channel.

II DC (1.4 m) was identified in sandy silt with an admixture of organic matter due to the high rate of diatomic valves (1.12×10^6/g dry matter) and the different composition of the dominant species. The periphyton species of *Epithemia* (33.4%) were taxonomically diverse; riverine plankton species of *Aulacoseira* were less abundant (up to 28.9%). Among the periphyton species (70% out of total) the most wide spread species was riverine (galophilic) diatom *Epithemia zebra*, *Aulacoseira granulata* and *Epithemia ocellata* had almost equal content (10% each). The predominance of boggy periphyton diatoms and the presence of organic matter in the early stages of peat formation indicate the stagnant sedimentation conditions. The possible accumulation of sediments occurred in a stagnant (with low hydrodynamics) shallow fresh (salinity up to 0.02‰) boggy reservoir. A large number of periphyton species indicates eutrophication.

I DC (1.0-1.3 м) is represented in silt with traces of soil formation in the upper part. It is proved by reduced concentration of diatom valves (about 200×10^3/g dry matter) of low preservation and presence of the aerophilic species *Hantzschia amphioxys*.

The high concentration of planktonic diatoms (60%), corresponding to low hydrodynamics was recorded in the sample from the 1.0-1.2 m. A significant number of benthic and periphytonic species could indicate the eutrophication of the aquatic environment during the sedimentation process. The sediments, probably, were accumulated as the result of rare flooding of the high floodplain level. In the lower part of I DC (1.3 m depth) the concentration of valves sharply increased to more than 2×10^6/g. This could indicate more intensive influence of river waters during the sedimentation. The prevalence of benthic and periphytonic forms (57.7%) is also the sign of more active hydrodynamics. Diatom assemblages of the dominants are common to the upper layer: *Navicula cuspidata* (17.8%) prevailing, *Aulacoseira granulata* (13.5%) and *Pinnularia brebissonii* (11.9%) were subdominant species. Periphyton halophilic aerophilic species *Hantzschia amphyoxis* (7.5%) and planktonic brackish *Stephanodiscus astraea var. intermedia* (6.4%) were also recorded.

In general, the sedimentation process was corresponding to floodplain conditions. The predominance of the pH-indifferent species and the significant proportion of alkaliphiles may indicate a neutral or slightly alkaline (pH 7-8) aquatic environment.

According to the diatom-inferred paleoenvironmental reconstructions, the formation of the deltaic sediments in the Rycha River area was influenced both by the local factors and the common tendencies for the whole Volga delta territory such as high sedimentation rate. For comparison with the results obtained, a set of cores of the well-studied Damchik site of the Astrakhan Reserve was chosen. The comparison was rather complicated due to the interposition of the cores and different responses of the territories to the Caspian Sea level changes. Diatom complexes I, II, IV tend to be formed mostly as the result of the influence of the local factors (intensive evaporation, eutrophication etc.). At the same time, DC III and V are supposed to reflect the common for the whole Volga delta territory processes of intensive sedimentation. Comparison was based on the annual sedimentation rate [Richards et al., 2014]. Thus, DC V could be formed during the migration of the Volga delta to the modern position of the Rycha River core and the relatively stable level of the Caspian Sea [Fig. 3, Overeem et al., 2003]. The DC III could be formed due to the increasing depletion of the Volga River [Overeem et al., 2003].

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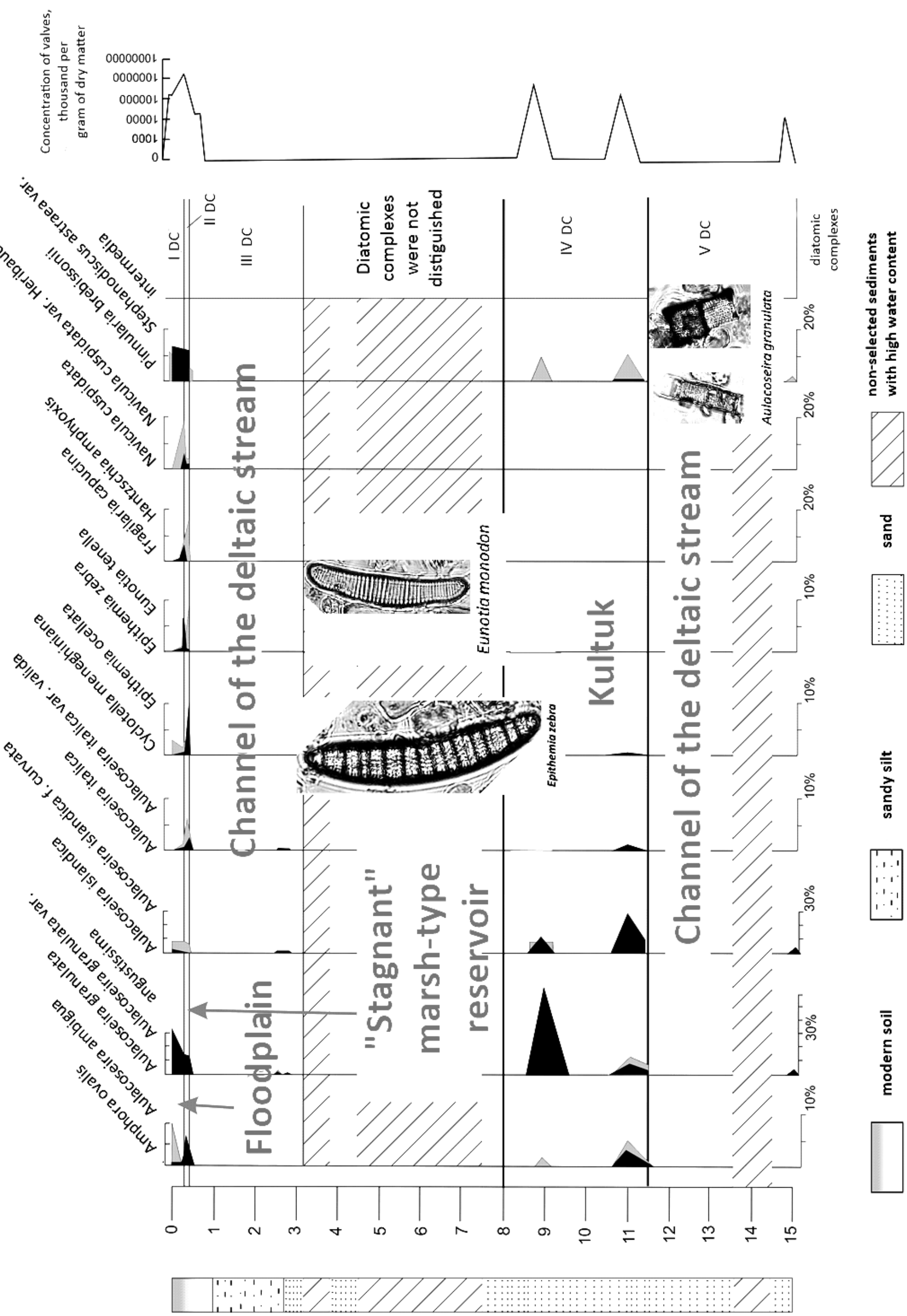

Fig. 1. The results of diatomic analysis of the core Poy-2016

PARATETHYAN OSTRACODS STUDIES: A HISTORICAL PERSPECTIVE

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ИССЛЕДОВАНИЕ ОСТРАКОД ПАРАТЕТИСА: ИСТОРИЧЕСКИЕ ПЕРСПЕКТИВЫ

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Ostracods have been an extensively studied object of research in the last century and are nowadays commonly used in paleoenvironmental reconstruction. Looking through past studies of Paratethyan ostracods one can find at least two pronounced issues involving working with the literature. The first one is related to relative sea level fluctuations and therefore the evolution of the Paratethys itself. The second one is represented by different authors approach.

Throughout periodical and continuous palaeoenvironmental changes in time and space along Paratethyan basins, the biota (including ostracods) repeatedly underwent conditions of extensively high pressure, that lead to an increasing rate of speciation. The high diversity in shape, size and ornamentation patterns of ostracod shells have evolved over time. The variety of paleoecological domains inside Paratethyan basins additionally encouraged the lateral diversification along the same basin. Studying only fossil material with no access to the soft tissue of the animal makes it challenging and somewhat questionable to be sure if one is in the presence of a new ostracod species or dealing with a morphotype which evolved due to local environmental changes. The so-called Pontocaspian ostracod fauna is amongst other things characterized by their endemicity, which can be observed along the Paratethys. This aspect leads to a high number of newly described species by different authors, often based on almost unnoticeable morphological features. As results, the scientific community is faced with a challenging identification and designation of Paratethyan ostracod, which has become problematic regarding reliable and uniform information on biostratigraphy and paleoenvironmental reconstruction.

Most of the Eastern Paratethyan ostracods were previously describes by pioneering authors like [Livental, 1929; Svejer, 1949; Suzin, 1954; Mandelstam and Schneider, 1963; Agalarova, 1967 and Vekua, 1975], using hand drawings.

Unfortunately the quality of the drawings varies drastically and often the described species is beyond recognition. During the last 30 years authors have tried to recognize the described species in their material but often end up with proposing additional new taxa. Recently ostracodologists working on Pontocaspian ostracods have published a series of papers utilizing more modern imaging approaches [Yassini, 1986; Boomer et al., 2000; Rostovtseva and Tesakova, 2009; Gliozzi et al., 2013; Van Baak et al., 2013, 2015; Chekhovskaya et al., 2014; Popov et al., 2016; Stoica et al., 2013, 2016].

The revaluation of originally described species, based on type collections and sections is urgently required. The implementation of taxonomic harmonization [Danielopol et al., 2015], using high-resolution SEM pictures and modern morphological investigation with specialized software (see *Morphomatica*) will bring a coherent vision on Paratethyan ostracods.

ANALYSIS OF SAMPLING METHODS FOR PLANKTON ROTIFERA

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АНАЛИЗ МЕТОДОВ ОТБОРА ПРОБ ПЛАНКТОННЫХ КОЛОВРАТОК

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Rotifera have long been recognized as an essential component of freshwater and marine ecosystems, as an important link in the pelagic food chain, and as indicators of environment quality, yet the information on their ecology and distribution is still scarce [Wallace et al., 2006].

Standard hydrobiological methods are used to collect plankton rotifers, [Kiselev, 1956; Abakumov, 1983, 1992; Kreneva, 1992] while they are accounted for as a part of general mesozooplankton community. Sampling is performed by Jedy and Epstein plankton nets with a 50-200 μm mesh. A lot of planktonologists [Ackefors et al., 1975; Kozhova et al., 1983; Evans et al., 1985, etc.] believe that nets of 150-200 μm mesh size are suitable for Copepoda sampling (except for nauplii). Since the majority of Rotifera are of 50-250 μm in size (except for a few Asplanchna species up to 1000-1500 μm) and belong to microzooplankton, the plankton nets used for sampling should be made of the densest silk fabric with the highest mesh numbers (No. 64-77) [Kutikova, 1970; Kutikova et al., 2010]. However, even those fabrics cannot ensure precise sampling of some smaller species (belonging to Keratella, Polyarthra genera, etc.) which pass through the net. Thus, when 90-200 μm nets are used, Rotifera underestimates may vary from 20 to 100% [Silina, 1987]. Therefore, L.N. Kutikova [1983] recommended collecting of plankton Rotifera by settling as an additional method because the reliability of their species composition and numbers depends, first of all, on the sampling technique. At present published sources (on various geographic regions) offer enough published works demonstrating several benefits of Rotifera collection using the settling method in comparison with net sampling [Galkovskaya, 1965; Kutikova, 1983; Silina, 1987; Matveeva, 1989; Lazarev, 2007; Semenova, 2010].

Our research was aimed to use both these sampling methods in order to reveal their advantages and drawbacks. Materials for the paper were provided by the zooplankton sampling campaigns carried out in the Sea of Azov and Taganrog Bay during 2004 (March, May, June, and July) and 2006 (January, March, April, May, and December). To compare the effectiveness of the two sampling techniques of plankton Rotifera collection (settling method, and sampling by vertical hauls of Jedy (125 μm mesh) and Epstein (75 μm mesh) nets) we employed nonparametric Wilcoxon test to check the differences between two simultaneous samplings. Test results are summarized in the Table 1, significant differences on the $P<0.05$ level are highlighted in bold type.

Table 1.
Statistical data of the examined parameters and Rotifera size frequency

Parameters	Observations	*P level*	Size, mm
n (settling)& n(net)	40	0.006232	
Gen.N(sediment) & Gen.N(net)	40	0.000022	
N, Asplanchna(sediment)& N, Asplanchna(net)	40	0.108044	0.5-1.0
N, Synchaeta(sediment) & N, Synchaeta(net)	40	0.116956	0.25-0.5
N, Brachionus (sediment) & N, Brachionus (net)	40	0.068017	0.1-0.25
N, Polyarthra (sediment) & N, Polyarthra (net)	40	0.000390	>0.1
N, Keratella (sediment) & N, Keratella (net)	40	0.000132	>0.1
N, Trichocerca (sediment) & N, Trichocerca (net)	40	0.002218	>0.1
N, Filinia (sediment) & N, Filinia (net)	40	0.010747	>0.1

Note. n – the number of species in a sample; N – quantity (ind./m^3).

Performed analysis allowed us to state the following: 1. Greater precision of the results obtained using the net hauls method was acheived for larger Asplanchna species; 2. Results obtained by the settling method were more reliable for smaller Brachionus, Polyarthra, Keratella, Trichocerca, and Filinia species, which tend to get underestimated during net sampling; 3. Comparison of the number of species per sample(n) and the total counts N(ind./м^3) also exhibits significant differences depending upon the species composition of Rotifera ranging in size from 50 to 1000 μm.

NEW DATA ON THE AGE OF THE UZUNLAR TRANSGRESSION OF THE BLACK SEA

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НОВЫЕ ДАННЫЕ О ВОЗРАСТЕ УЗУНЛАРСКОЙ ТРАНСГРЕССИИ ЧЕРНОГО МОРЯ

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The Uzunlar transgression of the Azov-Black Sea basin (Pontus) is an important paleo-geographic event in the history of the region. Its development is caused by the flow of Mediterranean waters into the basin of the Black Sea during the inter-glacial transgression of the Ocean. There was a gradual change of the Old Euxinian brackish-water basin with the wide distribution of brackish-water Caspian fauna with the predominant development of marine euryhaline mollusks [Neveskaya, 1963]. Brackish-water elements were forced into the estuarine regions of the sea after the mean salinity rose to 17-18‰; Yet, in some of these regions the influence of the Mediterranean fauna was not recorded at all. Such areas became the limans, which deposits have been described at the base of the well-known and sufficiently well-studied Beglitsa section on the northern coast of the Taganrog Gulf [Lebedeva, 1972; Velichko et al., 1973, 2006, 2009; Dodonov et al., 2005; Tesakov et al., 2007, 2010, and others].

Most of the section is represented by a subaerial loess-soil stratum, which is underlained by liman-type marine sediments. The latter were attributed to the Late Khazarian transgression of the Caspian Sea and were compared by the researchers who studied the section with the Dnieper (Moscovian) glacial epoch, mainly on the basis of findings of mammal bone remains of the Khazarian faunal complex.

We performed the dating of this layer by optically stimulated luminescence. The samples were taken at night in opaque bags. Also, additional material was selected for measuring the dose rate. The analysis was carried out at the Peking

University in the Laboratory of Earth Surface Processes under the guidance of Professor Zhou Liping. Dating was obtained by feldspar. The measurements were performed by the standard regenerative dose technique (SAR protocol) [Murray, Wintley, 2000].

Results of dating: sample Beg 36 L3239 taken from the depth (from the surface of the section) 12.1 m; The calculated age was 227.5 thousand years; An error was 20.8 thousand years.

The OSL date indicates the formation of liman-type sediments during the interglacial epoch of MIS 7, i.e. in the era of interglacial Uzunlar transgression of Pontus. Additional evidence of the attribution of liman sediments to the Uzunlar transgressive stage was found in the malacofauna represented by the genera *Bithynia*, *Valvata, Clessiniola, Anisus, Dreissena, Monodacna* and others [VIII Russian Conference on the study of the Quaternary period, 2013], *Didacna pallasi* Prav. and *D. borisphenica* Neves. (Personal communication of T.A. Yanina, who determined these species). *Didacna pallasi* is characteristic to the Early Khasarian transgression of the Caspian Sea. It invaded the Black Sea via Manych strait and spread there in the brackish Old Euxinian basin. In the marine Uzunlar basin, it was moved into the brackish estuary zone of the Don [Yanina, 2012]. The species *D. borisphenica* was described by L.A. Neveskaya (1963) as a characteristic species for the Old Euxinian basin, it also survived the salinization of the Uzunlar Sea in the brackish estuary regions in the Uzunlar time.

Thus, the dating,obtained by OSL showed the belonging of the liman sediments of the Beglitsa section to the Uzunlar transgression of Pontus (MIS 7), rather than to Late Khazarian, as it was previously thought. We have not met the absolute datings of the Uzunlar transgression of Pontus in the literature. Based on the OSL dating obtained, we can date the Uzunlar transgression in ~227.5 thousand years

ON THE AGE OF LOWER-KHVALYNIAN DEPOSITS OF LOWER VOLGA

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О ВОЗРАСТЕ НИЖНЕХВАЛЫНСКИХ ОТЛОЖЕНИЙ НИЖНЕГО ПОВОЛЖЬЯ

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Caspian Sea has experienced a lot of transgressions and regressions during its history. In the late Pleistocene the most extensive and transient was the Khvalynian transgression. However, there are many questions related to its causes, level and absolute age. The most extensive deposits of the Khvalynian transgression are so-called "chocolate" clays in the Caspian lowland, which, apparently, filled pre-Khvalynian relief-depressions during the transgression. "Chocolate" clays are interlayering of clays with thin silt and sands containing the index species of Khvalynian basin *Didacna protracta, D. ebersini, Dreissena rostriformis, Dr. polymorpha*.

Estimated age of these deposits by different researchers varied from 70,000 years to 11,000 years, i.e. from the first half of the wurm to the beginning of the Holocene. Estimated age are based on thermoluminescence dating [Shakhovets, 1987; Rychagov, 1997], electron paramagnetic resonance spectroscopy (ESR) [Molodkov, 1992], uranium-ionium [Kuznetsov, 2008; Arslanov et al., 2015], radiocarbon dating [Arslanov et al., 2013; Arslanov et al., 2015; Tudryn et al., 2013]. The results of thermoluminescence dating obtained in the laboratories of the USSR, are considered incorrect now, because of the revealed methodological errors. At the same time the dates obtained by the uranium-ionium and radiocarbon methods were rejected by many researchers who did not recognize too "young" age (20-10 ka) of the Khvalynian deposits.

To solve the problem of the age of "chocolate" clays it was decided to use the optically stimulated luminescence method (OSL), which is widely used now in Quaternary science. The method is based on the principles of quantum mechanics, according to which energy accumulates during their burial in the crystal lattice of weathered minerals (in our case – quartz and feldspar), the amount of which can be calculated (equivalent dose) and divided by the rate of energy accumulation in the sediments (dose rate).

Two sections were chosen for dating: in the northern part of the Lower Volga region – Srednaya Akhtuba (left bank of the Akhtuba River, N48.700420 E44.893512), and in its middle part – Nizhneye Zaymishche (right bank of the Volga River, N48.004341 E46.109790). In both sections the horizon of the Khvalynian "chocolate" clays is expressed very clearly, it includes index species of the malacofauna, it is underlained by atelian continental strata and is covered by post-Khvalynian subaerial sediments.

Sediments for OSL dating from the section were sampled by authors under the guidance of professor A.S. Murray, Aarhus University. Samples from the "chocolate" clays were sampled at distance (not less than 15 cm) from their boundary (to eliminate the radiation influence of the material of the upper and lower layers. Sediments were sampled at night with red LED-lighting in opaque bags.

Dating was performed in the Nordic Laboratory for Luminescence dating, University of Aarhus, under the guidance of professor A.S. Murray on quartz-grains. Three dates are received. For Srednaya Akhtuba: the upper part of the "chocolate" clays is 13 020 ± 610 years (Risoe laboratory number 150806), the lower part is 15 020 ± 1000 (Risoe laboratory number 150807). For the Nizhneye Zaymishche: the lower part of the horizon is 17 140 ± 890 (Risoe laboratory number 150867).

In the same sections there were sampled the Khvalynian malacofauna for radiocarbon (^{14}C) dating from thin sandy interlayers in chocolate clays. The ^{14}C dating by the scintillation method was carried out in the Laboratory of Geochronology, St. Petersburg State University by Arslanov (for which the authors are sincerely grateful). The values of the calendar age were obtained on the basis of the calibration program "OxCal 4.2" (calibration curve "IntCal 13"). Christopher Bronk Ramsey (https://c14.arch.ox.ac.uk). For Srednaya Akhtuba section the ^{14}C date (by *Didacna protracta* shell) was 11 680 ± 150 years (LU-7037), the calibrated age was 13 570±160 years. For the Nizhneye Zaymishche section the ^{14}C date (by *Didacna protracta* shells) was 11 610 ± 130 years (LU-8149), the calibrated age was 13 450 ± 130 years; by the shells of *Dreissena rostriformis distincta* received ^{14}C date 12 660 ± 200 years (LU-8150), calibrated age 14 940 ± 380 years.

It is important that the dates by different methods were performed on a different material – carbonate shells mollusks (^{14}C) and quartz grains (OSL), which eliminates the system error. Dates are close and reflect one paleogeographic epoch of sedimentation.

Thus, we can conclude that the Lower Khvalynian deposits of the Lower Volga region (chocolate clays) are 17-13 ka. Their accumulation occurred in the era of degradation of the Late Wurm (MIS 2, Late Valday, Ostashkov) glaciation of the East European Plain.

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PRESENT-DAY HEAVY METALS CONTENT IN WATER OF VOLGA, DON AND KUBAN RIVER DELTAS

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СОВРЕМЕННЫЕ КОНЦЕНТРАЦИИ ТЯЖЕЛЫХ МЕТАЛЛОВ В ВОДЕ УСТЬЕВЫХ ОБЛАСТЕЙ ВОЛГИ, ДОНА И КУБАНИ

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Water pollution by heavy metals is one of the most important factors affecting the state of communities and environments in the Pontocaspian river deltas, which focus water runoff and serve as a barrier for the chemical element flows. Heavy metal content in river water is highly variable due to hydrological, geochemical and anthropogenic factors, so that continuous monitoring is necessary for the comprehensive assessment of the environmental state of aquatic systems. The geochemical study of large Pontocaspian river deltas is carried out by Faculty of Geography MSU since 1990s. In this paper we present the recent data on heavy metal content in water and suspended matter of Volga, Don and Kuban River deltas (Fig. 1). These three deltas are the largest in the southern part of Russia, being located in densely populated and industrial regions with large cities (Astrakhan in the Volga River delta; Rostov-on-Don in the Don River delta; Temryuk in the Kuban River delta). It provides a significant anthropogenic influence on the environmental state of the deltas.

This work is based on the field data on heavy metal (Zn, Cu, Ni, Pb, Cd, Co) content in deltaic water and suspended matter. Sampling was carried out in summer-autumn low water period of 2016. All samples in three deltas were collected almost simultaneously during September-October 2016, which allows to get the comparable results. Heavy metal content was determined by ICP-MS. The results are presented in Tabl. 1.

The Don River delta is characterized by higher values of dissolved Ni, Co, Cd and suspended Pb, Cd, Ni, Co, Zn. This is due to the strong anthropogenic impact on aquatic systems of the delta and relatively low water discharge, which is not sufficient to dilute contamination. Minimum content of suspended heavy metals have been determined in the Volga River delta because of the huge water runoff.

Mean values do not always give objective information on water pollution. Content of dissolved heavy metals in the deltaic waters in general does not exceed the world averages, while maximum content of some metals (Zn (6.35), Pb (2.55), Ni (2.57)) exceeds it ten-fold. Maximum concentration of dissolved heavy metals observed downstream of cities.

Tabl. 1.
Heavy metals average content in water (μg/L) and suspended matter (μg/L) in summer-autumn low-water period of 2016

	Volga River delta (n=16)					
	Zn	Cu	Ni	Pb	Cd	Co
Dissolved	0.51	1.34	1.19	0.11	0.01	0.13
Suspended	136.3	–	76	20.4	0.4	19.6
	Don River delta (n=11)					
	Zn	Cu	Ni	Pb	Cd	Co
Dissolved	–	0.91	1.45	0.04	0.04	0.22
Suspended	264	–	55	40	1.5	17.4
	Kuban River delta (n=13)					
	Zn	Cu	Ni	Pb	Cd	Co
Dissolved	0.67	1.21	0.26	0.8	0.01	0.12
Suspended	159	40.8	69.9	22.3	0.3	17.7
	Rivers of the world					
Dissolved forms [Gaillardet et al., 2004]	0.6	1.5	0.8	0.1	0.1	0.2
Suspended forms [Savenko, 2006]	130	45	50	25	0.5	19

The dash means the content is below the detection limit.

Heavy metal content in suspended matter of Volga and Kuban River deltas is close to the average range. High Cu content in Kuban delta is probably related to Urup ore mining copper plant located in the Kuban River basin.

The study was conducted with the support of The Russian Geographic Society (Complex expedition “Deltas of the rivers of the South of Russia”).

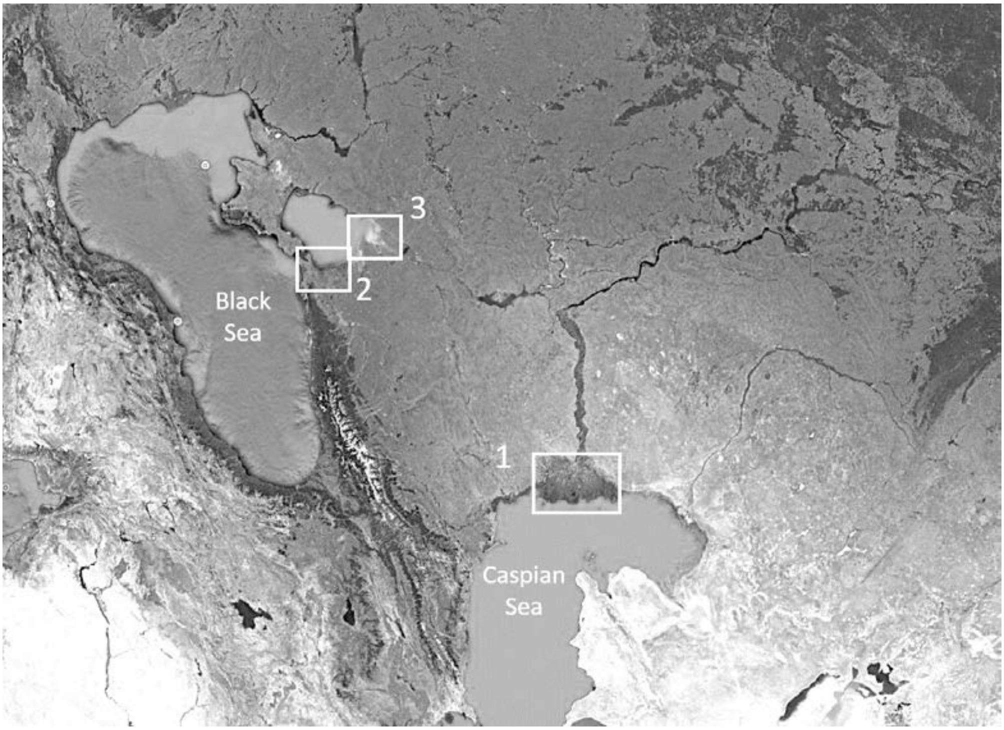

Fig. 1. Study areas: 1 – Volga River delta; 2 – Kuban River delta; 3 – Don River delta

THE EVOLUTION OF THE KUBAN DELTA'S COASTAL AREA IN THE LATE HOLOCENE

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ИСТОРИЯ РАЗВИТИЯ БЕРЕГОВОЙ ЗОНЫ ДЕЛЬТЫ КУБАНИ В ПОЗДНЕМ ГОЛОЦЕНЕ

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The Kuban Delta has been developing during the Holocene. The delta is characterized by the dynamic coastal area. The modern coastal area is partially digested by human. The main idea of the research is to explore the evolution of the Kuban Delta's coastal area in the late Holocene. The idea falls into some tasks. 1) Analysis of published materials; 2) description of geographical position and geologic & geomorphic structure of the coastal area; 3) sampling, sample analysis, interpretation of the results; 4) reconstruction of the evolution of the coastal area and of the hole ACHU-1's site. during the Late Holocene.

The RL of recent sediments and Pleistocene paleogeography sent an expedition to research the deltas of Southern Russia in 2016 summer. Author, as a member of field team, worked at the Kuban Delta. Geomorphic description of the delta sites was made. Two holes were drilled. Lithologic description of core and sampling to paleogeographic analyses were made. The object of my research is the hole ACHU-1 (16 m). It is situated near to Protoka mouth. Protoka is the right distributary of the Kuban River.

Then the ACHU-1's core was analysed in laboratory. Grain size (65 samples, N. Tyunin), carbonate content (65 samples, N. Tyunin), mollusc shell (D. Semikolennykh), geochemical (10 samples) analyses were made. In addition, three radiocarbon dates (H. Arslanov) were received.

As a result, author drew the geologic section of the hole. This section was divided to six layers. The first layer is swamp soil (0.2 m). The second layer is yellow fine sand (2.9 m; Md=0.199 mm) with debris and shells *Cerastoderma glaucum*. Radiocarbon age of the mollusk shells is 240±80 years (LU-8426). The carbonate content is 12.1%. The third layer is dark grey, blue-grey and black fine sand (3.2 m; Md=0.161-0.216 mm; carbonate content 3.8-18.9%) with silt. The fourth layer is dark grey and blue-grey loam (3.5 m; Md=0.005-0.008 mm; carbonate content 0.7-4.2%). The fifth layer is dark grey and black silt-clay (3.6 m; Md=0.003-0.005 mm; carbonate content 0.5-6.2%) with shell interlayers (*Cerastoderma glaucum & Mytilus edulis)*. The shells' radiocarbon age is 2880±100 years (LU-8427A) & 2860±100 years (LU-8427B) respectively. The sixth layer is brown and red-brown loess loam (2.6 m; Md=0.002-0.005; carbonate content 0.0-5.7%) with gypsum nodules.

According to contemporary view the Kuban delta was shallow sea gulf in the Early Holocene. The sea level often changed. The gulf is gradually occupied by sea & river sediments and divided to unconnected basins. The basins drew up slowly. The sea coastline changed its position time and again. The modern coastal area has been forming during last 2-3 thousand years.

The sediments of the hole ACHU-1 shows quick changes of the environment on this site during the Late Holocene. The sixth layer formed in semi-arid land conditions at the end of the Late Pleistocene (possibly). The fifth layer (~3000 years) corresponds to shallow-water sea, lagoon and then fresh lake. The fourth layer has sediments of the fresh basin. The Kuban distributaries sometimes flew into this basin. The third layer formed on the limit between beach and swamp. The second layer (~250 years) corresponds to beach. The first layer is modern swamp soil.

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PLEISTOCENE MARINE-LACUSTRINE ALTERNATIONS RECORDED IN THE DEEP BASIN OF THE BLACK SEA

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СМЕНА МОРСКИХ И ОЗЕРНЫХ УСЛОВИЙ В ПЛЕЙСТОЦЕНЕ ПО ДАННЫМ ИЗ ГЛУБОКОВОДНОГО БАССЕЙНА ЧЕРНОГО МОРЯ

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Throughout the Late Neogene, the Black Sea experienced large paleoenvironmental changes, switching between marine conditions when connected to the Mediterranean Sea and freshwater conditions at times of isolation. The most continuous records of Pleistocene environmental conditions in the deep basin of the Black Sea is still represented by the sites drilled during Deep Sea Drilling Project (DSDP) Leg 42B to the Black Sea (drilled in 1975). At the time, magnetostratigraphic dating was inconclusive because of the presence of the little understood iron sulfide mineral greigite (in sediments a precursor to pyrite) as magnetic carrier. We had a renewed attempt at dating these cores, using modern magnetostratigraphic and rock magnetic techniques. Previously published biostratigraphic and (geochemical) proxy records from these cores are plotted on this new time frame to identify the main moments of salinity change. For further insight, we compare our results to paleoenvironmental records elsewhere in the Black Sea region.

CONSERVATION PALEOBIOLOGY IN THE RAZIM COMPLEX: SHELLY SIDE OF THE STORY

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ОХРАНА ЭНДЕМИЧНЫХ СООБЩЕСТВ В КОМПЛЕКСЕ РАЗИМ ПРИМЕНИТЕЛЬНО К МОЛЛЮСКАМ

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The rising field of conservation palaeobiology uses geohistorical data to decide on biodiversity conservation strategies [Dietl & Flessa, 2011; Vegas-Vilarrúbia et al., 2011; Birks, 2012]. The Razim-Sinoie lagoon complex in Romania is an exemplary model system for this conservation method, as endemic Pontocaspian species are now in decline. In our research we combined two complementary geohistorical approaches: the shelly record of mollusk biodiversity and a facies reconstruction to understand the environmental dynamics that drove changes in the communities.

With this poster we want to focus on the Pontocaspian mollusks diversity changes in the past c 1500 years. The Razim-Sinoie lagoon complex is a system where endemic Pontocaspian fauna is found [Popa, 2009], but the ecosystem got out of balance and species are now under threat [Bologa & Sava, 2012]. Where did the Pontocaspians live in the past and how did the communities move through the lake system over time?

Eleven cores were chosen to study molluscs, covering all different environmental niches within the lagoon system. Samples were taken at regular 12 cm intervals and washed and sieved through a 63 μm mesh. Preservation was scored by a taphonomical index consisting of five scoring classes. Numerical analyses were performed to define assemblages and characterize biodiversity.

The mollusks were found in silty to sandy sediments, characterized by different types of preservation. The assemblage included of 46 species consisting of more than 26 000 individuals.

Multivariate cluster analysis show three groups whose species are characterized by different optimum habitats. The first community typically lives in freshwater habitats, but with individual species having maximum salinity tolerances for oligohaline conditions. Typical representatives are *Acroloxus lacustris*, *Gyraulus crista*, *Pisidium* sp., *Planorbis* spp. and *Valvata* spp. The second community consists of species that are endemic to the Pontocaspian area. These species thrive in habitats whose salinity range fluctuates between freshwater and oligohaline. Typical taxa are *Monodacna pontica*, *M. colorata*, *Hypanis plicata* and *Turricaspia* spp. The third community is composed of marine opportunistic species that prefer olgohaline to mesohaline conditions. The most abundant species in this group are *Lentidium mediterraneum*, *Abra segmentum*, *Cerastoderma glaucum* and *Ecrobia maritima*.

The distribution of species within and between cores shows a complex of shifting communities and paleoenvironments in the record. Faunal turnover events appear to reflect mostly salinity changes. Species richness and diversity of the endemic Pontocaspian species seems to have decreased in space and in time. The endemics still occur in some spots, but find optimum zones in small refugee areas that shift through time.

With this study a database with good illustrations of the small coastal Black Sea mollusc species will become available.

EARLY PLEISTOCENE FAUNAL CONNECTION BETWEEN THE PONTO-CASPIAN BASIN AND NORTH AMERICA

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ФАУНИСТИЧЕСКИЕ КОНТАКТЫ МЕЖДУ ПОНТО-КАСПИЙСКИМ БАССЕЙНОМ И СЕВЕРНОЙ АМЕРИКОЙ В РАННЕМ ПЛЕЙСТОЦЕНЕ

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Ecrobia is a cryptic mud snail taxon that occurs in coastal brackish waters. This model organism is known as a vector for parasites, and as an important food source for fish and migrating water birds. *Ecrobia* is the most widespread genus of the family Hydrobiidae: it has an amphi-Atlantic distribution (i.e. it occurs on both eastern and western coastlines of the Atlantic realm, and in the Arctic Ocean). Interestingly, the north-western Atlantic species, *Ecrobia truncata*, is more closely related to the Ponto-Caspian taxa, *Ecrobia maritima* and *Ecrobia grimmi*, than to the north-eastern Atlantic *Ecrobia ventrosa*. To confirm species delimitation and assess biogeographical processes that led to this peculiar sister-group relationship, we integrated dated molecular phylogenies, niche quantifications, and species distribution modelling. Our results indicate that the split of *E. truncata* from the Ponto-Caspian taxa took place during the Early Pleistocene, and was not followed by niche divergence. This time frame suggests that *Ecrobia* spp. underwent allopatric divergence in the arctic seas prior to the Pleistocene glaciations (e.g., possibly due to differences in ionic and physical structures of the arctic waters). This vicariant diversification was then followed by invasion of inland waters to the Caspian Sea, where the mud snail then further dispersed (e.g., by endo- or exozoochory). These findings support the assumption that there has been at least one faunal exchange between the Caspian Sea and the Arctic Ocean during the Pleistocene.

CURRENT TRENDS IN TAXONOMY OF FRESH- AND BRACKISHWATER GASTROPODA OF THE PONTO-CASPIAN REGION

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СОВРЕМЕННЫЕ ТЕНДЕНЦИИ В СИСТЕМАТИКЕ ПРЕСНОВОДНЫХ И СОЛОНОВАТОВОДНЫХ БРЮХОНОГИХ МОЛЛЮСКОВ ПОНТО-КАСПИЙСКОГО РЕГИОНА

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The general aim of my contribution is to outline the current situation with assessment of taxonomic diversity of fresh- and brackishwater snails (Gastropoda) in the Ponto-Caspian region (the region is restricted here to lower courses of the rivers of the Azov and nothern Black Sea basins as well as the Caspian Sea basin). There are two ways to define the Ponto-Caspian fauna. The first one is to take into consideration all the species living in the region, including taxa widely distributed in Eurasia and numerous invasive species of exotic origin. The second approach is to focus on taxa, whose ranges lie (entirely or mainly) within the borders of the region (=Ponto-Caspian species sensu stricto). Here I follow the later definition restricting myself to the systematics of endemic and subendemic species and genera of the studied region. The malacofauna defined in such a manner includes mostly various representatives of the families of branchiate snails such as Hydrobiidae s. lato, Neritidae, and Melanopsidae. An interesting and still underexplored part of this diversity is constituted by the aquatic gastropods living in caves of Caucasus. This group includes several genera and more than 15 species of hydrobiid snails, all endemics with very narrow ranges [Palatov & Vinarski, 2015]. The number of pulmonate taxa that may be treated as true Ponto-Caspian endemics is quite low, though there are several species of Planorbidae limited in their distribution to the Caspian Sea.

The history of systematic description of the Recent Ponto-Caspian malacofauna had started more than 220 years ago (S.G. Gmelin, P.S. Pallas), with several significant contributions made during the 19th century (works by Eichwald, von Baer, Grimm, W. Dybowski, Andrusov). Our current taxonomic knowledge of fresh- and brakishwater snails of the region is based chiefly on large revision works published in the 1960s-1970s [Golikov & Starobogatov, 1972 for the Black Sea; Logvinenko & Starobogatov, 1966, 1968 for the Caspian Sea]. Recently, large contributions were made by Ukrainian malacologists led by V. Anistratenko [Anistratenko, Stadnichenko, 1995; Anistratenko, Anistratenko, 2001; Anistratenko, 2007, 2013; Anistratenko et al., 2011]. M. Son [2007] published a review of non-indigenous aquatic Mollusca of the Northern Black Sea Maritime territory.

In 2016, an updated version of the catalogue of the continental aquatic Mollusca of the ex-USSR area was published [Vinarski, Kantor, 2016]. The authors listed all nominal species of the Ponto-Caspian snails that may serve as a starting point for the future investigations. However, it is utterly impossible to give here more or less exact estimate of diversity of the Ponto-Caspian fresh- and brakishwater Gastropoda at the species and generic level. Simply put, the current state of their systematics may be characterized as a chaotic one. First of all, many nominal species of snails of this region were described on a purely conchological basis and are still known from a very limited number of specimens that prevents their exact delimitation by means of biometrical study. Though there are several publications dealing with anatomical structure of the Ponto-Caspian endemics (for example, [Sitnikova et al., 1992; Sitnikova & Starobogatov, 1998]), the existing keys for species identification are based chiefly on shell characters. I have to note that, in the situation when the extent of intraspecific conchological variation of most species is unknown, such purely conchological keys may be misleading or completely useless. The so called 'comparatorial method' invented by Logvinenko & Starobogatov [1971] and once used intensively for identification of species and description of new taxa of the Ponto-Caspian snails (see, for example, [Anistratenko, 2007]) has recently been strongly criticized as leading to unwarranted splitting of species ([Graf, 2007; Bolotov et al., 2013]; but see objections presented by [Bogatov, 2012, 2013]).

Second, the molecular data are also unavailable for most species of the Ponto-Caspian fresh- and brakishwater snails. The absence of genetic data makes it almost impossible to assess the validity of endemic (morpho-)species and to resolve their true generic placement as well as phylogenetic affinities. Two serious shortcomings may result from it. We actually are not able to reveal the probable extent of the cryptic taxonomic diversity among the Ponto-Caspian gastropods that may be hidden behind apparent uniformity in shell characters of some species. On the other hand, the lack of molecular information may lead to taxonomic inflation due to ranking intraspecific morphs as valid species. Also I wish to highlight that the molecular study of the Ponto-Caspian snails is highly desirable since it may shed more light on evolutionary processes in this basin. High number of endemic taxa of the genus and species rank living in this area (especially among hydrobiid snails) indicates that extensive processes of adaptive (or, perhaps, non-adaptive; see [Wilke et al., 2010]) radiation may have taken place here in the past. It would be very tempting to study these processes in detail and to compare them with analogous events known to occur in other ancient lake basins of Eurasia (the Baikal and Ohrid lakes, the Miocene lake Steinheim in Germany, the Pliocene Chuiskoye Lake in Mountain Altai).

At last, the third impediment to taxonomic progress in the field is the nomenclatorial problems concerned with many species of the Ponto-Caspian snails. I mean chiefly such difficulties as the loss of the type series, inadequate and/or incomplete original descriptions, unresolved synonymies and so on.

Thus nobody is able today to say definitely neither how many species of fresh- and brackishwater Gastropoda inhabit the Ponto-Caspian region nor how to name them correctly. The data on geographic and bathymetric distribution of many taxa are also still lacking. All current estimates of species diversity as well as any schemes of biogeographic regionalization based on lists of nominal species (like those lists presented in [Vinarski & Kantor, 2016]) should be considered as very rough, and their scientific importance is rather limited. The situation needs to be improved in the nearest future since the endemic Ponto-Caspian malacofauna is currently threatened with many negative factors including habitats degradation, invasions of alien species, water pollution and some others. Several Ponto-Caspian endemic species of aquatic snails have already been assessed by the IUCN continental mollusks specialist group as vulnerable or critically endangered (see The IUCN Red List of Threatened Species web-site).

I see several ways how to increase the taxonomic awareness of the Ponto-Caspian aquatic snails among zoologists, biogeographers and conservation practitioners. 1. Extensive fieldworks are needed to gain more information about current distribution and abundance of the Ponto-Caspian endemic mollusks. It is especially important for the Caspian endemics, many species of which are still know from a handful of findings. To obtain fresh materials on these species means also to obtain specimens for macroanatomical and molecular genetic studies of these poorly known taxa; 2. The taxonomic revisions of endemic and subendemic genera and groups of higher rank (such as Pyrgulinae) should be carried out on the basis of the 'integrative' approach combining the morphological, molecular, zoogeographic and ecological data; 3. Special studies of intra- and interspecific variation in morphological traits of the Ponto-Caspian snails are desirable to develop reliable and 'user-friendly' identification keys for the use by non-malacologists. As a good example of this kind I would like to cite the identification key for the bivalve species of the Caspian Sea published several years ago (Kijashko in [Bogutskaya et al., 2013]).

As a conclusion, I wish to stress that efforts of a single nation are far from enough to complete the systematic description of the Ponto-Caspian malacofauna in accordance with the modern scientific standards. International collaborations such as PRIDE are strongly needed to form the team of experts in various branches of sciences (morphologists, taxonomists, molecular geneticists, paleontologists) working in different countries able to finish the process started more than 200 years ago by the first explorers of malacological diversity of the Azov, Black, and Caspian seas.

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CONSERVATION PALEOBIOLOGY IN THE RAZIM-SINOE LAGOON COMPLEX

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ОХРАНА ЭНДЕМИЧНЫХ СООБЩЕСТВ В КОМПЛЕКСЕ ЛАГУН РАЗИМ-СИНОЕ

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By using geological data it is possible to assess habitat dynamics and processes that affect distribution of modern species and communities. This information can help with the prediction how modern communities will react to changes in environment in the future. The newly emerging field where geological data are applied to biodiversity conservation is termed "conservation paleobiology" [Dietl & Flessa, 2011 and references therein]. Within the Razim-Sinoe Lake complex (Danube Delta area, Romania) we have an excellent model system to apply a conservation paleobiological approach. It hosts prime Pontocaspian mollusc habitat [Popa et al., 2009], yet signals are there that abundances and possibly species numbers are in decline. Using a set of 13 sediment cores that cover approximately the past 1200 years we are exploring three questions:

(1) What processes drive evolution of sedimentary environments in the Razim-Sinoe Lake complex?
(2) How have marine, Pontocaspian brackish-water and fresh-water communities responded to environmental change in the past?
(3) Based on these insights how can we best improve conservation efforts for Pontocaspian species?

The Razim-Sinoe Lake complex includes a number of lakes located at the Black Sea shore on the south side of the Danube Delta. It consists of three larger lakes and a number of smaller lakes (Fig. 1). In the north the main Razim Lake is a shallow, freshwater lake that receives freshwater input from small contributories that are connected to the Danube. The middle part of the lake complex is formed by Lake Golovitca. The western part is surrounded by reed swamps. Today it is a freshwater lake, yet before 1972 a wide inlet existed at the eastern end that formed a connection with the Black Sea. The southernmost lake is Lake Sinoe is separated from the Black Sea by a long beach ridge and there are currently two small inlets. Salinities in the lake range from lower oligohaline in the north to lower mesohaline in the SE. Lake Sinoe and Lake Golovitca are connected through a narrow canal. The lake system developed over an existing topography that includes earlier abandoned Danube Delta arm, beach ridges and coastal swamp environments. Prior to the 1972 closure of the main inlet the system had been to some degree open to the mesohaline Black Sea. After the closure an estuarine system developed with freshwater in the Razim and Golovitca Lakes and mainly oligohaline conditions in Lake Sinoe.

In total 13 sedimentary cores were made during two field campaigns (Oct. 2015 and July 2016). An initial sedimentary facies framework and age framework were made. Six sedimentary facies were defined that include modern oxidized mud, organic rich mud, plants rich mud, organic rich laminated mud, coarse sand and coarse shelly sand. The initial age framework was based on an arrival date of the invasive species *Potamopyrgus antipodarum* (Gray, 1853) that arrived in Europe in 1859 from New Zealand [Hubendick, 1950] and whose occurrence in some samples provide a maximum age. Furthermore a magnetic intensity profile was made for one of the cores and comparison with an archeological derived profile was made from Bulgaria [Kovacheva, 1997]. We estimate that the entire record in the cores may cover the past 1200 years, but further age analyses are under way.

Currently we are concluding faunal analyses. Mollusc species can be grouped into three associations. Association 1 consists of species whose optimum distribution is considered to be in freshwater habitats but with individual species having maximum salinity tolerances for oligohaline conditions. Typical representatives are *Acroluxus, Gyraulus, Pisidium, Valvata* and *Planorbis*. Association 2 consists of species with a Pontocaspian background. Such species are known from freshwater to oligohaline habitats in the Black Sea coastal region and include *Monodacna pontica/colorata*, *Hypanis plicatus*, *Turricaspia*, *Clessinolia* and *Clathrocaspia* species. Association 3 represents olgohaline to mesohaline conditions and includes *Lentidium mediterraneum, Abra segmentum, Cerastoderma glaucum* and *Ecrobia maritima*.

Through time the distribution of the three species groups has been variable in the Razim-Sinoe Lake complex. Lake Sinoe is dominated entirely by marine taxa (Association 3). However, these marine taxa were dominant in the entire lake complex until several decades ago and displayed a new increase a couple years ago. Thereafter the opportunistic brackish-water Pontocaspian and fresh-water fauna expanded in almost the entire lake system. Brackish-water Pontocaspians (Association 2) mostly occurred in the southern part of the Razim Lake and in Golovitca Lake. Whereas, in the northern part of the Razim Lake, close to the Danube Delta outlets, fresh-water taxa are entirely dominating faunas (Association 1).

Marine influence has varied in the Razim-Sinoe Lake complex throughout the past millennium and accordingly brackish-water Pontocaspian and fresh-water taxa have flourished or were suppressed. The communities additionally recorded coeval variations in spatial distribution throughout the entire lake during the last decades. The closure of the main Black Sea inlets due to the progressive formation of geological sandy barriers and due to the final anthropological closure in 1972 has resulted in declining salinities in the central part of the lake system. The salinity decrease seems to correlate with an expansion of brackish Pontocaspian and fresh-water fauna during the last decades. However, during our fieldworks the observed densities of Pontocaspian species seem to be very low throughout the entire lake system and so far we failed to recover any living Pontocaspian hydrobiids. The current data and insights suggest that increased conservation efforts should take in consideration the dynamic natural and anthropogenic drivers that impact the evolution through time and space of the very sensitive Pontocaspian habitats. The conservation status of the Pontocaspian species requires urgent reassessment.

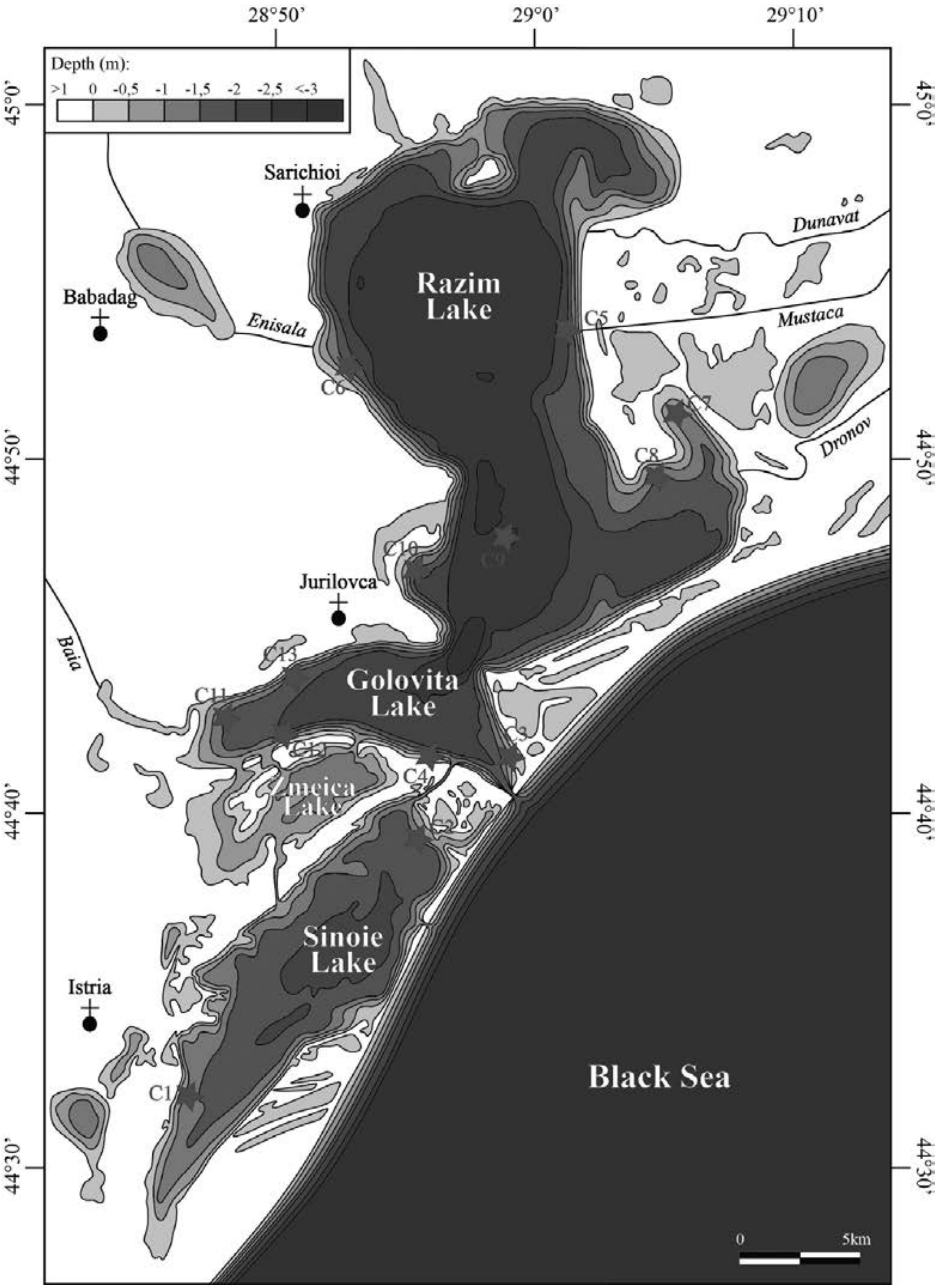

Fig. 1. The Lake system and location of the cores

ABOUT THE RFBR-RGO PROJECT "THE STUDY OF CUMULATIVE NATURAL HAZARDS DURING THE WINTER PERIOD AND THEIR IMPACT ON THE COASTAL AREA OF THE CASPIAN SEA"

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О ПРОЕКТЕ РФФИ-РГО «ИССЛЕДОВАНИЕ КУМУЛЯТИВНЫХ ОПАСНЫХ ПРИРОДНЫХ ЯВЛЕНИЙ В ЗИМНИЙ ПЕРИОД И ИХ ВОЗДЕЙСТВИЕ НА БЕРЕГОВУЮ ЗОНУ КАСПИЙСКОГО МОРЯ»

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The Caspian Sea is a unique largest in the world enclosed brackish waterbody. The main feature of the sea is the significant inter-annual fluctuations of the sea level. Due to peculiarities of geographical location the northern part of the sea is covered by ice during the winter period. The Caspian Sea is the important marine transport route, connecting five coastal states. Together with the coastal territories, the Caspian Sea forms a single natural and economic complex. The effectiveness of the functioning of this complex is determined, first of all, by the peculiarities of the internal processes dynamics of a closed reservoir. Along with this, the Caspian Sea is sensitive to fluctuations of external factors and quickly responds to such changes.

The beginning of the XXI century in the southern macro-region of Russia was marked by a number of weather disasters. Abnormally cold winters, such as the 2006 and 2012, when hummocks up to 2 m in height were observed in the Sea of Azov, the Black Sea was frozen to Bulgaria, and the Caspian Sea was covered by ice to Makhachkala. The number of extreme surges and storm surges have also increased.

Directly in the Caspian Sea a number of natural hazards, which have an impact to the socio-economic situation in the coastal region, can be identified: inter-annual (long-period) sea level changes; storms; wind surges (daily short-period sea level fluctuations); wave load on the coast and infrastructure facilities; extreme ice phenomena; strong winds, hurricanes, squalls; ships icing.

Hydrometeorological phenomena in the Caspian Sea are considered as dangerous if they correspond to the following criteria [Hydrometeorology … 1992]: wind speed 30 m/s and more; wind wave with wave height of 8 m and more; sea level fluctuations lower or higher of dangerous marks; formation of ice cover or fast ice in early dates; intense pressure and ice drift; ice cover impassable by ships. There is no need to argue that they can all be related to dangerous natural phenomena or natural hazards (NH). NH have the greatest impact on the shallow-water annualy freezing northern part of the sea. But the most catastrophic event is the “ice surge” or “ice storm”. The combination of rapid surging water level rise or extreme wind wave in the Caspian Sea with the ice cover can be the reason of severe economic losses in the coastal areas spatially on the background of the inter-annual sea level fluctuations. The greatest probability of occurrence of such combinations (cumulative effect) in November-December and March, when the fast ice and ice cover has not yet formed and ice can break and move toward to the shore side under the influence of storms or surges, destroying everything on its path.

Multifactority and complexity of NH evolution, related to climatic, hydrological, geomorphological factors, cause the problems of their research. Accounting of all factors and description of their joint interaction based on the primary hydrometeorological information for the instrumental observation period, geoinformation technologies and mathematical modeling are the key elements.

The topic that interested a young researchers team was supported by Russian Foundation for Basic Research and Russian Geographical Society by three-years grant. The aim of the work was to study the winter cumulative dangerous natural phenomena in the Caspian Sea for the period from 1900 to 2015 and their impact on the coast, coastal infrastructure and hydraulic structures. During the project a number of important fundamental and applied results will be obtained.

Based on hydrometeorological information on the long-term regime of each NH separately (sea level fluctuations, surges, storms and extreme ice phenomena, wave load on the coast and infrastructure facilities) calendar incidence of adverse and dangerous situations will be highlighted. The cases of winter cumulative NH will be highlighted by combining and summarizing the data obtained. The final calendar of winter cumulative NH will include: dates of occurrence and decline of cumulative phenomenon, duration (in hours), the values of each parameter, description of meteorological situation at the moment of occurrence and decline of cumulative NH. Comparison with previously documented in the literature will be performed.

A retrospective analysis of occurrence and degeneration of cumulative NH will be performed by a set of hydrodynamic and hydrological models.. Reanalysis of hydrometeorological characteristics fields will allow to understand the spatial specifics of the development of cumulative phenomena, in contrast to "point" field observations. Based on the restored data and reanalysis of meteorological parameters, analysis of the mechanisms of formation of unfavorable and dangerous winter cumulative NH, when two or more phenomena occur simultaneously and their total effect is intensified, will be performed.

Depending on the amount of simultaneous occurrence of adverse or dangerous hydrometeorological phenomena in the Caspian Sea from 1900 to 2015 (presence/absence surge phenomena, storm phenomena, extreme sea level increases/decreases, extreme ice conditions) the classification of winter periods will be developed. For each winter class on the basis of reanalysis the critical marks, after which the cumulative phenomenon is unfavorable or dangerous, will be determined (wind speed, water level, wave height etc). It should be noted that the danger criteria for cumulative NH will differ from the currently accepted criteria for individual NH, since the combined effects of unfavorable and dangerous values are achieved more quickly. Methodological description of the developed classification and criteria will be performed.

The quantitative assessment of the relationship between the number, frequency and timing of winter cumulative NH in the Caspian Sea with winter cumulative NH in the Sea of Azov and Black Sea will be received (RFBR research project №16-35-00318 мол_а).

Using hydrological mathematical models and spatial program modules the assessment of dynamic wave load on the coast, coastal infrastructure and hydraulic facilities, and the impact of surges on coastal areas and river deltas taking into account the ice conditions for identified cases of winter cumulative NH in the Caspian Sea will be implemented. Based on the simulation results the zonation of the Caspian Sea coast by the degree of sensitivity to the effects of the "ice storm" and "ice surges" will be conducted.

All results of the project will be published in electronic (on CD and Internet site) and in a paper edition of the "Atlas of winter cumulative natural hazards of the Caspian Sea during the XX-XXI centuries".

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PALEOGEOGRAPHY OF THE NORTHERN CASPIAN SEA IN THE LATE PLEISTOCENE

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ПАЛЕОГЕОГРАФИЯ СЕВЕРНОГО КАСПИЯ В ПОЗДНЕМ ПЛЕЙСТОЦЕНЕ

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The Caspian Sea is the largest isolated basin in the world, located in the depths of the Eurasian continent with an area of 380,000 km^2, a water body of 78,000 km^3 and a level of -27 m. The Sea is made of three major parts: the Northern Caspian, the Middle Caspian and the Southern Caspian that are divided by Mangyshlak and Apsheron thresholds. Although 95,000 km^2 in area, the Northern Caspian holds only 1% of the water reserve and most frequent depths are 5 m. The basin receives water from river systems of the Russian Plain, the Caucasus, and Ural, the main river is the Volga. The northern part of the sea receives 88% of the total freshwater inflow. The Caspian water balance depends on the river drainage, atmospheric precipitation (the incoming fraction), evaporation, and outflow into the Kara-Bogaz-Gol Bay (the outgoing fraction). Within the incoming fraction, the main role is that of river drainage, 80% of which is contributed by the Volga River. The water balance directly affects the sea-level fluctuations. The Northern Caspian is located within temperate continental climate. The salinity changes from 1 to 10‰, the lowest salinity is in a zone of influence of fresh waters of the Volga River. Maximum annual temperature amplitudes are observed on the north (25-26°).

The Caspian Sea was formed in the late Pliocene, after its separation from the Black Sea. From that time, it has experienced numerous transgressions and regressions with water level fluctuations of several tens of meters. The evolution of the entire Caspian Sea natural system and changes in its individual constituents depended of a number of factors including global climatic changes; glacial-interglacial rhythms on the Russian Plain and in mountains; neotectonic processes; volumes of groundwater and pore water inflow; etc. In the course of the geological history the impact of the listed factors varied in efficiency from one stage to another. In the Late Pleistocene the leading role belonged to the global climatic changes; those were manifested as alternating cold and warm epochs and resulted from variations in insolation due to changes in the Earth orbit elements (marine isotope stages MIS 5 to MIS 2).

In the history of the Caspian Sea the beginning of the Late Pleistocene (MIS 5) is marked by the late Khazarian transgressive epoch. According to drilling data, it proceeded in two stages known as late Khazarian and Hyrcanian ones. The transgressive late Khazarian basin was warm, its level standing at about -10 m. The malacofauna composition and characteristics, as well as palynological data obtained on the upper Khazarian core samples, strongly suggest relatively warm temperature of its water. Pollen analysis of sediments exposed in the coastal scarps also indicates a warm (interglacial) climate of the epoch [Grichuk, 1954; Abramova, 1974]. The Hyrcanian transgressive basin was also warm-water, as suggested by the presence of *Corbicula fluminalis*. Attribution of the two transgressive events in the Caspian Sea history to MIS 5 is confirmed by dating the late Khazarian stage at 127-122 ka BP, while chronological boundaries of the entire late Khazarian epoch are taken as 127 to 76 ka BP [Shkatova et al., 1991; Rychagov, 1997; Dolukhanov et al., 2009]. That agrees well with the Upper Pleistocene stratigraphy in the Manych valley, where deposits with late Khazarian, Karangatian, and Hyrcanian malacofauna form a kind of “layered pancake” [Popov, 1983]. According to the commonly accepted view, the Karangatian transgression of the Black Sea was a consequence of the interglacial Eemian transgression of the World Ocean. The Karangatian basin level was higher than that of the present day, and the sea formed an ingression basin deeply penetrating into the Manych valley [Popov, 1983; Yanina, 2012]. The complicated occurrence of Karangatian deposits in combination with those of the Caspian transgression confirms the simultaneity of those events and suggests instability of levels of those basins. A series of Th-U dates gave grounds to estimate the Karangatian transgression age at 140 to 70 ka BP [Velichko, 2002]. Radiocarbon dating of the Hyrcanian epoch has not produced any results except confirming the age is beyond the scope of the technique. Along the entire length of the Manych depression the Karangatian-Khazarian series are overlain with Hyrcanian deposits with fauna typical of that basin and indicative of the Caspian (Hyrcanian) water outflowing into the Black Sea basin. That could happen only if the Karangatian basin level dropped along with regression of the World Ocean at the transition from warm to cold (glacial) epoch. Obviously the onset of cooling was instrumental in increasing the positive constituent of the water budget of the closed Caspian Sea: it sustained its transgressive development and promoted the discharge into the regressing Pontian basin. Therefore, the paleographic data on the Late Pleistocene history of the Caspian provided evidence of the warm-water basins persisting within its depression throughout of the entire MIS 5 stage.

As the maximum cooling approached (MIS 4) and the climate became cold and dry, the Hyrcanian basin was shrinking. That is evidenced by traces of linear erosion and regressive series of the Atelian deposits clearly seen in seismic profiles and in the drilling cores. Radiocarbon dates obtained on the upper part of the Atelian deposits infilling the older erosional landforms strongly suggest them to have been deposited at the first half of the interstadial warming (MIS 3). It should be noted that those were final stages of the Atelian phase of the Caspian Sea evolution. Some corroborative data were obtained by optically stimulated luminescence dating of the upper part of the Atelian series in the Middle Aktuba section (the Volgograd Region) [Kurbanov et al., 2016; Tkach et al., 2016]. At the base of the series, in the sections at the lower reaches of the Volga R., there are well pronounced cryoturbations and ice wedge pseudomorphs which penetrate deeply into the underlying series of paleosols attributed to MIS 5; the cryogenic structures are evidently belong to the glacial epoch. Some of the supporting evidence came from pollen assemblages of definitely periglacial character recovered from the Atelian deposits in the Northern Caspian Lowland [Grichuk, 1954; Moskvitin, 1962], and from cores of boreholes drilled within the studied area [Bolikhovskaya et al., 2016]. So, the Atelian regression may be correlated with the first maximum of the Valday glaciation (MIS 4) and with the beginning of the MIS 3 interglacial warming. Judging from the data of seismic profiles and borehole cores, the Caspian Sea dropped to -100 m abs. at that time.

The onset of the global warming of interstadial rank resulted in a certain increase of the positive constituent of the Caspian water balance both due to increasing runoff from the drainage basin [Panin, Matlakhova, 2015], and to changes in rainfall-evaporation regime over the water area. Those changes brought about the first stage of the Khvalynian transgression recorded in the borehole sequences as deposits of a shallow and relatively warm basin. Radiocarbon dates support the attribution of that event to MIS 3 interval. The Last Glacial Maximum (MIS 2) was marked by exceedingly cold and dry environments even in the south of the East European Plain [Velichko, 2012], hardly favorable for a transgressive regime of the Caspian. Lowering of its level may be inferred from the presence of sandy layers in the Khvalynian series. Radiocarbon dates obtained for deposits adjoining Khvalynian ones provide support for their attribution to MIS 2 interval.

The ice sheet decay, together with permafrost thawing, both resulting from the global climate warming, induced the rise of the Caspian Sea level. The first phase of the transgressive changes in the sea level is evidently recorded in the predominantly clayey unit, the lower boundary of the latter being dated at about 19 ka BP. A transition to an active transgressive regime after a short-term fall of sea level was marked by erosion clearly seen at the base of the overlying clayey series. The sea level fall seemingly corresponds to a sharp cooling and increase in the climate continentality known as Oldest Dryas; according to reconstructions, the time was marked by a decrease of runoff from the Caspian catchment area [Thom, 2010]. The warmer intervals Bølling and Allerød were noted for an increased runoff [Thom, 2010; Panin, Matlakhova, 2015] and corresponded to the next transgressive stage in the Caspian Sea history (Khvalynian basin). In the sedimentary sequence the stage corresponds to the clay series, as is confirmed by numerous radiocarbon dates obtained on mollusk shells. A series of so called "chocolate" clays was accumulating in the Volga estuary and in depressions of pre-Khvalynian relief, presumably due to active thawing of permafrost and a great mass of fine material brought by rivers. A high rate of accumulation together with a considerable concentration of suspended materials account for the absence of mollusk fauna in the clays. The deposits of that transgressive stage are widely distributed in the coastal zone. The dates obtained using radiocarbon [Svitoch, Yanina, 1997; Leonov et al., 2002; Tudrun et al., 2013, 2016; Arslanov et al., 2008, 2016], thorium-uranium [Arslanov et al., 2016] and optically stimulated luminescence [Kurbanov et al., 2016; Tkach et al., 2016] methods are close to each other. The chocolate clay accumulation that took place within the time interval between the LGM and 13.8 ka BP is attributed to the Scandinavian ice melting and transportation of fine particles down the Volga River [Tudrun et al., 2016].

A remarkable climatic event of the Late Pleistocene was Younger Dryas when the vegetation in Europe was dominated by periglacial formations, not unlike those of the glacial time [Grichuk, 1982]. In the Caspian history it corresponds to a regressive stage, presumably due to a considerably reduced river discharge [Thom, 2010]. In the Upper Pleistocene sequences in the Northern Caspian the sea level drop was marked by deposition of a sandy layer. The very first dramatic warming of climate (generally taken as indicator of the Pleistocene – Holocene boundary) resulted in a high stand of the Caspian level – the last stage of the Khvalynian transgression. The presence of mollusks in abundance, and their larger and more massive shells resulted probably from more favorable environments, in particular, higher water temperature as compared with that in the Early Khvalynian basin. Palynological data [Abramova, 1974; Vronsky, 1976] provide evidence of a general warming in the region.

The regressive trend began to develop against the background of increasingly dry climate in the region, as is apparent from the pollen assemblages [Abramova, 1974; Bolikhovskaya, Kasimov, 2010] distinctly showing the transition from diversified tree species to xerophytic grasses and herbs. In the borehole cores the climatic changes are recorded by deposition of deltaic sediments and later by formation of depressions deepened into Khvalynian deposits and filled with freshwater sediments. This stage is known as the Mangyshlakian regression dated to the interval of 9860 to 6350 ^{14}C yr BP [Bezrodnykh et al., 2014]. Such was the Caspian response to increasing continentality of the climate in the Boreal period of the Holocene.

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SOME DATA ABOUT THE PALEOGEOGRAPHY OF THE ATELIAN PERIOD OF THE LOWER VOLGA REGION

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НЕКОТОРЫЕ ДАННЫЕ О ПАЛЕОГЕОГРАФИИ АТЕЛЬСКОЙ ЭПОХИ НИЖНЕГО ПОВОЛЖЬЯ

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Paleogeographic development of the Caspian Sea in the Late Pleisocene is characterized by alternation of transgressive and regressive stages. Unlike transgressive periods, the paleogeographical environment during regressive periods is less understood. The main reason is the lack of paleontological and paleobotanical remains (including malacofauna and pollen) in continental deposits of various genesis.

The longest period of a low Caspian Sea level in the Late Pleistocene is the Atelian regression. During this period a thick sequence of continental deposits was formed. This formation is widely spread within the Caspian Depression and is presented with subaqueous and subaerial deposits, including alluvial and aeolian deposits.

The main goal of this research is the paleogeographical reconstruction of the environment of the Lower Volga region during the Atel regression. To achieve this goal we have chosen the Raigorod section which is located in the northern part of the Lower Volga region, 50 km downstream from Volgograd. The main feature of this section is the highest observed thickness of atelian deposits (around 7 m), that are represented in the natural outcrop and underlie the Khvalynian “chocolate” clays. The upper part of atelian thickness is represented with monochromatic pale-yellow silty-loam (aleurite) unit. It is a homogeneous thick “loess-like” barren formation with plant residues and carbonate nodules. The main characteristics of this thickness are: its silty (aleuritic) grain size, high carbonate content, porosity, significant thickness and columnar structure. Additionally, the outcrop holds a very stable vertical position. All of the above mentioned points match the definition of typical loess. During the description this thickness was preliminary divided into several units for weak differences in colour and concentration of carbonate nodules. In the base of the thickness there are alluvial sandy deposits (Akhtuba sands) that penetrate the underlying layer as 25-30 cm deep fissures. These traces of the cryogenic process are the most important characteristic of the marking horizon in the sections of Lower Volga region.

For more reasonable subdivision of the homogeneous unit we carried out the magnetic susceptibility method. For this kind of deposits ("loess-like", supposedly aeolian genesis) the value of magnetic susceptibility (χ) reflects the presence of pedogenesis. Since it is considered that regressions of the Caspian Sea correspond to glacial periods on the Russian Plane, the traces of pedogenesis attests the period of climate mitigation. Magnetic susceptibility in deposits depends on three characteristics: type of magnetic minerals, its concentration and grain size. During the process of pedogenesis the value of χ increases.

During fieldwork we performed high-resolution sampling (every 2 cm sampled). Laboratory research included the measurements of χ for every second sample (every 4 cm depth). In the field, the value of χ for every sample was measured with ZHinstruments SM-30. In the laboratory, the χ for every second sample was measured in three types of magnetic fields (Low Field – LF, Medium Field – MF and High Field – HF) on the MFK1-FA Kappabridge. Then the frequency dependent χ (χ_{FD}) was calculated with the formula $\left(\frac{\chi LF - \chi MF}{\chi MF}\right)\cdot 100\%$. Frequency dependent χ represents the contribution of magnetic minerals of different sizes (viz. superparamagnetic grains, which are 0,001-0,5 μm for magnetite).

Fig. 1 shows three curves, that are research results. The first curve reflects the laboratory measurements in a low-frequency magnetic field. The second one shows the value of χ_{LF}, measured during fieldworks. The third graph illustrates calculated χ_{FD}. Dotted lines mark the atelian "loess-like" thickness, arrows indicate anomalies in χ_{FD} and χ_{LF}. As we can see the homogeneous "loess-like" atelian thickness is indeed different in magnetic properties. Reviewing the entire section we can also notice the maximum peak in the modern soil, in the Early Khvalynian "chocolate" clays horizon (MIS-2). We assume that these peaks in the atelian thickness attest the paleosoils.

The defenition of the atelian thickness in the Raigorod section as loess (according to the complex of typical loess features, traces of cryogenesis at the lower boundary and existence of paleosoils) confirms the hypothesis of cold periglacial depositional environment. The signs of pedogenesis, especially in the top part of the thickness, attest to inhomogeneity of the climate and phases of warming at the final stage of the regression epoch. This research is the first step towards the profound paleogeographical reconstruction of the environment of Lower Volga Region and Caspian Plane during Atel regression.

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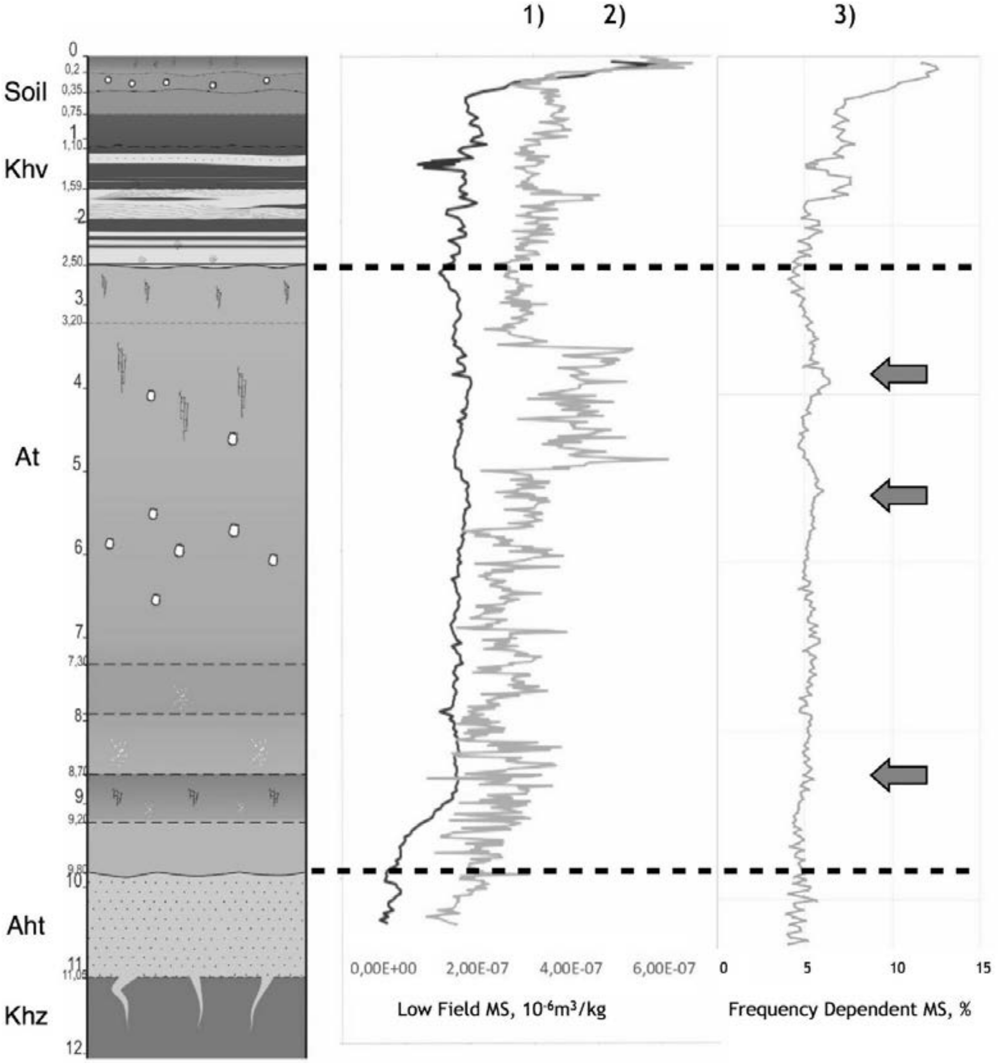

Fig. 1. The scheme of Raigorod section, curve plotted 1) on the laboratory data, 2) on the data from the field measurements, 3) calculated frequency dependent MS. Dotted lines mark the Atelian loess-like thickness, arrows indicate anomalies in MS

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