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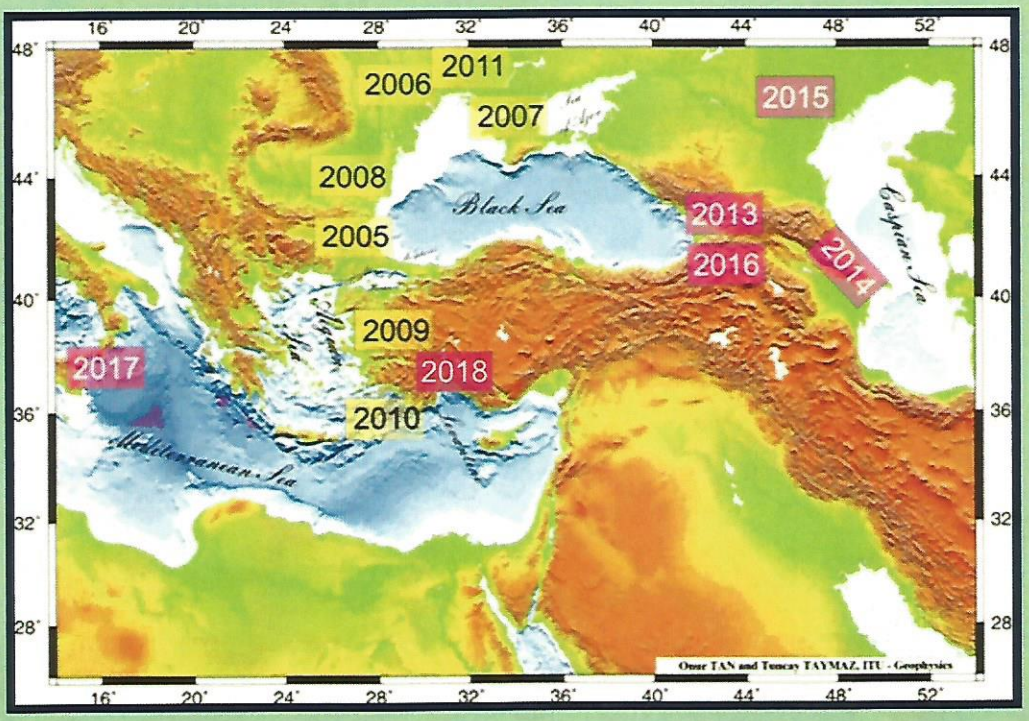

PROCEEDINGS

IGCP 610 "From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary" (2013 - 2018)

INQUA IFG POCAS "Ponto-Caspian Stratigraphy and Geochronology" (2017-2020)

THE CASPIAN - BLACK SEA - MEDITERRANEAN CORRIDOR: WATER EXCHANGE AND MIGRATIONS OF FAUNA DURING THE LASTCLIMATIC MACROCYCLE

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Introduction

The beginning of the last climatic macrocycle (Late Pleistocene) was marked by the Eemian interglacial, and most specialists think it correlates with the MIS 5e substage. Its duration has been estimated at 15 thousand years (130-115 ka BP), and its thermal maximum is positioned at approximately 126 ka BP (Shackleton, 1969; Turney and Jones, 2010; Velichko, 2012). The interval of MIS 5d-5a to MIS 4 corresponds to the Early Valdai glaciation, MIS 3 is correlated with the Middle Valdai mega-interstadial, and MIS 2 is correlated with the Late Valdai in the Russian chronostratigraphy. In the West European and Central European schemes, the sequence of events is as follows: the early glacial interval—MIS 5d-5a; the early Pleniglacial—MIS 4; middle Pleniglacial—MIS 3; and the late Pleniglacial—MIS 2 (Velichko, 2012). We assess the interval MIS 5d-5a as a transitional interglacial-glacial period. Within the above-named periods, warmings and coolings have been recognized, each of them being a few millennia long (Dansgaard et al., 1989, 1993; Walker et al., 1999; etc.). The Late Glacial (14700-11700 cal. yr BP) displayed relatively short-term climatic fluctuations known as the Bølling and Allerød—14700-14000 and 13600-12900 cal. yr BP separated by the conspicuous cooling of the Younger Dryas 12900-11700 cal. yr BP. During this entire interval, temperatures were changing at a considerable rate.

The generally accepted sequence of paleogeographic events taking place in the Caspian basin in the Late Pleistocene includes the Late Khazarian and Khvalynian transgressive epochs (the latter is commonly subdivided into early Khvalynian and late Khvalynian transgressive stages), with the Atelian regression between them. The existence of a Hyrcanian transgressive basin was established by Popov (1983) and confirmed by us (Sorokin et al., 2018). The scheme of the Late Pleistocene events of the Pontian basin includes the Karangatian (Karangatian and Tarkhankutian stages), Surozhian, and Neoeuxinian transgressions, and intervening regressions. In the Mediterranean Late Pleistocene, Tyrrhenian and Flandrian stages have been identified (Brückner, 1986; Keraudren and Sorel, 1987; Cita and Castradori, 1994; etc.). Transgressive stages were divided by regressions of different depth and duration. Various aspects of the environmental evolution within this time interval have been fully considered in a great number of published works.

The comparative characteristics of terraces, the Pleistocene deposits, and the paleogeographical events of the Ponto-Caspian and Mediterranean, have been studied by many researchers starting with Andrusov (Fedorov, 1978; Zubakov, 1986; Svitoch et al., 1998; etc.). Practically all researchers draw direct analogies between the Tyrrhenian and Karangatian seas. Usually, they are correlated with the Late Khazarian transgression of the Caspian Sea. According to Fedorov (1978), the classical Tyrrhenian correlated with the Karangatian and Late Khazarian events; the maximum of the Early Khvalynian transgression,

when dumping of waters into the Black Sea was noted, correlated with the Post-Karangatian and Grimaldinian regression. Svitoch et al. (1998) offered such correlations: Tyrrhenian – Karangatian – Late Khazarian transgressions; Early Khvalynian – Surozhian; Verzilian – Chernomorian transgressions; Post-Tyrrhenian – Neoeuxinian – Post-Khvalynian regressions.

Results and discussion

It is logical to consider first of all a question of comparison of events in the Mediterranean and Pontic basins. The mode of the Mediterranean Sea in the Pleistocene was defined by fluctuations in the level of the Ocean as communication of this sea with Northern Atlantic through Gibraltar was not interrupted. The transgressive and regressive condition of the Pontic basin depended on the level of the Mediterranean Sea. As well as in the Pontic basin, the level of the Mediterranean Sea during epochs of transgressions exceeded its modern level only a little (to 5-7 m). During regressions, the level to which the sea surface fell exceeded by many times its rise during transgressions.

The Tyrrhenian stage is the "brightest" paleogeographical epoch in the Mediterranean Pleistocene and is characterized by a broad movement of tropical fauna of Senegalese type with the chief representative *Strombus bubonius*. It is established that penetration of tropical elements of malacofauna began in the Middle Pleistocene, and the time interval of its existence covered part of the Late Pleistocene also (Zazo et al., 1984; Paskoff and Sanlaville, 1980; Ozer et al., 1980; etc.). On various coasts of the Mediterranean, four marine terraces are known, deposits of which contain varying degrees of Tyrrhenian malacofauna. The Karangatian transgression was the largest in the Quaternary history of the Black Sea, with a maximum water level approximately 6-7 m higher than today. Warm saline Mediterranean (Tyrrhenian) waters entered the Black Sea basin through the Bosphorus Strait, and a one-way migration of euryhaline and stenohaline Mediterranean fauna took place.

The Karangatian transgression extended all the way into the Manych Depression, but marine mollusk species never entered the Caspian basin. The Karangatian transgression developed in two phases. During the early Tobechikian phase (Nevesskaya, 1965), a mollusk fauna similar to that of the modern Black Sea fauna was established. Sea levels did not exceed modern levels. With further development of the interglacial Mediterranean transgression, the penetration of marine waters into the Black Sea led to the second phase of the Karangatian transgression. Stenohaline species (*Acanthocardia tuberculatum*, etc.), which are absent in the Black Sea today, flourished in the Karangatian basin. The age of the transgression according to a series of thorium-uranium dates, show a range 140-70 ka (Arslanov et al., 1975; Balabanov and Izmailov, 1989). The Karangatian transgression was caused by the interglacial (Eemian) transgression of the World Ocean and an ingression of Mediterranean waters into the Black Sea basin. During the same time in the Caspian Sea, the Late Khazarian transgression developed. The level of the basin did not exceed -10 m, and its surface area was not much bigger than the modern Caspian Sea. The mollusk fauna contained crassoidal-type *Didacna* and was characterized by the occurrence of *Didacna nalivkini* and *Didacna surachanica*. Abundant trigonoidal and catilloidal *Didacna* dominated in the freshened areas of the northern Caspian, influenced by Volga River inflow. The Caspian Sea was an isolated lake-sea that lacked any connection with the Black Sea basin.

After the maximum transgression, during the transition interglacial-glacial epoch, the Karangatian Sea lowered (the Tarkhankutian stage) after a decrease in the level of the Mediterranean Sea during a time of regression in the World Ocean. The Tarkhankutian stage was the residual basin of the Karangatian Sea, the final stage of its existence. The Mediterranean connection had ceased to exist at the time. The mollusk faunas were dominated by Mediterranean taxa but lacked stenohaline species (Nevesskaya, 1965). In the Caspian

area, the transgressive brackish water Hyrcanian basin existed after the Late Khazarian transgression (Popov, 1983; Sorokin et al., 2018). The Hyrcanian basin was inhabited by "Khvalynian-like" fauna with *Didacna subcatillus*, *D. cristata*, etc. Hyrcanian waters entered the Tarkhankutian basin through the Manych passage, and *Didacna* species invaded the basin margins on the northeast area (Popov, 1983; Yanina, 2012). They lived together with euryhaline Mediterranean mollusks.

In the Mediterranean Sea, the Tyrrhenian transgression was replaced by a long, uneven decrease in sea level (MIS 4-2). In the deep-water deposits referred to the MIS 4 time period, an alternation of layers is noted that contain complexes of warm-water and cold-water foraminifera, corresponding to climatic warmings and cold snaps. For the MIS 3 horizon, alternation of pollen ranges of subtropical and subboreal (boreal) vegetation, and also pro- layers containing different warm-water planktonic foraminifera have been established. During this epoch of warming, a transgressive rise in level was noted, reaching no more than -40 m. In the Black Sea, there was a regressive Post-Karangatian basin, too. The marine environment was replaced by brackish-water conditions (Kuprin and Shcherbakov, 1988). According to Popov (1983), during the Post-Karangatian epoch, the Surozhian transgression occurred. Sea levels reached -25 m. There was no connection with the Mediterranean Sea at the time. The existence of this basin is estimated at 40-25 ka (Shcherbakov, 1982)., During the cold maximum of the interval MIS 4, when regional climate was cold and arid, the Atelian regression developed in the Caspian Sea. The slightly warmer conditions of MIS 3 resulted in increasing precipitation and river activity in the East European plain and simultaneous reduction of evaporation over the lake basins. The water balance became positive, resulting in transgressions in the Caspian basin (the first phase of the Khvalynian transgression) and in the Pontian basin (the Surozhian moderately warm-water basin). The overflow event from the Caspian (Khvalynian) also occurred (Popov, 1983).

In the MIS 2 horizon of deep-water deposits of the Mediterranean Sea, cold-water foraminifera prevail (Shimkus, 1981). Proof of a deep regression from 100 up to 300 m haz been published (Segre, 1969; Senatore, 1980; Koreneva and Saidova, 1969; etc.). In the Pontian, after the Surozhian epoch, a deep regression developed (the Neoeuxinian lake) during the MIS 2 glaciation. Lake levels dropped from -110 m (Ostrovsky et al., 1977; Balabanov and Izmailov, 1989) to -150 m (Ryan et al., 1997). The Neoeuxinian includes regressive and transgressive intervals. The former corresponds to a deep regression during the LGM with mostly fresh water mollusks like *Dreissena*, *Viviparus*, *Valvata*, etc. A connection with the Mediterranena Sea was absent. The age of the regression is estimated at 22-16 ka (Shcherbakov et al., 1977; Balabanov and Izmailov, 1989) or at 25-22 ka (Degens and Ross, 1972). In the Caspian basin, however, the general transgressive trend was interrupted during the LGM. The climatic conditions resulted in a negative water balance for the Khvalynian Sea, causing a sea-level drop. The Khvalynian transgression resumed during deglaciation after the LGM. The Early Khvalynian transgression, having reached the level of the Manych threshold, created an erosive valley and discharged into the Neoeuxinian basin. This was the last time the Manych served as a spillway between the Caspian and Black Sea basins.

Transgression of the Caspian type began in the Neoeuxinian basin. The transgressive stage was initiated ca. 16 ka. Around 12.5 ka, its level reached -45 m. The transgressive interval was dominated by Pontocaspian mollusk species such as *Dreissena*, *Monodacna*, *Adacna*, and *Hypanis*. Rare occurrences of Khvalynian species such as *Didacna ebersini* and *Didacna moribunda* in the Neoeuxinian deposits confirm the overflow of Caspian waters. This interval corresponds to a rise in water level to -20 m. At the same time, the presence of Neoeuxinian faunas in the Marmara basin and northern Aegean suggests Black Sea overflow (Taviani et al., 2014; Büyükmeriç, 2016). We conclude that the Neoeuxinian and Khvalynian basins

developed with the deep regression coinciding with the LGM and the Neoeuxinian and Khvalynian transgressions with the deglaciation phase.

Postglacial glacio-eustatic increase in the level of the Ocean in the Mediterranean Sea carries the name of the Flandrian transgression. Its beginning belongs to the early post-glacial period (about 17-15 ky ago) (Ulzega et al., 1986; Kaplin and Selivanov, 1999; etc.). It is almost universally accepted that sea level rose to -30 m at about 10-9 ka BP. The transgression which began with the release of a large volume of water into the North Atlantic led to the distribution of the modern Mediterranean mollusks, represented by the rather thermophilic Mediterranean Lusitanian and Canary species (*Chlamys glabra*, *Mytilaster lineatus*, *Corbula mediterranea*, *Pitar rudis*, etc.), moderately thermophilic (*Mytilus galloprovincialis*, *Cardium paucicostatum*, *Donax venustus*, etc.), and preferring cool conditions (*Nucula nucleus*, *Ostrea edulis*, *Cerastoderma glaucum*, *Chione gallina*, *Solen vagina*, etc.) species. Penetration of waters from the Flandrian transgression into the Black Sea basin caused the Chernomorian (Black Sea) transgression with euryhaline and moderately stenohaline Mediterranean mollusks.

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