

NEOPLEISTOCENE STRATIGRAPHY OF THE PONTO-CASPIAN CORRIDORS

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There are many past/present geological projects in the "Ponto-Caspian Corridors." The most recent geological projects have been carried out by Odessa I.I. Mechnikov National University, Ukraine; Prichernomorskoe State Regional Geological Enterprise "Prichernomor GRGP," Odessa; Moscow M.V. Lomonosov State University, Russia; the Institute of Geography, Russian Academy of Sciences; the Department of Marine Geology and Mineral Resources of the National Academy of Sciences of Ukraine; P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences; Avalon Institute of Applied Science, Canada; the National Institute of Marine Geology and Geocology, Romania; the Geology Institute of the Azerbaijan National Academy of Sciences; the Museum of Natural History, Bulgaria; the Institute of Oceanology, Bulgaria; IFREMER, France; Memorial University, Canada; Lamont-Doherty Earth Observatory of Columbia University, USA; Temple University, USA; Delaware University, USA; *Istanbul* University and Istanbul Technical University, Turkey; and many others. These efforts have produced a variety of geochronological scales for the Ponto-Caspian Corridors.

Geological data obtained by past and present projects were analyzed by many scientists, such as N.I. Andrusov, A.D. Arkhangelsky, N.M. Strakhov, M.M. Zhukov, V.M. Muratov, L.A. Neveeskaya, P.V. Fedorov, G.I. Popov, A.A. Svitoch, V.A. Zubakov, E.F. Shnyukov, A.L. Chepalyga, F.A. Shcherbakov, A.B. Ostrovsky, N. Panin, V. Yanko-Hombach, T.A. Yanina, A. Mamedov, P.N. Kuprin, V.M. Sorokin, E. Aliyeva, G. Oaie, M. Melinte, I. Motnenko, G. Karaivan, Ya.A. Izmailov, S.A. Nesmeyanov, LP. Balabanov, N.V. Esin, M. Filipova-Marinova, D. Petko, G. Lericolais, R. Hiscott, A. Aksu, P. Mudie, W.B.F. Ryan, I. Buynevich, E.P. Larchenkov, R. Martin, M.N. Cagatay, H. Koral, Y. Yilmaz, O. Algan, and many others.

A stratigraphic scale for the Ponto-Caspian region was developed based on mollusks (e.g., Neveeskaya, 1965; Fedorov, 1978; Yanina, 2013) and foraminifera (Yanko, 1989; Yanko-Hombach, 2007). This, in turn, enabled reconstruction of the hydrological regime of the basins as well as an approximate correlation of major events in this region with those in the Mediterranean Sea and the World Ocean. Scientists more or less agree to the following correlation between stratigraphic units and MISs in the Black Sea, Caspian, and Mediterranean regions, respectively: Bakinian-Chaudian-Sicilian (MIS 19-13), Early Khazarian-Old Euxinian+Uzunlarian-Paleotyrrenian (MIS 11-7), Late Khazarian-Karangatian-Tyrrenian (MIS 5), Khvalynian-Neoeuxinian- Grimaldian (MIS 4-2), and Novocaspian-Chernomorian- Verzilian (MIS 1). However, many questions remain unsolved. For example, there is no unanimous opinion on the correlation of local horizons not only with each other but with MISs as well. This is because the absolute age of the sediments in the holo-, lecto-, neo-, hypo-, para-, and boundary stratotypes (defined here as QPCR STRATOTYPES) varies depending on the method used, e.g., ²³⁰U/Th, thermoluminescence, etc. (Zubakov, 1986) and requires revision. There is no unanimous opinion on the number of transgressive and regressive stages and their amplitude in certain geological epochs.

Because of this lack of agreement, some researchers are trying to use alternative methods to clarify the order of events, thereby introducing even more confusion. For example, Badertscher et al. (2011) used oxygen isotopesignatures in stacked speleothems from Sofular Cave in northern Turkey to propose that the Black Sea and Mediterranean connection as well as that between the Black Sea and Caspian have been open for a greater number of periods than previously thought. In particular, Caspian- Black Sea connections opened at least seven times, while Mediterranean-Black Sea connections occurred

at least twelve times since 670 ka BP. However, Yanko-Hombach and Motnenko (2011) respond that if the data of Badertscher et al. (2011) are correct, we would see corresponding alternations of faunal assemblages in coeval age sequences exposed in stratotypes of the Kerch and Taman peninsulas, and the Caucasian coast. However, foraminifera show that the Caspian-Black Sea and Mediterranean-Black Sea connections existed four and six times, respectively, since the Matuyama-Brunhes reversal (i.e., the last 780 ka), and in most cases, these connections did not occur synchronously with those of Badertscher et al. In summary, despite over 150 years of intensive field studies and interpretative research, there is no up-to-date high-resolution stratigraphic scale for the Corridor as well as exact timing of the water exchange between adjacent basins.

This paper intends to provide an outlook on the existing geochronological scales and demonstrate the number, time, and direction of MS and CS water intrusions into the BS during the Pleistocene. In our work, we follow the Russian divisions of the Quaternary System, which separates the Quaternary into the Eopleistocene [1.8-0.78 Ma], the Neopleistocene [0.78-0.01 Ma], and the Holocene [0.01-0.0 Ma]. The boundary between the Eopleistocene and Neopleistocene coincides with the Matuyama-Brunhes reversal [MBR], which is readily traced in both the BS and CS regions at the bottom of the Lower Chaudian and Tyurkanina horizons, respectively.

The Caspian region

Stratigraphy of the Caspian Neopleistocene is based on changes in the evolutionary patterns and ecological assemblages of the mollusk genus *Didacna* Eichwald (Andrusov, 1915; Pravoslavlev, 1939; Zhukov, 1945; Fedorov, 1957, 1978; Vekilov, 1969; Popov, 1983; Svitoch, 1991; Svitoch and Yanina, 1997; Nevesskaya, 2007; Yanina, 2005, 2013; and others). The researchers subdivided the Neopleistocene Caspian deposits with high resolution and detail; however a number of unresolved questions remain.

The Bakinian horizon (lower Neopleistocene) in all schemes is divided into two divisions - lower and upper. But some researchers (Fedorov, 1957, 1978; Vekilov, 1969; Popov, 1983; Nevesskaya, 2007) allocate them at the rank of subhorizon with a stratigraphic break between them, while others (Zhukov, 1945; Svitoch, 1991; Yanina, 2013) consider them as layers with a gradual transition between them. Fedorov (1978) and Nevesskaya (2007) labeled Urundjikian layers as part of the Bakinian horizon; and Yanina (2012) considers it a horizon at the beginning of the middle Neopleistocene.

In the middle Neopleistocene, the lower Khazarian horizon is present in all stratigraphic schemes. However, some researchers dismember it into three subhorizons (Yanina, 2013) or three layers (Fedorov, 1978; Svitoch, 1991). Others (Vasilyev, 1961; Vekilov, 1969; Nevesskaya, 2007) consider it as a uniform stratigraphical unit. In some schemes, the upper Khazarian horizon is included in the middle Neopleistocene (Vekilov, 1969; Popov, 1983; Rychagov, 1997).

A debated question of the upper Neopleistocene stratigraphy is the existence of the Girkanian horizon (Popov, 1983) or subhorizon (Yanina, 2013). It is denied by Fedorov (1978), Shkatova (2006), and Svitoch (1991). Researchers placed the Khvalynian horizon in the second half of the upper Neopleistocene, having divided it into two subhorizons (Fedorov, 1957, 1978; Vekilov, 1969; Popov, 1983; Rychagov, 1997, etc.) or two layers (Svitoch and Yanina, 1997). Vasilyev (1961) distinguishes two marine units of the lower Khvalynian horizon divided by the regressive Elton layers. Chepalyga (2006) also separates the Khvalynian horizon into three layers.

The majority of researchers allocated only one marine horizon to the Holocene - Novocaspien. Fedorov (1978) and Svitoch and Yanina (1997) break it into three layers. In Svitoch's latest work (2011), Dagestan layers indicating an independent Holocene transgression are identified. Moreover, Svitoch transfers the late Khvalynian subhorizon to the Holocene.

As we see, the stratigraphic scheme of the Caspian Neopleistocene has no uniform systematics, as well as reconstructed paleogeographical events. So, on the basis of so many different stratigraphic schemes, the number of functioning epochs within the Manych Passage has been variously reconstructed by researchers: eight (Goretsky, 1966; Popov, 1983), seven (Fedorov, 1978), six (Yanina, 2012), and four (Svitoch et al., 2010).

The biostratigraphic scheme of the author (Yanina, 2013) is one of the latest schemes. It is an ecostratigraphic and paleoevent scheme as well, because all recognized stratigraphic units are related to the paleogeographical events at varied hierarchical levels (transgression, stage, phase) in the development of the Caspian Sea.

The Pontian region

The stratigraphic subdivision and interpretation of the Neopleistocene events of the Pontian region have no uniform agreements also. All researchers are agreeable about placing the Chaudian horizon in the lower Neopleistocene. The Pre-Chaudian regression is recognized by many scientists (Fedorov, 1978; Dimitrov et al., 1979; Krystev et al., 1990, etc.). At the same time, according to Kitovani (1976), deposits of the Gurian basin were gradually replaced by Chaudian sediments. Numerous disputes have arisen around a question about the "Bulgarian Chauda." This basin was assigned to the regressive early Chaudian (Chepalyga, 1997; Fedorov, 1982; and others) and to the late Chaudian (Dimitrov and Govberg, 1978). The distribution of Caspian fauna in the Chaudian basin was noted as occurring twice (Fedorov, 1978; Popov, 1983; Neveeskaya, 2007), or once (Yanina, 2005). According to the majority of researchers (Arkhangelsky and Strakhov, 1938; Fedorov, 1978; Dimitrov, 1978; Khrishev and Shopov, 1979; and others), the Chaudian basin level was negative. Water from the Chaudian basin exited through the Bosphorus into the Sea of Marmara and Dardanelles. It is obvious that sea level changed repeatedly. Seismoacoustic profiles testify to it (Limonov and Krystev, 1990). The first intake of Mediterranean water and euryhaline fauna into the Chaudian basin is recognized in the Neopleistocene (Fedorov, 1978; Yanko et al., 1984; Chepalyga, 1997). The stage with marine fauna was named the Epichaudian basin by P. Fedorov (1978), the Karadeniz basin by A. Chepalyga (1997), and the Patray basin by V. Zubakov (1986). Its deposits terminated the lower Neopleistocene sedimentation stage.

The Euxinian-Uzunlarian epoch of the middle Neopleistocene has been differently reconstructed in the stratigraphical schemes also. One alternation of Caspian and marine type deposits (Old Euxinian and Uzunlarian) has been recognized by Arkhangelsky and Strakhov (1938) and Neveeskaya (2007); two alternations were identified by Fedorov (1978) and Chepalyga (1997); three were proposed by Ostrovsky et al. (1977), Nesmeyanov and Izmailov (1995), and Yanina (2012). Thus, from one to three invasions of Mediterranean water and fauna have been identified respectively. The subsequent regression was noted by Fedorov (1978), Popov (1983), and others; the absence of a break between the Uzunlarian and Karangatian deposits was noted by Khrishev and Shopov (1979) and Grigoriev et al. (1985).

The beginning of the late Neopleistocene was marked by the Karangatian transgression. Its deposits are widespread and have been well studied (Arkhangelsky and Strakhov, 1938; Neveeskaya, 1965; Fedorov, 1978; Yanko et al., 1984, 1990; Grigoriev et al., 1985; Kuprin, 1988; Chepalyga et al., 1989; Nesmeyanov and Izmailov, 1995; Chepalyga, 1997, 2002; and many others). In the fullest stratigraphic schemes (Yanko et al., 1984, 1990; Chepalyga, 2002), deposits from three or four stages are identified; they differ on the basis of the presence of various stenohaline and euryhaline groups of organisms. The gulf of the maximum phase of the Karangat Sea extended to the watershed of the Eastern and Western Manych.

G. Goretsky (1966) and G. Popov (1983) recognized deposits from the Surozhian transgression, the existence of which has not been agreed upon by many researchers (Fedorov, 1978; Neveeskaya, 1965; etc.). The upper Neopleistocene ended with deposits of the Neoeuxinian basin, with a minimum level of -110 m (Ostrovsky et al., 1977; Balabanov and Izmailov, 1988) to -150 m (Ryan et al., 1997).

On the Holocene stratigraphy of the Black Sea, consensus is also absent. The structure of the deposits and the development of macro- and microfauna testify to stages in the basin's evolution, concerning which there is no agreement among researchers. According to Neveeskaya (1965), salinity increase in the sea and colonization by Mediterranean fauna proceeded gradually; she established four stages for such a development (Bugazian, Vityazevian, Kalamitian, and Dzhemetian). Fedorov (1978) assigned two phases of transgression: Old Chernomorian and Neochernomorian; in the late Holocene, he identified the Phanagorian regression and the Nymphaean transgressive phase. Other researchers (Balabanov and Izmailov, 1988; Yanko-Hombach et al., 2007) consider that the sea level rose gradually with an oscillating mode. In the Holocene, they noted not less than 5 transgressive and regressive phases in turn,

complicated by smaller rhythmic. According to the opinion of Ryan et al. (1997, 2003) and others, the Holocene transgression had a catastrophic character (Flood). This hypothesis divided scientists even more from a uniform point of view on the geological and geographical events in the region.

The basic goal of the IGCP-610 Project is to obtain new data on the environmental evolution of the Caspian-Black Sea Corridor using a multidisciplinary research strategy that comes with the advantage of mutual cross checking of results received independently from varied specialists. The results may lead to many consensus conclusions regarding the development of the region during the Quaternary as well as correlations of local events with adjacent areas.

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