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On the lower boundary of the Quaternary System in the Azov-Black Sea Basin

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Abstract. The data on the lowering of the lower boundary of the Quaternary System below the Gelasian Stage at 2.588 million years are presented in the paper. In Azov-Black Sea basin this boundary takes place within the middle of the Kuyalnikian Regionalstage and related to the magnetostratigraphic boundary Gauss-Matuyama and should be drawn under

the deposits of the upper Kuyalnikian regionalstage, Taman layers of the Akchagylian, alluvium X terrace of the Dnister, Danuba, Prut rivers, the Naprovan layers of the Priazovie and under sediments of the Siverian stage in the loess-soil series of the Ukraine. Below there lie the deposits of the Bogdanivkian stage and the lower Kuyalnikian rocks. The deposits of the Lowerkuyalnikian regionalstage, upper and lower Poratian beds and sediments of the Bogdanivkian, Kizlyarkian and Jarkian stage in the loess-soil series related to Piacencian stage and Upper Pliocene. Kuyalnikian deposits in the Odessa (Kryzhanivka) region are the upper part of the Upperkuyalnikian regionalstage, above the Tamanian beds and correlations with a Beregovian stage in the loess-soil series. Beginning of the maximum Akchagylian transgression in the Black Sea coincides with a sharp cooling Climate period (2,5-2,6 million years) and compares with the Middle Akchagylian transgression of the Caspian basin. Signs of the late Akchagylian mollusks at the basal beds of the Kuyalnikian of the Priazovie requires additional research, as at that time the formation of the lower Poratian deposits took place in a (with *Rugunio lenticularis*) Warm climate. The most probable version is the invasion of Akchagylian mollusks during the cocking in Ajdarian time. The author opinion on the reasoning of the lowering of the boundary and the problems of its use in geological mapping are also stated.

Key words: Dniester River Valley, Priazovie, Pliocene, Quaternary, stratigraphy

Про нижню границю четвертинної системи в Азово-Чорноморському басейні

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Анотація. В статті приведені матеріали щодо зниження нижньої границі четвертинної системи під відклади гелазійського ярусу в 2.588 млн. років. В Азово-Чорноморському басейні ця границя розміщується в середині куюльницького регіоярусу і співпадає з магнітостратиграфічною границею Гаус-Матуюма і буде проводиться під відкладами куюльницького регіопід'ярусу, таманськими верствами акчагілу, алювієм X терас Дніпра, Дунаю, Прута, хাপровськими верствами Приазов'я і відкладами сіверського етапу лесово-грунтової серії України. Нижче залягають відклади богданівського етапу та нижньокуяльницькі відклади. Відклади нижньокуяльницького регіопід'ярусу, верхньо- і нижньопоратських верств, богданівського, кизилярського і ярківського етапів лесово-грунтової серії співставляються з п'яченцьким ярусом і віднесені до верхнього пліоцену. Куюльницькі відклади району м. Одеса (Крижанівка) складають верхню частину верхньокуяльницького регіопід'ярусу (над таманськими верствами) і співставляються з берегівським етапом лесово-грунтової серії. Початок максимальної акчагильської трансгресії в Чорному морі співпадає з різким похолоданням клімату (2,5-2,6 млн. років) і співставляється з середньоакчагильською трансгресією в Каспійському басейні. Ознак пізньоакчагильської трансгресії в Азово-Чорноморському басейні не виявлено. Знахідки акчагильських молюсків в самих низах куюльнику Приазов'я потребує додаткових досліджень, оскільки в цей час відбувалось формування нижньопоратських відкладів (з *Rugunio lenticularis*) при теплому кліматі. Найбільш ймовірним є варіант інвазії акчагильських молюсків при похолоданні в айдахський етап лесово-грунтової серії. Викладено також думку автора про обгрунтування пониження нижньої границі і проблеми її застосування при геологічній зйомці.

Ключові слова: куюльник, пліоцен, стратиграфія, Приазов'є, долина Дністра.

Introduction. The question of the lower boundary of the Quaternary System has been considered by the geological community on many occasions. In 1839, Charles Lyell, author of the name «Pleistocene», proposed to define the lower boundary in marine sediments, if the assemblage of marine organisms contains 90% of modern species. With the development of Quaternary geology, the identification of glacial and interglacial deposits, the rhythmicity of subareal formations became of primary importance in solving the problems of boundaries, which involved the climatic component. So in 1948, at the 18th International Geological Congress (IGC) in London, it was proposed to draw the lower boundary of the Quaternary System under the marine Calabrian deposits, in which the first Arctic species of molluscs and foraminifera appeared in the Mediterranean Sea. In the continental sediments, this boundary had to be placed under the deposits of the Villafranchian Stage. However, the proposed version of the lower boundary was adopted only during the 27th IGC, which was preceded by detailed work on the choice of the Calabrian stratotype. The argument has already clearly outlined the climatic paradigm, such as penetration into the Mediterranean basin of cold-water migrants from the Atlantic (in particular, *Arctica islandica*), the appearance of the Pretiglian spore and pollen assemblage in the Quaternary deposits of Western Europe, which marked the global cooling in the Northern Hemisphere. The appearance of the Villafranchian association of large mammals was also mentioned. The section “Vrika” was chosen as the Global Point. In this section, the lower Quaternary boundary is positioned above the subchron Oldway - 1.81 million years (Ma). Later studies have shown that the migration of marine species of fauna from the North Atlantic (such as *Arctica islandica*) and the occurrence of Pretiglian assemblage of pollen took place much earlier than 2 million years ago, and the Calabrian corresponds only to the upper Villafranchian.

Supporters of the lowering of the Quaternary lower boundary have chosen a significant cooling-(ice age) of about 2.5 million years, which corresponded to the critical point of the evolution of the Earth’s climate system, namely the appearance of glaciation in the Northern Hemisphere. This argument was the main one of the proposed options (Head, Gibbard, Salvator, 2008; Finney, 2010) and endorsed by the Executive Committee of the International Union of Geological Sciences. The changes in the International Stratigraphic Scale (ISC) for the Neogene and Quaternary systems were ratified. According to these changes, the lower boundary of

the Quaternary System is drawn in the section of the Global Stratotype and the Global Point (GSSP) of the Gelasian Stage “Monte san Nicola” on the southern shore of the island of Sicily near the city of Gala, 1 m above the magnetostratigraphic boundary of Gauss - Matuyama, at the beginning of the “warm” isotope stage of IOP. Above this boundary the extinction of carbonate nanno-fossils *Discoaster pentaradiatus* and *D. surculus* is recorded. In the justification of the abovementioned idea, we should note the beginning of loess sedimentation in China, human development and practical considerations.

Thus, stratigraphy of the Quaternary System has a clearly expressed climatic paradigm, as opposed to the stratigraphic one, which is incorporated in the construction of the ISS. On the one hand, this approach to the Quaternary System is justified, taking into account the frequency of glaciations, interglaciations, formation of loesses and buried soils, regressions and transgressions. Selection on this basis of climatostratigraphic subdivisions is the basis for regional stratigraphic schemes, and the development of the isotope-oxygen scale (MIS) has proved the global nature of climate changes. However, no matter how perfect climatostratigraphic subdivisions are, without biostratigraphic, paleomagnetic and absolute age data, they do not solve one of the main tasks of geological survey - the correlation of glacial and interglacial subdivisions of different regions and sedimentation environments. As an example, we can cite the age identification of the Don moraine, which was compared with that of the Dnieper moraine. However, after the processing of the paleontological material, in particular, the remains of small mammals, the difference in age of the abovementioned moraines was proved. Such examples are also known in the stratigraphy of loess formations.

Returning to the question of the validity of the definition of the Quaternary lower boundary by the climatic factors, there is no guarantee of a re-examination of the problem. After all, significant cold fluctuations are observed at the boundaries of 3.2, 3.4 million years (not to mention 5.5 million years), glaciation of Greenland - 3.3 million years, the data on the beginning of loess sedimentation in 2.8 million years. At the same time, we must admit that addition of the Gelasian Stage to the Quaternary System can serve as an example of a combination of climatic and biostratigraphic criteria, which we will discuss in the following sections of this article.

Discussion of the problem of the lower boundary of the Quaternary System in the Azov-Black Sea Basin. In accordance with the approved lower boundary of the Quaternary System at 2.588 million

years in the Azov-Black Sea Basin, it takes place within the middle of the Kujalnikian Regio-stage (Gozhik, Matoshko, 2011), the upper part of which belongs to the Pleistocene, and the lower part - to the Pliocene.

In this paper there is no possibility and need to discuss all the papers on the Kujalnikian Stage, so we focus on the main localities where freshwater molluscs, mainly unionids and viviparids, have been found. The choice of these mollusks is dictated by directional evolution during the Pliocene, with broad migration on the background of global climate change. All this is the basis for the subdivision of the Kujalnikian deposits and correlations with the Akchagilian and alluvial deposits in the river valleys of the southern part of the East European Platform.

The “Kujalnik Beds” were discovered by I.F. Sintsov (1875) near the city of Odessa, where they overly with erosion the Pontian and Meotian deposits. After processing the paleontological material, he subdivided these beds into 2 horizons: the lower horizon - with the marine and freshwater molluscs and the upper one - with the freshwater ones. Among the freshwater molluscs a new species of viviparid was established - *Viviparus subconcinus* Sinz., which occurs both in Kujalnikian and in the coeval alluvial deposits. I.F. Sintsov (1877, 1897) assigned the lower and upper horizons to the new (upper) Pliocene.

The stratigraphic position of the Kujalnikian deposits has long been controversial. E. Andrusov (1897) placed them above the ore-bearing layers of the Kerch-Taman region.

N.P. Mikhailovsky (1902, 1905), studying the deposits near Pakveshi village at the Galizga River, which overlie Kimmerian rocks, mentioned a fauna somewhat different from that described by I.F. Sintsov around the city of Odessa. Considering the Kujalnikian deposits in the rank of the stage, he believed that the beds of the Galizga represent the lower horizon of the Kujalnikian Stage, and that the deposits described by I.F. Sintsov belong to the upper Kujalnikian (Mikhailovsky, 1909).

V.D. Laskarev (1912) compared the upper horizon with the remains of mammals with the Villafranchian Stage. T.A. Mangikian (1929) believed that there were no grounds to distinguish two horizons within the section of the Kujalnikian deposits in Odessa region due to the identity of the freshwater mollusc assemblage in both of them. The new species distinguished by Magnikian (*Unio tanphilevi*, *U. kujalnicensis*, *U. alexeevi*, *Viviparus pseudoachetinooides kujalnicensis*) later were mentioned, as a rule, by other researchers from the Kujalnikian deposits of the Azov Sea area.

An important stage of the knowledge of Kujalnikian deposits was the study of V.N. Krestovnikov (1928). He established and described several new species of molluscs: *Limnocardium limanicum*, *Pachydaena subkujalnicensis*, *Dreissenssia theodori kubanica* and *Valvata vanciana*, which became characteristic of the lower Kujalnikian deposits (in the understanding of N.P. Mikhailovsky) of the Taman and Kuban regions.

A.G. Eberzin (1931) discovered deposits with the Akchagilian mollusc *Avimactra subcaspia* in the Crimea and included them in the Tamanian Horizon, which, in his opinion, could not be older than the upper horizon of the Kujalnikian Stage. The Akchagilian molluscs were discovered by IM Gubkin (1931) in the overlying ore-bearing strata of the area of Durnoselivka village and adjacent territories of the Taman Peninsula. Having subdivided the strata into 3 horizons, he noted that the Kujalnikian molluscs as well as the Kimmerian ones are characteristic for the lower horizon, the Kujalnikian and the freshwater ones – for the middle horizon, and the Akchagilian and Kujalnikian ones - for the upper one. It is important for us to emphasize that in the middle horizon among the freshwater molluscs Gubkin identified *U. tamanensis* and the gastropods similar to those occurred in the Paludinian beds of Slovenia. He considered the upper horizon to be the youngest Kujalnikian described by V.N. Krestovnikov (1928) and that it corresponded to the upper horizon of the Kujalnikian.

G.I. Molyavko (1948) significantly expanded knowledge of the distribution area of the Tamanian deposits of A.G. Eberzin in the Crimea and noticed the presence there of large debris of unionids of the Levantinian appearance.

Generalization of data on the Kujalnikian sediments of the Azov-Black Sea region was performed by A.G. Ebersin (1940). He assigned the Krasnodarskian Horizon with *Unio sturi* Horn., the Tamanian Horizon with *Avimactra subcaspia* Andr. and the Kujalnikian Stage with *Limnodaena limanica* Krest. to the Upper Pliocene.

The second most important region of the distribution of the Kujalnikian deposits is the Priazovie, where they were studied mainly using drilling data, which were rarely accompanied by the collection of paleontological material.

G.I. Molyavko (1950) established the distribution of Kujalnikian deposits within the limits of the Lower Dnipro and Melitopol district, the Prisivash and the Crimea. The Kujalnikian deposits are represented by mainly clays with interlayers of clayey sands and only

in the Lower Dnipro area - by sands, inequigranular at the base with pebbles of sedimentary and crystalline rocks (the facies of erosion). In the upper part of the section the remnants of molluscs were practically not collected, but in the lower part the following fossils were found: *Dreissena theodori* Andr. var *kubanica* Krest., *D. polymorpha* Pall., *D. fogti* Ebers., *Prosodacna sinzovi* Ebers., *P. subkujalnicensis* Krest., *Limnocardium skadovkaense* Ebers., *Momodacna cf. sibrigeli* Sinz., *Unio* sp., *Viviparus subconcinus* Sinz., *Valvata* sp., *Lithoglyphus* sp. Subsequent studies of the Kujalnikian sediments revealed the remnants of freshwater molluscs also in the upper horizon, among which *Viviparus subconcinus* Sinz, *Planorbarius* sp., *Planorbis* sp., *Valvata* sp. and others were identified.

The discovery of the "Levantine" unionids in the Lower Kujalnikian deposits of the Azov Sea area, described by G.I. Molyavko and Yu.I. Selin (1957), was extremely important. In the area of the villages of Botievo and Orlovka *Unio cf. rumanus* Cob., *U. lenticularis* Sabba, *Unio* sp., *Dreissena polymorpha* Pall., *Melanopsis* sp., *Viviparus* sp., and *Valvata* sp. were found in the cores of boreholes. The presence of sculptured unionids and melenopsids of the Levantine appearance gave the authors the basis for correlation of the Kujalnikian deposits with the lower horizon of the Levantine (Poratian) Stage.

In the Skadovsky district the valve of *Unio bielzi* Czek was found in the sandy strata of the borehole at the depth of 90 m near the village of Karga. In the same area, according to the data of the abovementioned authors, at the depth of 85.1 m A.G. Ebersin identified the Kujalnikian molluscs *Pachydacna kujalnicensis* Krest., *Limnocardium limanicum* Krest. and the fragments of gastropods of the Levantine appearance (emphasized by us).

Detailed investigations of the Kujalnikian and Kimmerian sediments performed by V.M. Semenenko (1960, 1966, 1975, 1987) significantly supplemented the data on the distribution and species composition of marine and freshwater molluscs. He distinguished two horizons in the Kujalnikian strata. The upper one is most clearly represented in the Melitopol region, where in the clays, sometimes sandy ones, and siltstones *Unio kujalnicensis* Mang., *Unio tenphilevi* Mang., *Viviparus subconcinus* Sinz., *V. bethinicus* Mang. and others were discovered, that is, the species typical for the Kujalnikian deposits of Odessa region. The lower horizon of the Kujalnikian here contains *Limnocardium limanicum* Krest., *Pachydacna kujalnicensis* Andr., *P. subkujalnicensis* Krest., *Prosodacna cf. miser* Ebers., *Didacnomya vulgaris* Sinz. In a generalized list of fauna of the lower Kujalnikian, V.M. Semenenko (1987) indicated the

following freshwater molluscs: *Dreissena theodori kubanica* Krest., *Dr. rostriformis* Desh., *Potomida neustruevi* Andr., *Unio lenticularis* Sabba., *U. cf. rumanus* Cob., *U. krajovensis slanicensis* Teiss., *Viviparus ex gr. turritus* Bog., *V. aff. subconcinus* Sinz., *Lithoglyphus neumayri* Sabba, *L. acutus* Cob., *Bithynia uncotinovici* Brus., *B. spoliata* Sabba, *Melanopsis esperoides* Sabba. *U. neustruevi* and *U. lenticularis* are of particular interest. Unfortunately, there was no indication which part of the lower Kujalnikian contained the abovementioned unionids.

In the basal part of the Kujalnikian deposits of the Northern Priazovie V.M. Semenenko (1975, 1987) registered the remains of *Avimactra subcaspia* Andr. and *Cárdium dombra* Andr., which raises the question of the time of the first migration of Akchagilian molluscs to the Black Sea.

The Kujalnikian deposits in the Steppe Crimea with *Limnocardium limanicum* Krest., *Dreissena theodori kubanica* Krest., *Viviparus sinzovi* Pavl. and *Unio* sp. overlie the Pontian, and on the Kerch Peninsula - the Kimmerian rocks. In the Indole and Chigerchinska troughs above the Tamanian strata A.G. Ebersin (1940) discovered the fragments of *Didacna ? cf. digressa* Livent - the marker of the Gurian layers of the Black Sea. In the Steppe Crimea above the Tamanian layers, G.I. Molyavko (1938) identified greenish waxy clay with numerous *Coretus*, *Planorbis*, *Limnaea*, *Dreissena* and smooth *Unio* (Tjup-Dzhankoian beds).

According to V.M. Semenenko, the Lower Kujalnikian deposits of the Azov Sea area and Western Georgia are directly magnetized and belong to the Gauss era. The Upper Kujalnikian, Tamanian and Tjup-Dzhankoian beds are inversely magnetized and correspond to the lowermost part of the Matuyama epoch, as well as the middle- upper Akchagilian deposits of the Caspian Sea basin.

From the material above, it follows that a number of issues concerning the Kujalnikian deposits are still controversial. These are their subdivision, correlation with the Akchagilian and Tjup-Dzhankoian layers, the volume of the upper Kujalnikian and its correspondence to the Tamanian Horizon, appearance of the Akchagilian molluscs in the Azov-Black Sea region and the definition of the lower boundary of the Kujalnikian Regio-Stage in the continental formations (Semenenko, 1987; Vernigorova, 2016). In this regard, let us discuss the geological, paleontological and climatic factors of these problems.

First of all, let us consider the structure of the reference section of the Kujalnikian deposits near the village of Kryzhanivka, described in detail by M.F. Veklych (1968). The upper horizon, defined

by I.F. Sintsov (1877), is represented by the eluvial, lacustrine and alluvial deposits (Fig. 1), which M.F. Veklych compared with the Berezanian stage of the formation of the loess-soil series of Ukraine. At the base of the horizon there are inequigranular sands with the interlayers of gravels and pebbles (erosion facies), in which the remains of small mammals of the Odessa complex (Shevchenko, 1965) corresponding to the early stage of the Tamanian faunal assemblage have been discovered. The freshwater molluscs were found both in the alluvial and lacustrine sediments. However, in the alluvial deposits, rheophilous molluscs dominate, and in the lacustrine deposits – stagnophilous ones. Among the rheophiles that evolved more rapidly during the Pliocene, we should note *Unio kujalnicensis* Mang., *U. tanphilievi* Mang., *U. alexeevi* Mang., *Viviparus subconcinus* Sinz., *V. sinzovi* Pavl., *V. pseudoachatinoidea* Desh., *Melanopsis esperoides* Sabba., *Bithynia vucatinoviei* Brus., *B. spoliata* Sabba. The lower horizon of I.F.

Shintsov, compared by M.F. Veklych (1968) with the Beregovian stage, is represented by marine, alluvial-marine and lagoon-swamp formations (Fig. 1). The remains of small mammals were collected from the gravel interlayers and distinguished as the Kujalnikian assemblage (Shevchenko, 1965), which belongs to the Haprovian faunal assemblage. The freshwater molluscs discovered in the alluvial-marine and marine sediments are mainly rheophilous and have almost the same composition as in the upper horizon. Characteristic forms, *Unio kujalnicensis* Mang., *U. tanphilievi* Mang. and *Viviparus subconcinus* Sinz., are distributed far beyond the stratotype (Kryzhanivka village) from the Priazovie to the Taman Peninsula (the Taman beds), the Pskepus River valley, Akchagilian of the Volga region. I.Ya.Yatsko (1954) discovered *Unio rumanus* Tourn. and *Limnoscapha semiornata* Bolgin. together with *Unio kujalnicensis* at the base of the Kujalnikian eastwards of the Tiligul estuary, which gave grounds to suggest the proximity of the

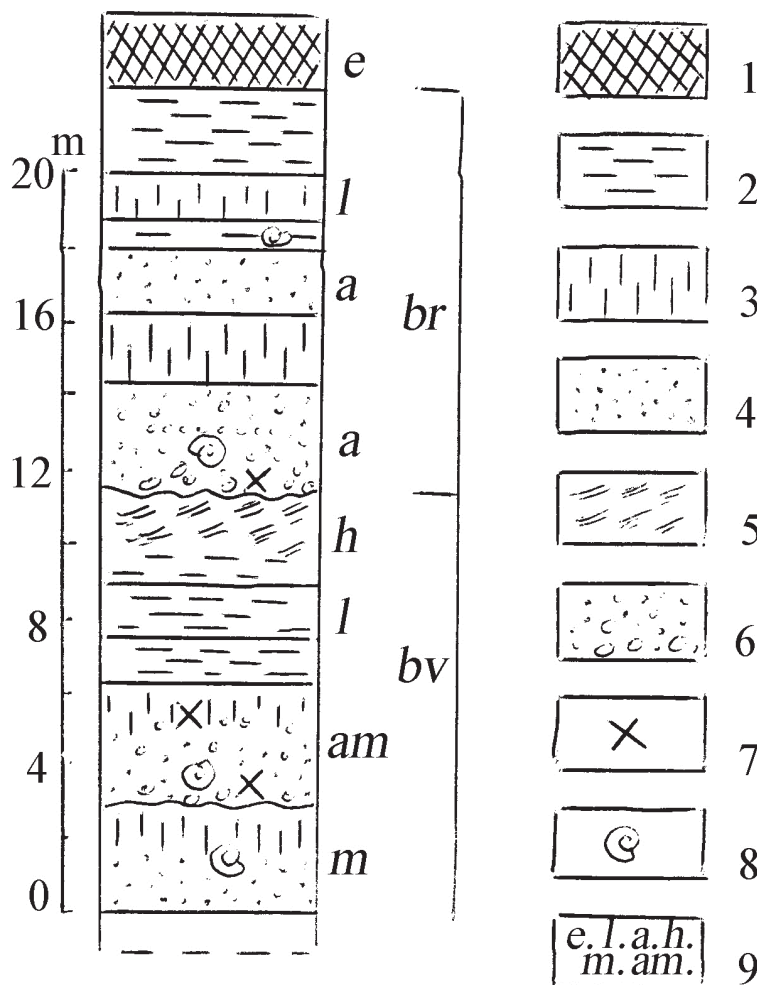


Fig. 1. Section of the Kujalnikian deposits near the village of Kryzhanivka
 1 - red-brown buried soil; 2 - clays; 3 - sandy loam, loam; 4 - medium-fine-grained sands; 5 - lagoon-marsh soil formations; 6 - inequigranular gravels and pebbles; 7 – remains of small mammals localities; 8 – molluscs’ localities; 9 - genetic indices: e - eluvium; deposits: l - lacustrine, a - alluvial, h - marsh, m - marine, am – alluvial- marine.

Kujalnikian Stage to the Dacian.

Deposits of the upper and lower horizons have inverse magnetization (Matuyama), and only at the boundary between them is there a zone of directly magnetized rocks (Tretiak, Volok, 1976), which can be compared with the subchron Oldway (1.77-1.95 million years). Taking into account the paleontological and paleomagnetic data, M.F. Veklych (1982) identified the age of the Berezanian phase as 1.90-1.61 million years, and the Beregovian at 2.430-1.90 million years.

Freshwater molluscs from the Lower Kujalnikian sediments of the Azov Sea area deserve special attention due to the occurrence of unionids characteristic of the lower and upper Poratian strata. Their belonging in the stratotype area to the NSM11 Zone - *Moldavunio lenticularis* - *Valachunio iconomianus*, identifies the age of 3.7- 2.7 million years (Andreescu, 2009). The early Poratian species *Moldavunio* (= *Rugunio*) *lenticularis* Sabba belongs to the NSM11a Subzone, and the late Poratian species *Pelendunio* (= *Rytia*) *bielzi* Czek belongs to the NSM11c Subzone. According to the paleomagnetic data, the NSM11 zone is comparable to the Gauss epoch, in which, as noted earlier, the Lower Kujalnikian deposits are placed. Accordingly, *M. lenticularis* should correspond to the lower part, and *P. bielzi* - to the upper part of the Kujalnikian Regio-Stage. Besides Wallachia (Romania), *M. lenticularis* was found in the Lower Poratian (= Lower Levantinian) deposits of the lower part of the Prut River. M.I. Andrusov (1963) described *Unio lenticularis* Sabba var *samarica* and *U. neustruevi* Andr. var. *geometrica* from the deposits of the Wolf's gully of the Volga River area

The Upper Poratian deposits which contain the remains of *Pelendunio bielzi* Czek., unconformably (with erosion) overlie the Dacian rocks in the Danube River valley and are placed in the stratigraphic scheme above the Lower Poratian. Besides the lower reaches of the Prut and the Danube rivers (Ripa Skortselska and Dolynske), *P. bielzi* was described from the middle-upper Paludinian beds, of Slavonia, Pelendavian Substage of Romania, the lower Kujalnikian of the Priazovie, the Don Valley near the station of Nagavska (so-called the Nagava beds). The late Poratian species were recorded also in alluvium of XI (Vadyluivodska) terrace of the Dniester River (Chepalyga, 1967).

Viviparus turritus Bog., the characteristic form of the Kinel beds of the Volga River region, was found in the lower Kujalnikian of the Priazovie and the Upper Poratian near the village of Dolynske (the Danube River Valley). Numerous remains of late Poratian viviparids such as the sculptured *V. bifarcinatus* Bielz.

and *V. rudis strossmayerianus* Brus., as well as those with smooth shells *V. turritus* Bog., *V. sinzovi* Pavl., *V. craiovensis* Poz. and *V. proserpinae* Bog. occurred in inequigrained sands with gravel near Dolynske. As the sculptured viviparids were not found in the younger deposits, it is logical to admit that a significant cooling preceded the formation of the Upper Poratian deposits.

Bogatschevia (= *Unio*) *tamanensis* Ebers. and *B. bugasica* Ebers are characteristic forms of the Tamanian Horizon. The narrow stratigraphic range of *B. tamanensis* is the basis for correlation of the marine Tamanian and middle Akchagilian deposits with the alluvial ones. The continental (terrestrial) equivalents of the Tamanian beds are the alluvial deposits of the Psekups River near the Saratovska stanytsya, Haprovian beds of the Priazovie, alluvial deposits of the X terrace of the Dniester River (the Rashkivska, Ferladanska), the Danube River (Kotlovynska), the Prut River (the Roshska). The remains of small mammals of the deposits correlated with the Tamanian Horizon belong to the Haprovian faunal assemblage.

The Romanian researchers (Andreescu, 2009; Andreescu et al., 2010) assigned the deposits with *Bogatschevia tamanensis* and with boreal *Unio kujalnicensis* to the Wallachian Regio-Substage in the 2.4-2.0 million years range, *Bogatschevia sturi* Hornes was dated as 1.8- 1.6 million years. The presence of *B. sturi* in the alluvium of the IX terrace of the Dniester and Danube river valleys and the Lower Apsheronian deposits of the Kuban does not contradict that.

Detailed analysis of the spore-pollen complexes of the Kujalnikian and subaerial deposits of the Priazovie, represented by O.A. Sirenko (2017), showed that the upper Kujalnikian corresponds to the Beregovian stage, the middle Kujalnikian – to the Siver stage, under which the magnetostratigraphic boundary Gauss - Matuyama is fixed. Thus, the lower boundary of the Quaternary System of 2,588 million years is drawn under the Siver deposits. Below lie the deposits of the Bogdanovkian Stage and the lower Kujalnikian rocks. At the same time, Sirenko came to the conclusion that the essential cooling took place at the beginning of the Siver stage, with which we associate the invasion of the Akchagilian molluscs into the Black Sea, which most likely occurred between 2.6 and 2.4 million years. This is the time of maximum Akchagilian transgression in the Azov-Black Sea Basin, whose traces were found on the shores of the Dardanelles Strait (Taner, 1970).

As for the occurrence of the Akchagilian molluscs at the base of the Lower Kujalnikian in the Priazovie, it was obvious that this could have happened at the end of the Pontikipean time, when there was a

Table 1. Subdivision chart of the Kujalnikian deposits

Age (Ma)	ISC		Polarity	Regional			Azov-Black Sea Basin	Alluvium sediments terraces	Fresh – water Molluscs			
	System	Stage		Stage	Substage	Climatolites						
1.8	Q u a t e r n a r y	C a l	C1			Lower Gurian	IX Boshernitsa	<i>Margaritifera arca</i> , <i>Bogatschevia sturi</i> , <i>Unio apsheronicus</i>				
2.0	G e l a s i a n		C2n	U p p e r	K u j a l n i k i a n	Upper Kujalnikian	X Ferladany	<i>Planorbium corneus</i> , <i>Planorbis</i> , <i>Limnea</i> , <i>Valvata</i> , <i>Unio</i>				
2.2												
2.4										Tamanian beds	XI Vady Luj Vode Upper Poratian beds	<i>Bogatschevia tamanensis</i> , <i>Unio kujalnicensis</i> , <i>Dreissensia theodori kabanica</i> , <i>Rugunio lenticularis samarica</i>
2.6										Galizgian beds	Beds with Akchagilia ?	<i>Pristinunio pristinus</i> , <i>P. davilai</i> , <i>Rytia bielzi</i> , <i>Viviparus turritus</i> , <i>V. bifacinctus</i>
2.8												
3.0						P i a c e n c i a n		C2An-1n	L o w e r	Lower Kujalnikian		Lower Poratian beds
3.2												
3.4					Bacteria beds							
3.6			C2An-3n									

significant cooling, recorded in the deposits of the Aidar stage of the loess-soil series of Ukraine.

Conclusion. An analysis of the available material makes it possible to draw the following conclusions. The lower boundary of the Quaternary System should be drawn under the deposits of the upper Kujalnikian, Taman layers of the Akchagilian, alluvium of the X terrace of the Dniester, Danube and Prut rivers, the Haprovian layers of the Priazovie and under the sediments of the Siver stage in the loess-soil series. This boundary of 2.588 million years is related to the magnetostratigraphic boundary of Gauss - Matuyama (Table 1). The Kujalnikian deposits in the Odessa region are the upper part of the upper Kujalnikian Substage, above the Tamanian beds.

The lower boundary of the Kujalnikian Regio-Stage takes place at the level of 3.6 million years, separating the cold Aidar stage and the Yarkov - the warmest in the Late Pliocene, to which the formation of the lower Poratian deposits belongs. The upper part of the lower Kujalnikian is compared with the accumulation of the upper Poratian deposits and the Bogdanovkian stage of soil formation. The climate cooling and activation of erosion activity took place between the accumulation of the lower and upper Poratian.

The beginning of the maximum Akchagilian transgression in the Black Sea coincides with a sharp cooling period (2.5-2.6 million years) and compares with the middle Akchagilian transgression of the Caspian basin. Signs of the late Akchagilian transgression in the Azov-Black Sea basin were not registered, however, according to paleomagnetic data at the Voyevodino section, it can correspond to the time of sedimentation of the Tjup-Dzhankoy sediments.

Occurrence of the Akchagilian molluscs at the basal beds of the Kujalnikian of the Priazovie requires additional research, as at that time the formation of the lower Poratian deposits took place in a warm climate. The most probable version is the invasion of Akchagilian molluscs during the cooling in the Kyzyllyarian time.

Drawing the lower boundary of the Quaternary System at 2.588 million years created a number of inconsistencies in conducting geological surveys. Previously, the Kujalnikian deposits in full volume had been shown on the geological map, but by the current position of the abovementioned boundary, the upper Kujalnikian would be represented on the map of the Quaternary deposits, and the lower Kujalnikian - on the geological map. At the same time, it should be noted that 70% of the territory has already been surveyed and geological maps of scale 200,000

published. The remaining geological sheets will have a different loading and will cause some difficulties in the modeling of the geological structure of the regions and sedimentary basins in the future.

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