УДК 551.465+551.242

© E.Konikov, S.Faschevsky, G.Pedan, 2009
Odessa National University, Ukraine

EXTREME FLUCTUATIONS OF THE BLACK SEA LEVEL IN NEOEUXINE-HOLOCENE AS THE ALTERNATIVE OF CATASTROPHIC FLOOD HYPOTHESIS

This paper presents the pictures of paleogeography and variations of sea level of the Black Sea basin in Neoeuxinian and Holocenian stages under discussion relative to the hypothesis of catastrophic flooding presented by Ryan W et.al. (1997, 2001). Based on lithologic-genetic analysis of sediments, biostratigraphy, absolute dating tests and chemical composition of interstitual water on the shelf and estuaries, paleographyc maps for the main events of the Late Neoeuxinian-Holocenian history of basin was constracted. It is given evedences against probability of catastrophic flooding in the early stage of Neoeuxinian transgression and over Holocene.

Introduction. Recently, one could notice few publications in foreign geological magazines, presenting new vision on the Black Sea region paleogeography in Late Pleistocene, i.e., from an Early Neoeuxine till the beginning of Holocene. This “new vision” largely deviates from the existing notions, based upon nearly 100 years long studies of the basin.

In their articles, W.Rayan with co-authors [27, 28] has mainly exposed to revision two fundamental milestones of the Black Sea history in Neoeuxine: 1) the extent of the Neoeuxinian regression; 2) dynamics and rate of transgression of the sea in the period between 18–9 kyr BP. Using relatively scarce drilling data originating from the outer shelf and upper part of the continental slope, as well as seismic-acoustic profiles at the North-Western sector of the Black Sea, the authors make conclusion that the surface of the Neoeuxinian “sea-lake”, during the maximum of Wurm cold event (W_3), was 140–150 m below the contemporary level. Speaking about the second milestone, a hypothesis of catastrophic flooding is valid in their opinion, as to the fact by almost momentary, in terms of geology, water uprise: just in two years the sea level moved from −140m till circa −50 m (between 11 и 10 kyr BP). This happened through an influx of salty waters via the Bosporus straits, and as a consequence was a massive extinction of fresh water molluscs and fishes, as well as invasion of stenohaline species of marine fauna. It also argued to be 3 floods at minimum: two ones in Neoeuxine and one in Early Holocene (8.4 ky BP). Hereby, W.Rayan with co-authors [27, 28] refer to reports of well-known researchers, although these references are not always convincing to our opinion.

It should be noted that the ‘flood’ concept is not so innovative. Back to 1979, N.G.Avenarius presented calculations of the Black Sea balance; based on them an assumption was made that the sea level had been rising by 1m/yr in average after 18 kyr BP, as a result of climate warming and increased run-off of rivers, until the sill level of Bosporus straits (~ 60–50 м) has been reached. If so happened, the up rise of water level could have taken 70 years only [1].

Majority of Russian and Ukrainian experts of Pleistocene and Holocene of the Black Sea (including the ones W.Rayan refers to), have expressed as assumption or insisted that the level of the Neoeuxinian basin was not below –90...–110 м in its regressive phase [5, 6, 19, and others), while in opinion of [2], not below than –60 м. Beginning from 1the 18 kyr BP (or 14 kyr BP after some other publications), the sea level began rapidly rising and, by approximately 9 kyr BP, it stabilized at 20–30 м below the contemporary sea level [20]. That means that the transgression had an average rate of circa 10 мм/year. After that, for the last 9th.years, the sea level has gradually reached a nowadays sea level and, even, overcome it by 2–3m, in the period of climatic optimum (5–6 th. years ago). Hence, the rate of transgression is gradually slowing down in Holocene (the rate has reducede till 3–2 mm/year in average).

Well proven is also that the sea level fluctuations in Holocene represented transgressive-regressive rhythms having a frequency of 1800–2000 years and amplitude 5–15 m [3, 5, 10, 17, 18, and others]. As to the similar rhythms in Neoeuxine, only few suppositions are found in monography by edited E.F. Shnyukov [5]. To clarify this issue, a thorough analysis of the sediments at the shelf, their structure, is required involving all initial data already available and, possibly, making additional drillings and absolute dating of the sediments.

The ‘flood’ hypothesis has caused a polemics in various publications and valid, as to our opinion, criticism by several experts [22, and others]. With this article the intention is to take part in this discussion, as we have an extensive archive of drilling projects at the shelf available, as well as outcomes from lithological, hydro-chemical, geophysical and paleontologic studies at North-Western and other areas of the Black Sea shelf.

In this publication, it is one more time attempted to analyze and systemize the actual facts available with us, make an inventory of information from publications and our own notions regarding this stage of geology of the Black Sea basin. An outcome of these studies is an number of paleontologic and paleogeographic models of Neoeuxinian-Holocenian time. These models are presented for the main reference points (time marks) of the Neoeuxine-Holocene in the form of a set of paleogeographic maps and maps of litho-genetic structures.

Data and methods of research. To meet the objectives established, the authors of this publication have reviewed as many as more than 300 rotary core drillings (boreholes), 20–100 m deep, as well as more than 2000 vibrocores, up to 4,5m in depth. Special attention was paid to analyzing bedding patterns of the sediments containing typical for Neoeuxinian association of shell-fish (for most of the drills, fauna has been studied by N.N.Traschuk, Institute of Geological Sciences, Kiev, Ukraine). For several drills, an assessment of geotechnical properties, chemical composition and mineralization of pore waters down the column has been made.

To analyze a number of the Geological Public Enterprise ‘Odessmorgeo’ seismic-acoustic profiles have been scrutinized in order to study regional variations of bedding conditions, composition and properties of the different in age sediments. Besides, an inventory of publications and archives containing absolute dating has been made. Table presents an inventory of absolute dating measurements of the Early Holocene and Neoeuxinian sediments of Black Sea shelf and near-shore estuaries or limans (Fig. 1). This information is used to demarcating the stratigraphical borders and constructing reliable paleogeographic models. Sampling points are shown at the map of data (Fig. 1).

One of the main techniques for constructing the maps of lithography was litho-genetic (facial) analysis, including also biostratigraphic description of the sediments. While the paleographic maps were in the process of development, a

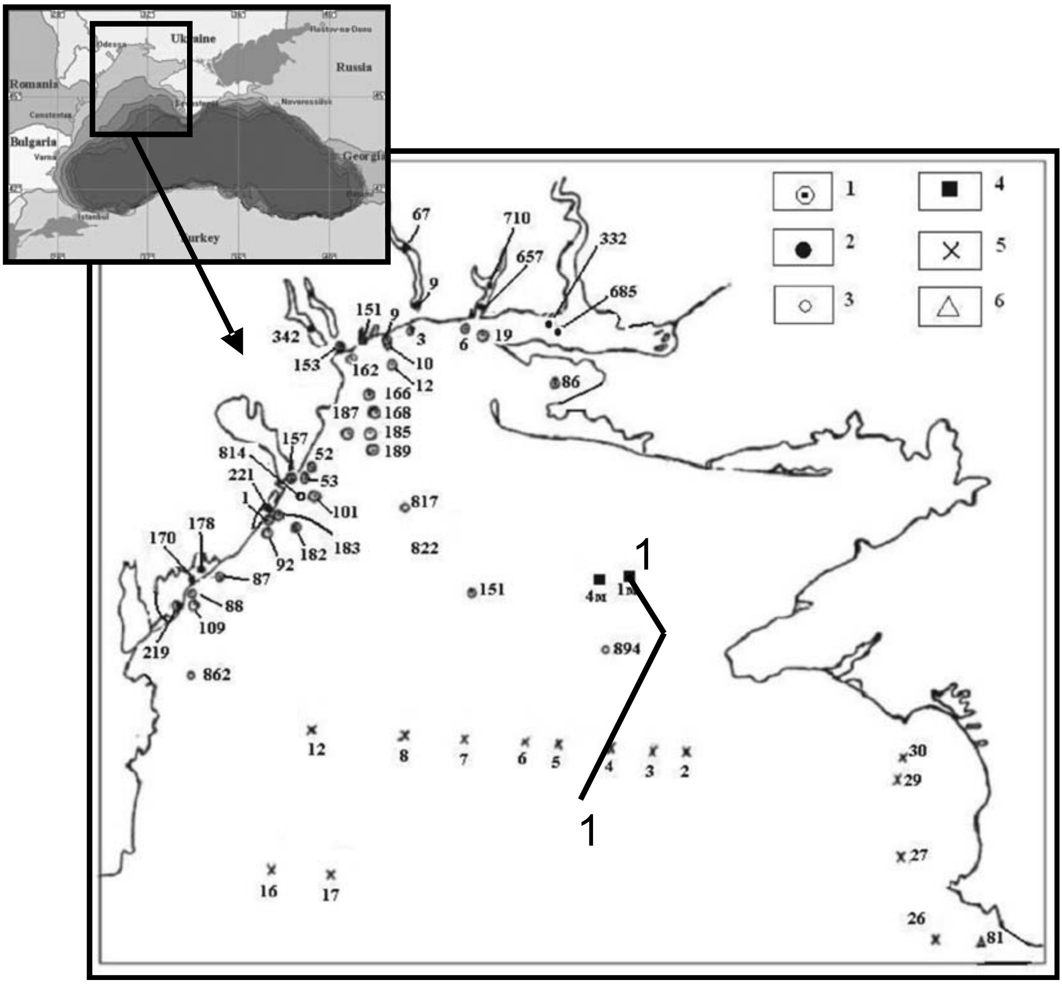

Fig. 1. Sampling points are shown at the map of data: 1 – borehole, Black Sea Regional Geological Public Enterprise "Prichernomorgeologia" (Odessa, Ukraine); 2 – vibrocore, Moscow Lomonosov University "MGU" (Russia); 3 – vibrocore, Odessa National University "ONU" (Ukraine); 4 – borehole, Odessa Marine Geology Enterprise "Odessmorgeo" (Ukraine); 5 – borehole, Ukrainian Civil and Hydro Surveys Institute "Ukrgiprovodhoz" (Kiev, Ukraine); 6 – vibrocore, Institute of Geological Sciences "IGN" (Kiev, Ukraine)

special attention was at demarcating the near-shore facies of sediments, which, in essence, pinpoint ancient coastlines; in this connection, the radiocarbon dating of sediments was also taken into account. To restore paleo-landscapes, a thickness of Holocene sediments has been taken into consideration. The sedimentation conditions were studied through the review of chemical composition and salinity

Radiocarbon dating (^{14}C) of Late Pleistocene sediments related to various bathymetric levels of the North-Western Shelf, Black Sea

№	№ and name of a drilling	Bathymetric level, м		Short description	Absolute dating, years	Location of a sample in a profile. Sampling point.
		Collar of drill	Level of a sample			
1	2	3	4	5	6	7
1.	81, MU*	100	102,73	Shell valves of Dreissena rost., present in shell-silty muds.	13500 ±450	Basic part of Holocene layer – upper edge of novoevskin sediments.
2.	"–"	"–"	104,99	Sandy shell stone	17780±200	Bottom of Pleistocene sediments, beach facie.
3.	894, OMGE	63	64,30	Inclusion of shells of Dreissena polim. in shell sandy muds.	12400±500	Top of Pleistocene sediments – bottom of Holocene sediments.
4.	822, ONU	31	34,80	Yellow-gray sandy clay with shell debris and valves.	12700±500	Top of Pleistocene sediments. Alluvial-marine facies.
5.	1M, OMGE	29,7	32,00	Inclusion of shells of Viviparus fasc. in shell silty muds	12050±470	Boundary between novoevksin and Holocene sediments. «Golicino» structure.
6.	4M, OMGE	30,0	32,00	"–"	10200±450	"–"
7.	289, OMGE	+0,3	26,7	Inter-layers of organic matter in sandy muds of a barrier spit.	8610±170	Basic level of Holocene sediments. Bolshoj Adzhaljukskiy liman.
8.	10, BSPRGE	17,8	28,70	Peat with remnants of flora.	8240±80	Basic level of Holocene sediments. Great Dnieper Delta
9.	9, BSPRGE	11,5	27,80	"–"	8880±290	"–"
10.	12, BSPRGE	9,5	25,10	"–"	8400±300	"–"
11.	19a, BSPRGE	6,0	16,0	"–"	10800±300	Basic level of Holocene sediments.
12.	817, ONU	20,0	22,70	"–"	7100±105	"–"
13.	53, BSPRGE	10,0	13,0	Sandy clayed loess, upper boundary of a layer.	33600±1500	Seaside of Dniestrovskiy liman.
14.	814, ONU	10,0	12,30	Shelly sand.	15100±370	Alluvial-limnetic (cut-off meander) novoevksin sediments.
15.	19a	"–"	14,30	Shell-sandy mud.	8500±200	Bottom of Holocene sediments.
16.	648, UCHSI	8,9	25,0	Peat with remnants of flora.	17300±500	Facies of floodplain-cut-off meander in the area of Dniepro-Buzhskiy liman.
17.	657, UCHSI	10,95	24,8	Remnants of flora in clayed deposits.	11700±180	Top of novoevksin sediments, lagoon facies at Berezovskiy liman.
18.	67, UCHSI	5,2	15,1	Silty clay with remnants of flora and shells.	9500±190	Top of novoevksin sediments, at Tiligulskiy liman.

Completion of table

1	2	3	4	5	6	7
19.	221, UCHSI	2,1	19,0	Sandy clay with debris and shells.	8200±105	Bottom of Holocene sediments, Budakskiy liman.
20.	"–"	2,1	23,0	Silt with detritus of Dreissena pol.	11570±140	Liman-lagoon facies, Budakskiy liman.
21.	"–"	2,1	24,0	Grey brown hard silt.	17050±400	Facies of floodplain-cut-off meander, Budakskiy liman.
22.	153, BSPRGE	+1,7	32,2	Peat.	9800±400	Barrier spit of Kuyalnik liman.
23.	10, IGN	9,5	23,1	Dreissena pol.	10400±180	Odessa bar.
24.	10, IGN	"–"	24,4	Viviparus vivip., Theodoxus pallasi, Fagota esperi	9600±120	"–"
25.	"–"	"–"	25,5	Peat	10800±600	"–"
26.	162, BSPRGE	10,3	28,5	Dreissena pol.,Dr. rostriformis, Litoglyphus naticoides, V. vivip.	9500±150	Odessa bay.
27.	166, BSPRGE	25,0	27,5	D.pol., V.vivip., L.natic.	9100±120	Seaside of Dniestrovskiy liman.
28.	168, BSPRGE	18,4	25,8	D. polim., V. vivip., Micromelania lincta, Unio sp.	10500±180	"–"
29.	189, BSPRGE	15,1	23,5	D. polim., V. vivipa., L. natic., T. pallasi.	6000±90	"–"
30.	"–"	"–"	26,4	"–"	11700±150	"–"
31.	"–"	"–"	27,5	Peat	12500±130	"–"
32.	187, BSPRGE	14,0	17,7	Dreissena poly., Clessinioba variabilis, L. natic., V. vivipa.	9400±180	"–"
33.	185, BSPRGE	16,2	21,5	Peat	9700±150	"–"
34.	101, BSPRGE	11,6	23,2	Peat	10600±300	"–"
35.	157, BSPRGE	+1,5	25,2	Peat	8700±150	Barrier spit, Dniestrovskiy liman.
36.	182, BSPRGE	16,9	23,6	Silt with remnants of flora.	9000±100	Seaside of Dniester delta.
37.	183, BSPRGE	9,5	21,8	Abra ovata, D. pole., Monodacna caspia	7880±90	"–"
38.	109, BSPRGE	14,3	16,4	Mud saturated with organic matter and shells.	12000±120	Seaside of Shagany lake.
39.	151, BSPRGE	42,3	45,3	Peat.	8900±130	Basic level of Holocene sediments. Outer area of shelf. Palae-lagoon.
40.	92, BSPRGE	7,2	9,0	Silty mud saturated with shells.	6600±150	Seaside of Dniester delta, top of Holocene sediments.
41.	"–"	7,2	25,2	Peat with remnants of flora.	13850±280	Alluvial-limnetic sediments, seaside of Dniester delta.
42.	88, BSPRGE	7,7	24,8	Peat with remnants of flora.	9000±120	Seaside of Shagany lake.
43.	87, BSPRGE	8,5	26,7	"–"	9100±140	"–"
44.	219, BSPRGE	+1,8	30,3	Inter-layers of organic matter in sandy muds.	7250±190	Barrier spit, Budakskiy liman.

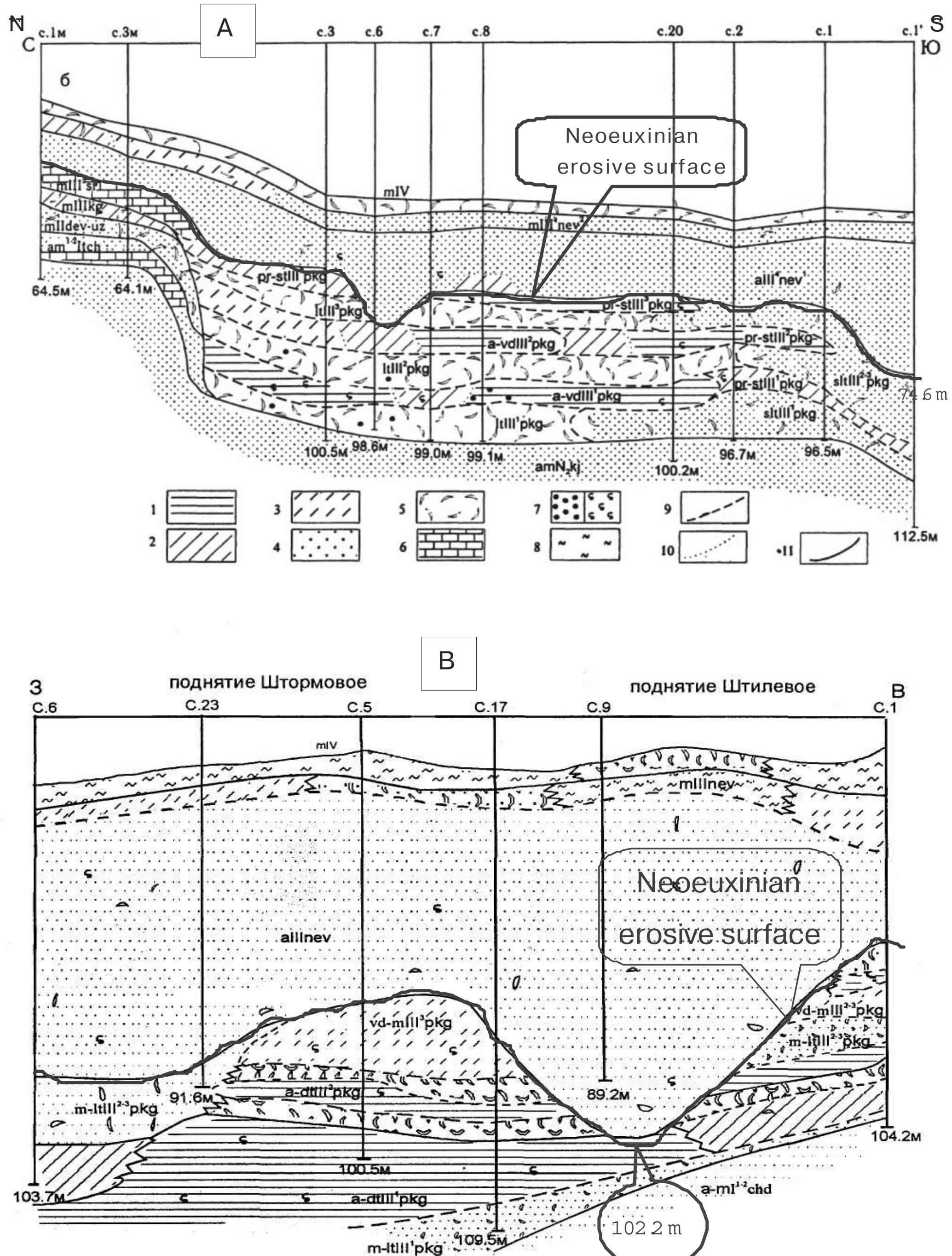

Fig. 2. Litho-geological profile along the line 1 – 1 (A) and 2 – 2 (B). Lithological variations: 1 –clay; 2 – loam; 3 – sandy clay; 4 – sand; 5 – shell rock; 6 – limestone; 7 – gravel, round-stone and remnants of flora ; 8 – mud. Boundaries: 9 – litho-genetic variations; 10 – lithologic; 11 – uneven aged layers

of porous waters, as these properties could reflect hydro-chemical conditions of sedimentation and further processes of diagenesis [7]. An important element of methodology for paleogeograpic reconstructions was taking into consideration

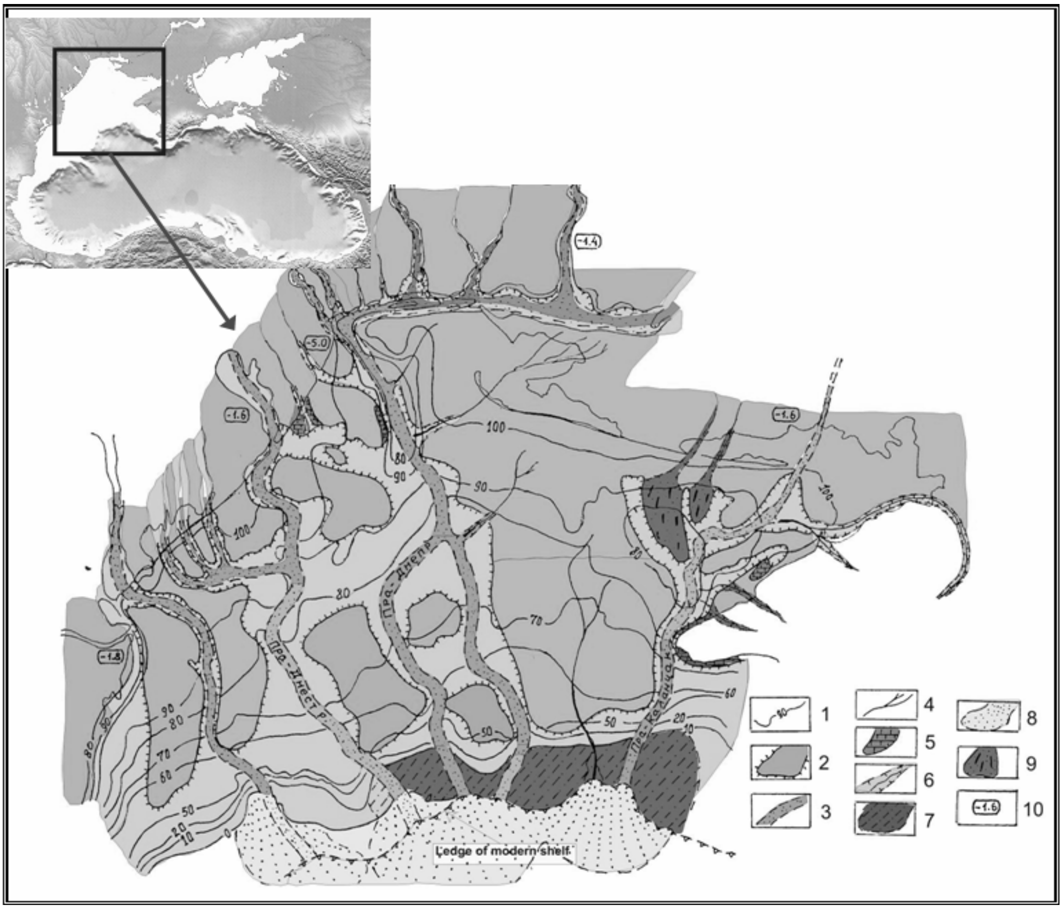

Fig. 3. Paleogeography at the stage of regression of the Neoeuxinian basin (circa 18-th.years ago). 1 – Contour line; 2 – Land; 3 – Large river; 4 – Small river; 5 – Structural terrace; 6 – River valley; 7 – River delta; 8 – Debris cone; 9 – Proluvium cone; 10 - Velocity of neotectonic movement

and analysis of newest and contemporary tectonic movements; this is based both on appraisal of paleo-landscape's bathymetry and morphology, as well as on digital measurements of ground control points [16].

Study results. Out of analysis of the drilling samples from the North Western shelf of the Black Sea and by application of the above methodology, a series of lithologic cross-profiles and schematic maps of stratigraphy, genesis and lithologic facies was constructed. One of such maps – a scheme of a maximum Neoeuxinian regression was showed in our publication [9] and corresponding profile are presented at Fig. 2 A, B.

These maps visualize how terrestrial and marine sediments, those which had formed at the shelf before the Neoeuxine, i.e., from 25–26 til 18 kyr BP, vary in space and in genesis. It is noteworthy the sediments of fluvial, aeolian-diluvial genesis period are most common for that period. Various fluvial facies are making valleys and river terrains, whereas aeolian-diluvial, diluvial, proluvial sediments are making water sheds and river slopes; there are also sporadic remnants of marine shell-sandy, often lithified, sediments of karangat time. Similar in content is a schematic map is constructed for Neoeuxinian sediments

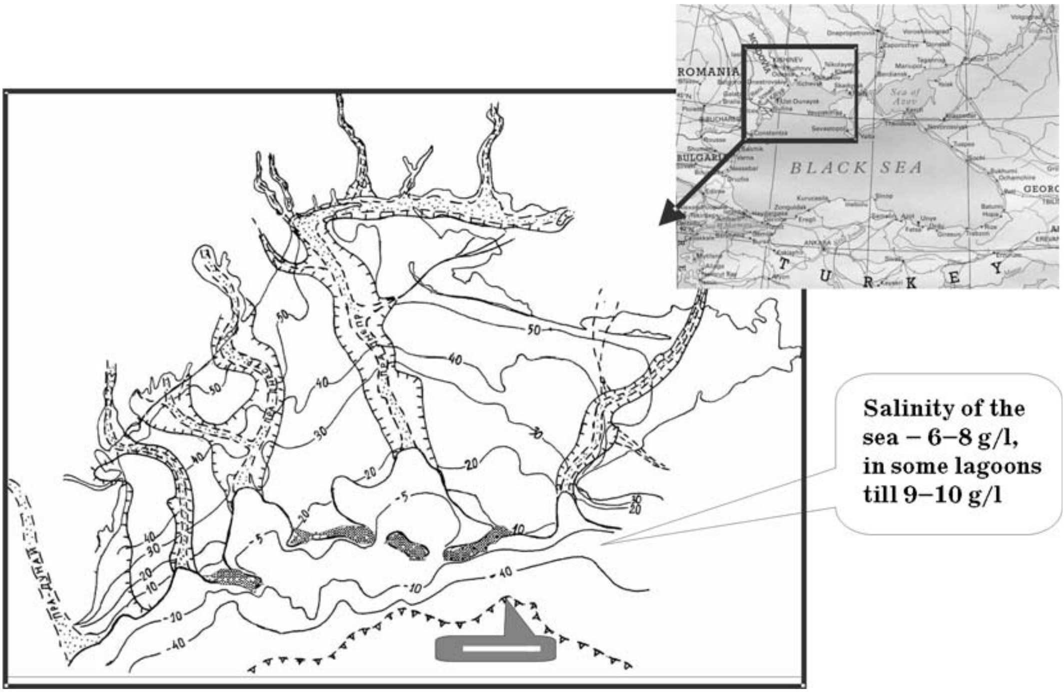

Fig. 4. Paleogeography at the stage of beginning of the Neoeuxinian transgression (circa 15-th.years ago). Key – in Fig. 3

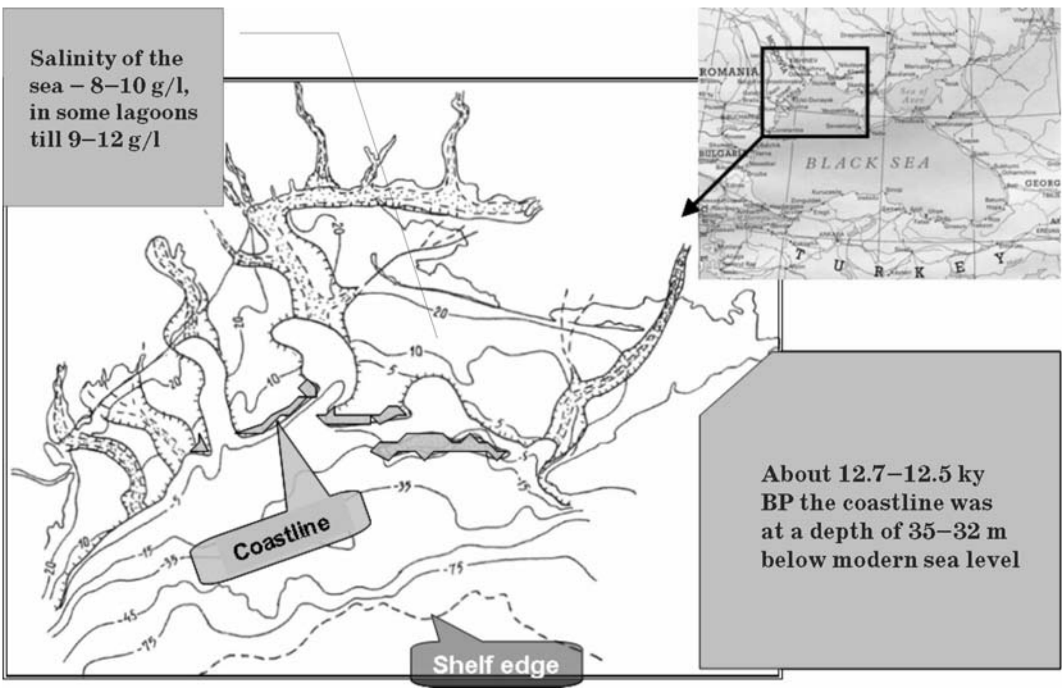

Fig. 5. Paleogeography at the stage of middle of the Neoeuxinian transgression (circa 12,5-th.years ago). Key – in Fig. 3

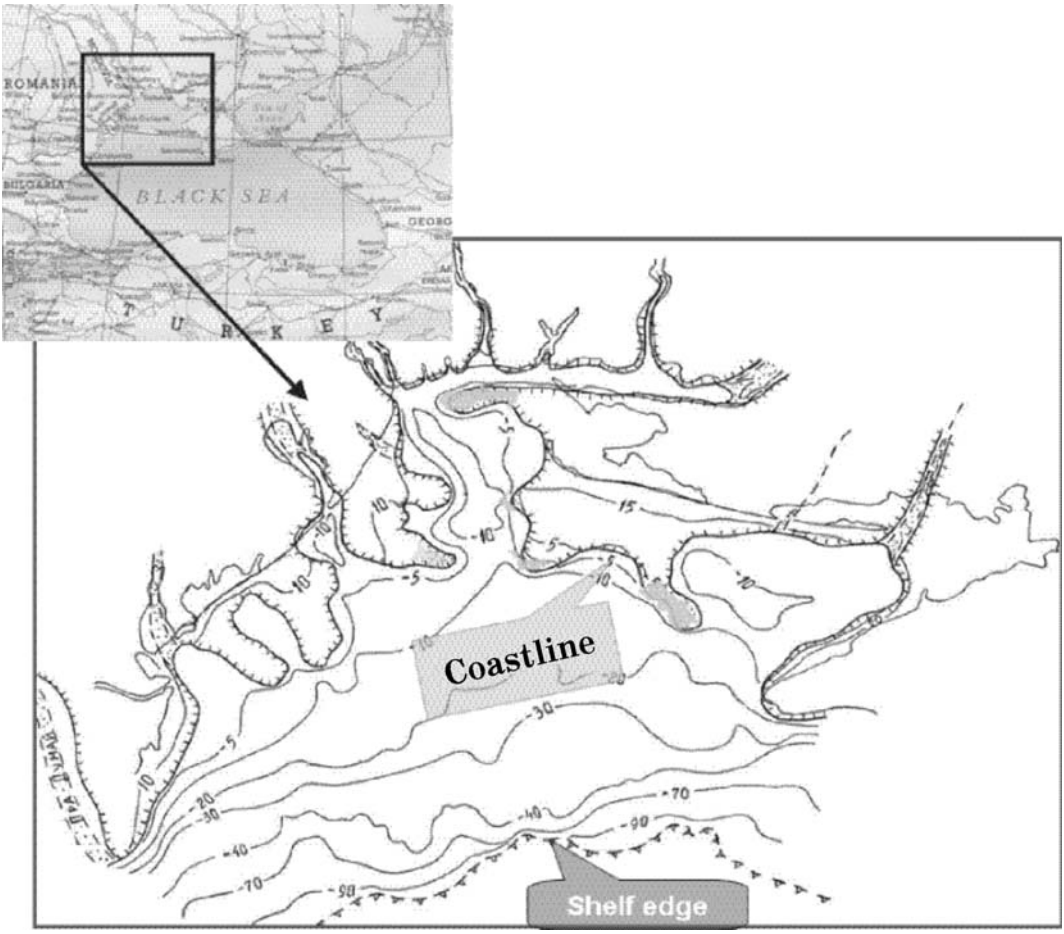

Fig. 6. Paleogeography at the stage of closing of the Neoeuxinian transgression and beginning Holocene (circa 9,5 – 9,0-th.years ago). Key – in Fig. 3

related to the phase of transgression (the map is not presented as to limited volume of the article). The sediments of shelf vary much in genesis: marine, lagoonal, liman, alluvial-limnetic, shallow waterish, alluvial, deluvial, etc. it should be mentioned that these lithologic and facial models are in good correlation with the studies of chemical properties and salinity of porous waters, and with the hypothesis of hydro-chemical evolution of the Black Sea basin [7]. Neoeuxinian sediments differ so much from under and above laying sediments in chemical compositions, degree of metamorphisation and salinity of porous waters, etc. Salinity of pore waters in Neoeuxinian sediments scales up from 4–6 g/l до 10–13 g/l, although sometimes fluctuations from this trend are observed, indicating certain variations in sedimentation conditions. Hence, the composition of pore waters often is a more responsive indicator of sedimentation conditions than the faunal complexes.

Based on the maps mentioned above and with the reference to radiocarbon datings (table), a number of paleogeographic maps is constructed for the main events of the Neoeuxine stage: the maximum of regression, beginning of transgression and final stage of evolution of the Neoeuxinian basin (Fig. 3, 4, 5, 6).

An important intermediate conclusion from analyzing the cross profiles at the shelf and Black Sea limans is that the depth of the rivers incision in Neoeuxine have rarely exceeded 70–90 m, with max. at –110 m, where as at the outer edge of the shelf it tends to be at –80...–90 m (Fig. 2).

Discussion. Our detailed studies of bedding conditions, lithological and facies structure, location of the marine-neashore facies, building up coasts, spits and bars,and it correlation with absolute dating made it possible to trace the following sequence of events at the North Western Black Sea shelf during the Neoeuxine.

Borehole № 81 (Fig. 7) is situated in south-western sector of the Crimean shelf. At elevation -104.99 m, it penetrated into shelly-sand bar sediments, a layer which well demarcates an ancient shoreline; it's age was dated by ^{14}C as 17.7 kyr BP (Table and Fig. 7). The analysis macro and micro fauna [29] completely confirms this statement.

This gives us an evidence that the sea level could not be at lower than –107...–110 m as far as 18 kyr BP; and, by no means it could have been at –140...–150 m, as claimed by W.Rayan with co-authors [26–28].

Next "range" of near-shore facies is found at –60...–70 m. As the result transgression of the sea, the central area of the shelf was the place where a number of large lagoons have originated. The sea waters penetrated into the ancient deltas of Dniepr, Dniester and smaller rivers, while the water level in theses lagoons was banked up till circa – 55 m (Fig. 5).

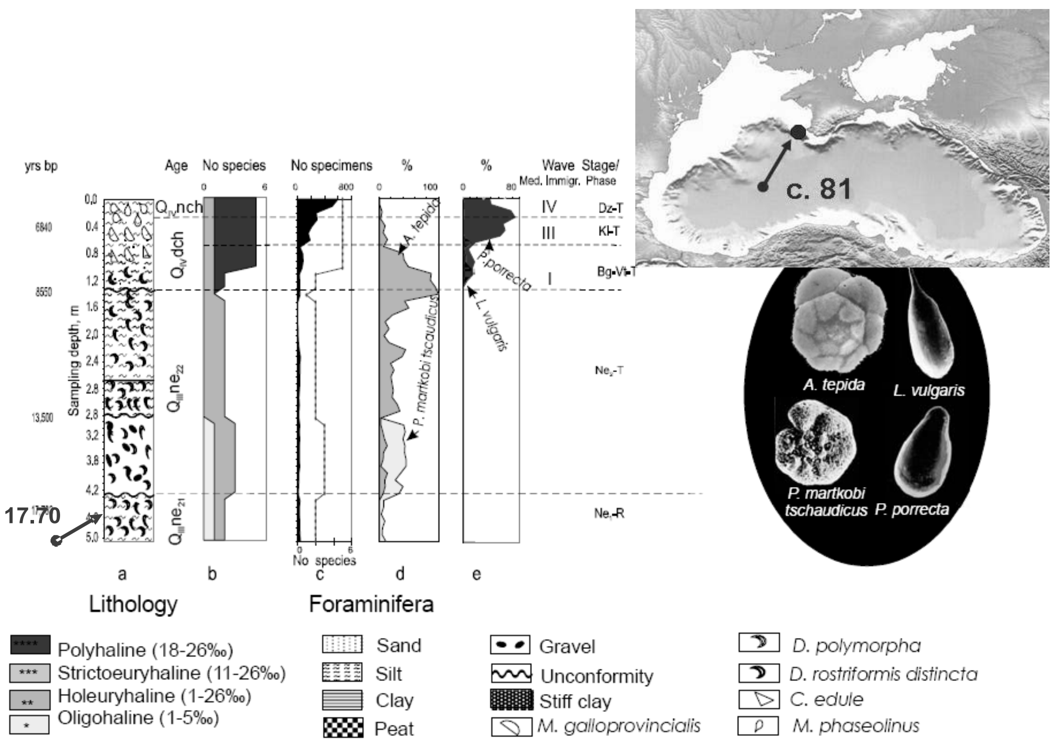

Fig. 7. Diagrams for Core 81 (44° 24'N, 33° 28'40E, water depth 104.99 m) modified after [30]

It is reasonable to ask: when this happened? By analyzing the results the absolute dating provided (table 1), we came to a conclusion that the sea level have reached the above elevations not later 13–13.5 kyr BP. In monograph of E.F.Schnukov [5], an age of this shoreline is assumed as 15.5–16 kyr BP. We are prone to accept this point of view, as the "younger" paleo-landscapes stick to the higher hypsometric level, which agrees with the data presented by W.Rayan with co-authors [28].

Submerged sand dunes are described by W.Rayan with co-authors [28] at the level of –80...–85 m. Their time formation is assumed by this publication to be 8.5 kyr BP. The age of these geomorhological forms is either elder or younger than 16 kyr BP. It could also be supposed that their origin is somewhat earlier than 16 kyr BP; they originated in the course of a short time period when the sea level has stabilized at the above mentioned level. It appears to be logical to regard their formation with a phase of regression, approximately 15.1–14.8 kyr BP. High probability of such event is indirectly supported by the paleoclimate studies, refereed by Shmuratko and Zubakov [6, 16, 17].

The wave-cut terrace described by W.Rayan with co-authors [28] at the depth of 120 m and dated as 14.7 kyr BP by ^{14}C could either be a prove of the basin's regression by more than 40 m, or their nowadays location may not be identical to their initial one in the above mentioned time. The second option is more likely. The profiles presented by the mentioned authors show a sharp bend of the bottom surface just few kilometers beyond the terrace. Such configuration is controlled to our mind by the neotectonics, i.e., by the foundering exposed to the shelf periphery. Should we would take the first option as a baseline, then most of sediments deposited at the elevation of –60...–70 м must be eroded, but this is not actually a case.

After these events, the Black Sea transgression was rapidly developing. Already at the turn of 13–12 kyr BP, the sea level had reached the elevation of –30m. This is suggested by absolute dating of several samples of the shelf sediments (fig. 1). Approximately, by 9 kyr BP the Neoeuxinian basin has raised till –16...–20 m elevations [9, 10].

A concentration of ancient, from 13 till 9 kyr BP shorelines at –30...–20 m elevations is not accidental. As a matter of case, a sharp bend of bottom surface is controlled by neotectonic movements, which caused a "fold", a structure which is clearly recognized at seismic profiles [16]. This structure is likely to have emerged in between middle and Late Pleistocene. Another distinct structural fold is much more narrow; it is demarcated by a bend of –70…–80 м isobaths.

Large, semi-isolated and shallow lagoon in the area of Karkinitsky Bay, spacious limans in deltas of ancient Dnieper and other rivers, – all these forms are related to the maximum of sea transgression. This phase is characterized by ingression of the Neoeuxinian Sea waters into the river valleys, at the place where the contemporary limans (Dniepro-Buzhkiy, Tiligulskiy, Khadzibejskiy, Kuyalnickiy) are situated. As the top of novoevskin sediments is found up to –16 м, we may assume the seawaters to ingress as far as till 20 – 30 km away from the outflow of the contemporary limans (Fig. 7) [3, 4].

The interval of 13 – 9 kyr BP is quite disputable in the history of Neoeuxinian basin; whether one or more phases of regression took place at that

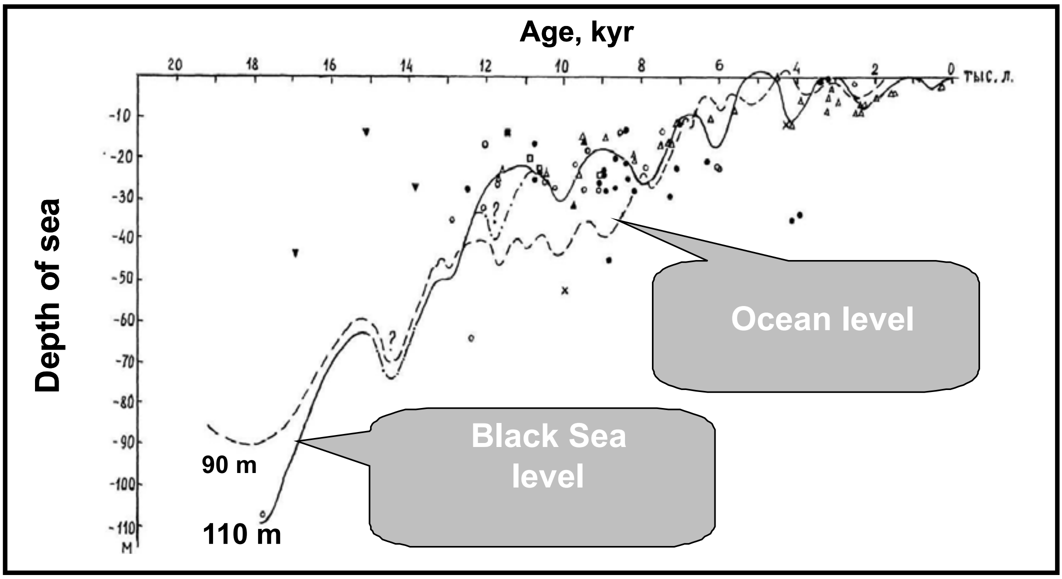

Fig. 8. Curve changes of Black Sea level and the World Ocean. On the figure points of approbation for radiocarbon age are shown.

time. Some researchers [5, 13, 20] are of opinion that two regressions are likely to happen, circa 11.7 and 10 kyr BP (shown in Fig. 8). We have found no evidence of these regressions, neither at shelf, nor limans. It could probably be explained by a relatively inconsiderable oscillation of the sea level during the regressions, so that the shore lines related to the regression may almost fall together with more ancient, transgressive coastlines.

The paleogeographic reconstructions presented above cover the main milestones of the Neoeuxine, from the maximum of Wurm regression till the Holocene; these reconstructions lead to first conclusions regarding, the pattern, dynamics and regime of the Black Sea transgression.

Rapid, up to 22.5 mm/year transgression of the sea at the beginning; then it is slowing-down and possibly turning out into regression of the sea around 15.5–14.8 years ago. Further on, a new speedy sea level uprise, circa 12.5 mm/year, until 12.5 kyr BP. Later on, until 9 kyr BP, the transgression was at a slow pace, circa 5.5 mm/year (a stagnancy or even two regressions of the sea level with a small amplitude are quite likely). The mean rate of transgression in Holocene could be estimated at 2.2 mm/year. At the same time, one should take in account quite distinct time rhythms, lasting 1800 – 2000 years and with having considerable amplitudes [3, 13, 15]. These distinct rhythms, typical for Holocene, could not be distinguished in the Neoeuxine, as to either a lack of data or other reasons. For instance, the traces of the continent's humidity rhytms, between 18–10 kyr BP, are wiped out by an excess influx of fresh water with the run-off of rivers and melting of glaciers.

Conclusions

1. Based on extensive factual data, their analysis and classification, a series of schematic maps of genesis, lithologic facies and paleogeography was

constructed for the main events of the novoevksin history of the Black Sea basin. When there was a regression, a Black Sea was a desalted lake and, where the North-Western Shelf is now, fluvial, aeolian and deluvial deposits were accumulating. Step by step, as the sea level was rising, the alluvial-limnetic, lagoonal and estuarial sediments were prevailing at the shelf. Ancient shorelines are mostly demarcated by the position and hypsometry of paleo-landscapes related to shallow sea, land-swell zone and bars.

2. Analysis of drilling data from the outer brink (edge) of the contemporary shelf, bio-stratigraphic features of the sediments, as well as the absolute dating tests of the shallow sea facies, all this information let us conclude that 18 kyr BP, the sea level did not fall below −107...−110 m. One could assume the drop of the sea level till −140...−150 m, at the maximum of the Neoeuxinian regression, if it is so, this could only happen much earlier, circa 22–23 kyr BP.

3. Simple calculations related to the mean rate of transgression do not support the hypothesis of catastrophic flooding, as presented by W.Rayan with co-authors, either at Neoeuxine (mean rate of transgression is 10.4 mm/year), and at Holocene (2.2 mm/year); although it should be admitted that the rate of water level uprise could have been quite high at some points of transgression, for instance it could have reached 10.4 mm/year in ”Nimphey” phase. The records made in nowadays time (e.g., such as measurements of the weather station “Odessa – Observatory”) have revealed rather high mean rate of the sea level up rise, 3.7 mm/year in the period from 1921 г. till 1991 [25]; however we do not intend to call this up rise as a catastrophic flooding of the Black Sea.

4. The paleogeographic reconstructions of the sea level fluctuations between 18–9 kyr BP, hereby referred by the article, are based on explorations of the North Western Black Sea shelf, but these reconstructions are applicable to the entire Black Sea basin.

1. *Авенариус И.Г.* [Avenarius, I.G., 1979] Палеоклиматы, водный баланс и уровни Черного и каспийского морей в позднем плейстоцене – голоцене // Позднечетвертичная история и седиментогенез окраинных и внутренних морей. – М.: Наука, 1979. – С. 106 – 111.
2. *Возовик Ю.И.* [Vozovik, Yu.I., 1982] К вопросу об амплитуде предголоценовой регрессии Черного моря //Проблемы четвертичной истории шельфа. – М.: Наука, 1982. – с. 68 – 73.
3. *Воскобойников В.М., Ротарь М.Ф., Коников Е.Г., Леонов Ю.В.* [Voskoboinikov, V.M., Rotar, M.F., Konikov, E.G., Leonov, Yu.V., 1982] Закономерности формирования инжененрно-геологических свойств лиманных и морских отложений северо-западного шельфа Черного моря //Материалы по изучению четвертичного периода на территории Украины - Киев: Наукова думка, 1982. – С. 123 – 132.
4. *Геология шельфа УССР. Лиманы*/ Под ред. акад. Е.Ф. Шнюкова. [Shnyukov, E.F. et al., 1984] - Киев: Наукова думка, 1984. – 189 с.
5. *Геология шельфа УССР. Литология*/ Под ред. акад. Е.Ф. Шнюкова. [Shnyukov, E.F. et al., 1985] - Киев: Наукова думка, 1985. – 192 с.
6. *Зубаков В.А.* [Zubakov, V.A., 1986] Глобальные климатические события плейстоцена. - Ленинград: Гидрометеоиздат, 1986. - 288 с.
7. *Коников Е.Г.* [Konikov E.G., 1993] Гидрогеохимическая эволюция Азово-Черноморского бассейна в позднем плейстоцене и голоцене// Океанология. – Т. 33. – № 2. – С. 217–223.

8. *Коников Е.Г., Митропольский А.Ю., Фащевский С.Н., Шипилов А.Л.* [Konikov E.G., Mitropolskij A. Yu., Fashchevskij S.N., Shipilov A.L., 1999] – Оценка изменчивости физических свойств Средне – Верхне-Плейстоценовых отложений Каркинитского залива Черного моря в свете его геологического развития. – Геологический журнал, 1999. -№ 1. – pp. 53 – 62.
9. *Коніков Є.Г., Педан Г.С., Фащевський С.М.* [Konikov, E.G. et al., 2006] Реконструкція рівня і міграції берегової лінії Чорного моря у новоевксині й голоцені в світлі дискусії про «катастрофічний потоп // Вісник ОНУ, 2006. – Т. 11. – Вип. 3. – С. 196 – 206.
10. *Коников Е.Г.* [Konikov, E.G., 2007] Модель процесса осадконакопления на северо-западном шельфе Черного моря// Геология и полезные ископаемые мирового океана. –Киев, 2007.- №2. – С.34-47.
11. *Ленгерсгаузен Г.Ф.* [Lengersgauzen, G.F., 1963] О периодичности геологических явлений и изменений климатов прошлых геологических эпох// Проблемы планетарной геологии. – Москва: ГОНТИ. - 1963. - С. 7-49.
12. *Осадконакопление на континентальной окраине Черного моря* /Отв. ред. П.А. Каплин. [Kaplin, P.A.et al., 1978] – М.: Наука, 1978. – 211с.
13. *Островский А.Б., Измайлов Я.А., Щеглов А.П., Арсланов Х.А. и др.* [Ostrovskij, A.B., Izmaylov, Ya.A., Scheglov, A.P., Arslanov, Kh.A., et al., 1977] Новые данные о стратиграфии и геохронологии плейстоцена морских террас Черноморского побережья Кавказа и Керченско-Таманской области //Палеогеография и отложения плейстоцена южных морей СССР. – М.: Наука, 1977. – С. 142.
14. *Свиточ А.А., Селиванов А.С., Янина Т.А.* [Svitoch, A.A., Selivanov, A.S., Yanina, T.A., 1998] Палеогеографические события плейстоцена Понто-Каспия и Средиземного моря (материалы по реконструкции и корреляции). – М.: МГУ, 1998. – 292.
15. *Федоров П.В.* [Fedorov, P.V., 1982] Послеледниковая трансгрессия Черного моря и проблема изменений уровня океана за последние 15000 лет / В книге: «Колебания уровня морей и океанов за последние 15000 лет». – Москва: Наука, 1982. – С. 151-155.
16. *Шмуратко В.И.* [Shmuratko, V.I., 1982] О методике построения карты скорости вертикальных тектонических движений земной коры в пределах северо-западного шельфа Черного моря// Геологический журнал, 1982. – Т. 42, # 5. – С. 27 –35.
17. *Шмуратко В.И.* [Shmuratko, V.I., 2001] Гавитационно-резрнансный экзотектогенез. – Одесса: Астропринт, 2001. – 330 с.
18. *Шнитников А.В.* {Shnitnikov A.V., 1969] Внутригодовая изменчивость общей увлажненности континентов. - Ленинград: Недра, 1969. – 246 с.
19. *Щербаков Ф.А.* {Scherbakov, F.A., 1979] Особенности седиментогенеза на континентальных окраинах океанов и внутренних морей/ Палеогеография и седиментогенез окраинных и внутренних морей СССР. – М.: Наука, 1979.
20. *Щербаков Ф.А.* {Scherbakov, F.A., 1982] Отражение изменений уровня моря в разрезах позднечетвертичных морских отложений //Колебания уровня морей и океанов за последние 15000 лет. – Москва: Наука, 1982. – С. 112 – 120.
21. *Aksu A.E., Niscott R.N., Mudie P.j., Roghon A., Kaminski M.A., et al.* Presistent Holocene outflow from the Black Sea to the eastern Maditerranean contradicts Noah's Flood hypothesis //GSA Today. - #12. – P. 4 –10.
22. *Balabanov I.P.* Holocene sea-level changes of the Black Sea In: The Black Sea Flood Question: changes in coastline, climate, and human settlement. / Eds: V. Yanko-Yjmbach, A. Gilbert, N. Panin, P. Dolukhanov. – Dordreght: Springer, 2007. – P. 711–730.

23. *Degens E.T., Ross D.A.* 1972 – Chronology of the Black Sea over the last 25000 years// Chem. Geol. V.10. # 1. p. 1 –6.
24. *Konikov E.G.* Sea-level fluctuations and coastline migration in the northwestern Black Sea area over the last 18 ky based on high-resolution lithological-genetic analysis of sediment architecture / In: The Black Sea Flood Question: changes in coastline, climate, and human settlement. / Eds: V. Yanko-Yjmbach, A. Gilbert, N. Panin, P. Dolukhanov. – Dordreght: Springer, 2007. – 405-435 p.
25. *Likhodedova O, Konikov E.G.* Analysis of sea-level changes in the Black Sea for the past 140 years and forecast for the future //In Extended Abstracts: 3 Plenary Meeting and Field Trip of Project IGCP-521 Black Sea – Mediterranean Corridor During the Last 30 ky: Sea level change and Human Adaptation (2005-2009). Gelendzhik-Kerch, Russia-Ukraine, 2007. pp. 109-111.
26. *Ryan W.* Status of the Black Sea Flood hypothesis/ In: The Black Sea Flood Question: changes in coastline, climate, and human settlement. / Eds: V. Yanko-Yjmbach, A. Gilbert, N. Panin, P. Dolukhanov. – Dordreght: Springer, 2007. – 63-88 pp.
27. *Ryan W., Major C., Lericolais G., Goldstein S.L.* Catastrophyc flooding of the Black Sea //Annu. Rew. Earth Planet. Sci., 2003. - #31. – P. 525 – 554.
28. *Ryan W., Pitman W., Major C., Shimkus K., Moskalenko V., et al.* Abrupt drowning of the Black Sea shelf //Mar.Geol., 1997. – 138. – P. 119 – 145.
29. *Yanko-Hombagh V.* Black Sea Floods // Geotimes, February, 2004. – P. 27–28.
30. *Yanko-Hombagh V.* Controversy over Noah's Flood in the Black Sea: geological and foraminiferal evidence from the shelf / In: The Black Sea Flood Question: changes in coastline, climate, and human settlement. / Eds: V. Yanko-Yjmbach, A. Gilbert, N. Panin, P. Dolukhanov. – Dordreght: Springer, 2007. – 149-204 p.

У статті наведено уявлення про палеогеографію та мінливість рівня Чорного моря за новоевксину (18–9,2 тис. р. т.) та голоцену (9,2–0,0 тис.р.т.) , які обговорюються у зв'язку з гіпотезою В. Райяна й співавторів (1997, 2003) про "катастрофічний потоп". На підставі літолого-генетичного аналізу відкладів, біостратиграфії, радіовуглецевого датування та даних про хімічний склад і солоність порових вод по значному обсягу колонкового (біля 200 свердловин) та віброноршневого (біля 1000 свердловин) буріння на шельфі та у Причорноморських лиманах було побудовано палеогеографічні карти-зрізи для головних етапів новоевксинської історії басейну. Наведено докази, що скасовують імовірність "катастрофічного потопу" на ранньому етапі новоевксинської трансгресії, а також протягом голоцену.

В статье приведены представления о палеогеографии и изменении уровня Черного моря в новоэвксине (18 – 9,2 тыс. л. н.) и голоцене (9,2 – 0,0 тыс.л.н.), обсуждаемые в связи с гипотезой В. Райяна и соавторов (1997, 2001) о «катастрофическом потопе». На основании литолого-генетического анализа отложений, биостратиграфии, радиоуглеродного датирования и данных о химическом составе и солености поровых вод по большому объему колонкового (около 200 скважин) и вибропоршневого (около 1000 скважин) бурения на шельфе и в Причерноморских лиманах были построены палеогеографические карты-срезы для главных этапов новоэвксинской истории бассейна. Приведены доказательства, опровергающие вероятность «катастрофического потопа» на раннем этапе новоэвксинской трансгрессии, а также на протяжении голоцена.