BLACK SEA TRANSGRESSIONS DURING THE LATE HOLOCENE

Radu OLTEANU

"Emil Racovitză" Speological Institute, 31 Frumoasa Str., Bucharest, Romania

Abstract. The Ostracoda communities suggests that the Danube Delta area was flooded by brackish water species three times during the Upper Holocene.

Key words: Danube Delta, Holocene, Ostracoda, transgression, regression

INTRODUCTION

The Danube Delta is situated in an area of high mobility of the Earth crust, repeatedly affected by strong subsidence and important sediment accumulation. Presently, the subsidence of the coastal zone nearby the Danube Delta mouth is estimated between 1.5 and 1.8 mm/yr. The observations from the last century show the tendency of sea level rising by 1.5-4.0 mm/yr. (Panin, 1999).

The Danube Delta edifice (300-400 m thickness of sedimentary material) was formed mainly during the Upper Pleistocene (Karangatian, Sourojshian, Neo-Euxinian) and especially during the Holocene (Panin, 1998, 1999). Generally, the Danube sediment discharges is almost 55 M. t./yr. (Panin, 1999).

Some of the more important determinants in the development of a delta include the discharge regime and sediment load of the contributing rivers, climate, the coastal wind regime, the strength and direction of coastal currents, the width and slope of the continental shelf and, of course, fluctuations of the sea level.

Over a long period of time extensive deltaic plains may be produced by abrupt changes in or lateral migrations of the active river mouths deposition. During the Holocene, the Danube Delta seemed to change the number and position of its mouths. Greek historians noted about five (Herodot) and even seven (Strabon) Danube mouths. They also described the Halmyris gulf (Razelm liman), the Thiagola Lake (Pardina depression) and the Achille's land (Peuce island).

The Holocene chronicle has been punctuated by brief sea flood over the Danube Delta area according to the so-called "little ice age events". However, the sea level fluctuated several meters at times. Thus, the Danube Delta geography was far from stable, but was in a continuous state of dynamic change.

The Black Sea flooding waters advanced several kilometers for a few decades or a century and then retreated once more. The frequency of the sea advances increased during the last three millennia and strongly influenced the life of Hellenistic colonists on the "Pontus Euxinus" coast. For instance, the Histria town suddenly died after 650 A. D. (after almost one millennium of life), just when a temple with big marble columns brought from Anatolia with a big galley was under construction. The temple remained unfinished.

It could be what is known as Istrian regressive phase (Bleahu, 1962) or Phanegorian regression (Fedorov, 1971).

The following are some ideas on the evolution of this area.

1. The actual deltaic conditions established in the Danube gulf during the Quaternary (?), when the Danube River started flowing into the Black Sea basin. What was before the Danube River, which did itself have a history closely related to the evolution of the Dacian basin?

During the Romanian stage, a large lake was here, therefore fresh water with an "explosion" of the fossil endemic Unionidae (almost one hundred species), but there were also many *Viviparus, Melanopsis* species (a part of them found in the so-called "Paludinian Beds") and even Caspian elements of fauna (as *Caspia* and *Baicalia* species, Pana, 2003). It suddenly became extinct somewhere around the Lower Pleistocene boundary. Meanwhile, a huge quantity of fresh water vanished. It flowed, most likely, towards east into the Black Sea building the first route of the Danube River.

The Danube Delta (as many other low lands) area was above the sea level during post-Karangatian, and certainly, during the Neo-Euxinian phase.

2. When the general Black Sea level was lower than the Bosphorus strait, the further variations of the Black Sea level were determined by specific regional conditions, the fauna being a direct descendant of the specific Pliocene fauna.

The post-Karangatian regression and especially that of the Neoeuxinian episode of the Black Sea (= maximum point to 18,000 yr BC), when the sea level lowered to -90-100m, brought about the intense erosion of these older Quaternary paleo-sediments. We may still recognize some remnants of these older sediments (assigned to Karangatian and Sourozhian), preserved behind some relics of the predeltaic (or paleodeltaic)

relief (Panin, 1998). In the Letea-Caraorman area found some mesolitic artifacts were found.

The key for this question is the Bosphorus strait evolution. The paleontological analysis of the history of a brackish-water ecosystem like the Black Sea means, in fact, the ostracoda and mollusk community evolution (both with highest diversity and biomass) and nothing more. Their evolution means the biostratigraphycal interpretation.

The stratigraphical nomenclature on the Black Sea history is prolix and abundant. We used the temporal symbols after Fedorov (1978), Nevesskaya (1985) and Panin & Popescu (in press). It would constitute a subject of dispute, with reference to whether they are a stage, a simple episode or a facies pertaining to their stratigraphical age. In fact, there were some successive dimensinal changes of the basin and different ecological conditions according to the fluctuation of the Black Sea water level.

The classical picture of the Black Sea history, is summarized below (Table 1):

Table 1 Transgressions and regressions in the Danube Delta area during in Quaternary time

Years	Episods	Events	Level fluctuations
		Sea level slow rising up to present (I, II)	
		Sea level is low	**- 1 – 2 m**
1,000	Dzemetinian	Nymphaean (Istrian) transgression	**+ 1 + 3 m**
3,500	Kalamitian	Phanegorian regression	**- 5 - 8 m**
	(„New Black Sea“)	First Hellenic colonists on the western coast	
	Bugazian-Viteazian	transgression over the low land	**+ 3 – 5 m**
8,500	Upper Neo-Euxinian	The sea level rose quickly (rivers and the melting water from the glaciers). “Neo-Euxinian acceleration”. Overpass the Bosphorus sill towards the Aegean Sea (?). Bosphorus III. (Ostashkovian, Allerodian)	**– 10-12 m**
	Middle Neo-Euxinian	la 18.000 maximum of regression	**- 100-120 m**
	The Black Sea isolated.		
28-23,000	Lower Neo-Euxinian	Gradual lowering of the sea level.	
43-30,000	Sourozhian transgression	The sea level rose to actual level	**– 10 + 1 m**
		The Danube flowing into the Black Sea basin	
		Marine influences. Bosphorus II	
72-45,000	Post-Karangatian regression. Oligohaline water. It is interrupted connections with Mediterranean Sea and Caspian Sea.		**– 60 - 70 m**
70-90,000	Karangatian	trangression. Bosphorus I	**+ 8 - 12 m**
	(Riss-Wurm, Mikulinian)	In connection with Mediteranean Sea and Caspian Lake	
125,000			
	Upper Paleo-Euxinian	regression. Caspian fauna (?)	**- 100 m**
	(= Riss glacial)		
	Middle Paleo-Euxinian	transgression	**+ 20 - 40 m**
	(Uzumlar=Riss-Mindel)	In connection with Caspian Lake (=Bakunian episode)	
	Lower Paleo-Euxinian	regression	
	(= Mindel)	fossil mammals from Tiraspol	
	Upper Ceaudian	transgression	**+ 100-130 m**
	(=Mindel-Gunz)	In connection with Caspian Lake during the Apscheronian	
	Lower Ceaudian	regression	**- 150 m**
	Lower Ceaudian	regression	**- 150 m**
	(= Gunz glacial)	fossil mammals from Taman-Nogaysk	

The start of the Bugazian-Viteazian (Nevesskyi, 1967 or “Old Black Sea”, after Fedorov, 1971) transgression occured 8-7,500 years ago, and it was coeval with the Flandrian from the Western Europe (according to Fedorov, 1971). It happened 6.800 years ago according to other authors (Nevessky, op. cit., Panin, 2000). The maximum of the water level was 3 m above the current level. The mollusks community was rich, but commonly: *Cardium edule, Cardium exiguum, Mytilus galloprovincialis, Mytilaster lineatus, Ostrea taurica, Venus gallina, Nassa reticulata* etc (recent community). To be sure, such lifting of the sea level “invaded” the Delta area including the brackish fauna.

The Phanegorian regression started with more than 3,000 years ago.

From a faunal point of view, all these are just an ecological matter. The Black Sea history was always a succession of episodes of brackish water stages, never completely fresh, or completely marine. As a matter of principle, there is a risk in generalizing the glacial as an epoch with little contribution of water, while the interglacial, as an epoch of huge water quantity. In this

case, the eustatical mobility of the Danube Delta area played undoubtedly an important role.

Major *et al*. (2002) remarks four major changes have occurred 15,000, 12,800, 8,400 and 7,100 yr. B.P. Retreat of ice between 15-14,000 yr. B. P is recorded by an increase in clays. The return toward glacial values occurred during the Younger Dryas cold period and brought about lowering of the sea level, and consequently a lacustrine facies on the Danube Delta area. The analyses of mollusks shells demonstrated an increase in 0-18 at 12,000 yr. and a simultaneous appearance of inorganic calcite with low 0-18, which is compatible with an early marine water influx (the inorganic calcite precipitation is caused by increased evaporation in the basin).

The stratification of the water in the Black Sea starts 7,160 yr. ago, when the water below -200 m was anoxic (Jones and Gognon, 1994). It is just an opinion. The water stratification could have occurred with every marine influx from the Mediterranean\ Sea.

In short, the marine influx to the Black Sea depends on the sill depths of the Bosphorus and Dardanelle channels (-80 m). The first flooding of the Marmara Sea was around 12,000 yr. B.P. The bedrock gorge of the Bosphorus reaches depths exceeding -100 m (comared to the present level), though it is now filled with sediments as shallow as -32 m. (Major *et al*., 2002).

According to Nevesskaya (1965), the first marine mollusk to immigrate into the Black Sea during the Karangatian time, were *Paphia senescens* Coc. and *Ostrea edulis* Linnaeus, and during the second marine episode (Sourozhian), the new "fauna wave" with *Cardium edule* Lamarck, *Chione gallina* (Siem.), *Mytilus galloprovincialis* Link, *Spisula subtruncata triangular* (Costa) and *Cerithium vulgatum* Bryg appeared. All of them disappeared during the Neoeuxinian time and triumphantly returned with the last glacial transgression. The radiocarbon determinations showed that *Paphia senescens* and *Ostrea edulis* appeared before 40,000 yr B.P., and starting with the XI-XIIth millennium B.P., the marine species increased (Panin *et al*., 1982).

RESULTS

We examined six cores from the Danube Delta area. The first of them is located near Sf. Gheorghe town (Coşna drilling, from 3.40 m to 277.00 m). The second one is near Tulcea town (Pardina drilling, from 4.70 m to 71.50 m). The other four short cores are in the middle of the Pardina area (the ancient Thiagola Lake) (core nr.1, from 2.10 m to 29.00 m, nr. 4222, from 0.60 m to 1.54 m and nr. 4240, from 0.40 m to 1.67 m)

The first samples collected from the Cosna drilling start at 3.40 m depth and the last ones at 277.00 m. Between 5.00 and 5.40 m, a mixed ostracod species is found. Some of them are lacustrine species (*Candona complanata* (G.W. Muller), *Candona schweyeri* Shornikov, *Pseudocandona albicans* (Brady), *Darwinula stevensoni* (Brady and Robertson), *Scottia* aff *browniana* (Jones). Many others are the brackish-water species (*Tyrrhenocythere amnicola donitziensis* Dubowsky, *Leptocythere reticulata* Şornikov, *Leptocythere relicta* Sornikov (close related by *Euxinocythere punctata* Olteanu, from Upper Kouialnikian)) and *Amnicythere striatocostata* (Schweyer). Such influx of brackish ostracods is a result of the sea transgression.

Between 5.50 m and 14.40 m, the ostracod ansemblage is exclusively lacustrine, which is the result of the regressive Phanegorian phase. Under these lacustrine sediments, at 14.40 m, there are a typical brackish-water ostracod fauna with *Euxinocythere bacuana* (Livental), *Leptocythere* aff. *multipunctata* (Seguenza), *Costa edwardsi* (Roemer), *Loxoconcha* sp., *Xestoleberis* sp.. This brackish biotope seems to be an effect of another sea influx into the Danube Delta area (with Caspian and Mediterranean species). At 16.20 m, again a mixed fauna episode is found with *Pseudocandona albicans, Darwinula stevensoni*, but also with *Leptocythere villosa* (Kulieva), *Leptocythere multipunctata* and *Costa* aff. *edwardsi*. At 16.50 m the new marine elements appear with *Pontocythere* sp., *Semicytherura* sp., *Loxoconcha* sp., *Xestoleberis* sp. and a new species of "*Eucypris*". This facies continues to 25.00 m, suggesting a classical littoral field. Its time, according to canonical symbols, could belong to the Sourozhian phase.

At 25.10 m, the last ancient pontic-origin species appear in an exclusive community: *Semicytherura colchidica* Imnadze, *Loxoconcha gibboida* (Livental), *Loxoconcha. petasa* (Livental), *Amnicythere quinquetuberculata* (Livental), *Amnicythere. caspia* (Livental), *Callistocythere* sp., *Leptocythere* sp., *Tyrrehenocythere* sp. and the single foraminifer, *Ammonia beccari*. No marine, Mediterranean Sea immigrants appear in this episode. All these species belong to the Ponto-Caspian source.

At 33.50 m, the second wave of the marine species appear, allied with the local, brackish species: *Carinocythereis carinata (*Roemer*)*; *Semicytherura* sp. 1, *Semicytherura* sp. 2 (marine) and *Amnicythere quinquetuberculata, Amnicythere. cymbula, Amnicythere longa* Negadaev-Nikonov, *Advenocypris* aff *duabiensis* Vekua (brackish) and few lacustrine taxa (specimens of *Ilyocypris*, *Darwinula, Cypriotus, Pseudoandona*).

At 36.00 m, the maximum of marine ostracod diversity occurs: *Carinocythereis carinata*, *Pterigocythereis jonesi* (Baird), *Semicyherura* aff. *acuticostata* (G. W. Muller), *Semicythrurua* aff. *sanmarinoensis* Ruggieri, *Semicytherura* aff. *praeacuta* Mostafawi*, Pontocythere* aff. *tchernjawskii* (Dubowskyi), *Loxoconcha lepida* Stepanaitys, *Loxoconcha* aff *eliptica* Brady, *Loxoconcha* aff *granulosa* (Sars), "*Heterocythereis"* n. sp., "*Echinocythereis"* n. sp., *Sclerochilus* n. sp., *Cytheroma* sp. n., "*Hemicythereis"* n. sp. There are similar species in all samples to 41.00m, depth forming a well outline unity of the ostracod community. It is a sharp, marine inflow over the local brackish community. This first wave of Mediterranean immigrants could belong to the Karangatian phase. Below, at 44.00 m depth found just lacustrine species are found suggesting a regressive phase. Most likely, it corresponds to the Riss glaciation epoch (Moskovian regressive phase, with Caspian type of ostracods).

The four sites drilled in Pardina depression, (the middle area of the Danube Delta (about 50 Km from the recent littoral of the sea), give us some dated reference sections that can be studied to determine the nature of the ostracod origin and ecological position.

1. In the Pardina-A drilling, the mixed ostracod fauna begins at 4.70 m and continues to 7.60 m. The samples collected from from this interval contain similar lacustrine and brackish species (*Darwinula stevensoni, Limnocythere inopinata, Cyprideis torosa, Tyrrheno-cythere amnicola (*dominant*), Amnicythere quinque-tuberculata, Amnicythere striatocostata, Euxinocythere lopatici, Euxinocythere. reticulata).*

Under this sequence, between 7.60 m and 10.60 m the ostracods are exclusively limnic species (*Pseudocandona albicans, Scottia browniana, Darwinula stevensoni*, *Limnocythere inopinata, Candona neglecta, Cyprideis torosa littoralis*). No the brackish or marine elements of fauna are found in this sequence. Deeper (10.60-11.20 m), the community is mixed with lacustrine and brackish species (in symbolic terms, it belongs to first Sourozhian transgression into the Danube Delta area).

2. In the core no. 1-Pardina, at 2.10-2.90 m, the lacustrine ostracod species are found (*Darwinula stevensoni, Pseudocandona albicans, Notodromos nicomacha* (O. F. Muller), *Cyprideis torosa*). Between 7.20 and 7.60 m the examined samples show a brackish water ostracod association (*Tyrrhenocythere amnicola* (Sars), *Euxinocythere lopatici* (Sornikov), *Amnicythere quinquetuberculata* (Livental), *Pontocythee bacescoi* Caraion and *Cyprideis torosa*). This sequence suggests a real brackish ostracod community that could be a result of the Nymphaean sea level rising.

Under this brackish water episode, there is another lacustrine facies, down to 29.00 m depth.

3. In the samples collected from core no. 4222, I found a similar situation. At 0.60-0.91 m depth, the ostracod fauna is typically lacustrine (*Romaniella dacica* Olteanu, *Cyprinotus salinus* (Brady), *Candona neglecta, Limnocythere inopinata, Darwinula stevensoni, Pseudo-candona albicans, Candona fabaeformis, Cyprideis torosa*, oogons of Characee. Between 0.93-1.00 m, a short brackish water episode appeared with *Amnicythere cymbula* (Livental), *Amnicythere propinqua* (Livental), *Amnicythere longa (*Negadaev-Nikonov*), Amnicythere quinquetuberculata (*Livental*)* and reworked Miocene foraminifers (Globigerinae).

Between 1.27 m and 1.54 m the ostracod fauna is exclusively fresh water fauna (with anterior cited ostracod species and *Ammonia beccari*).

4. In the core no. 4240-Pardina, the fresh water facies starts at 0.41 to 1.10 m *(Darwinula stevensoni, Candona neglecta, Paracandona albicans, Cyprideis torosa, Limnocythere inopinata, Cyprinotus* aff. *salinus* and many oogons of Characee). In the sequence between 1.10-1.15 m, besides *Cyprideis torosa* and *Limnocythere inopinata*, the *Amnicythere quinque-tuberculata, Euxinocythere* aff. *reticulata* and *Ammonia beccari* appear. Underneath, almost 2 m of sediments with the fresh water common ostracod species follow.

The brackish water ostracod species suggests that the Danube Delta area was flooded by brackish water from the Black Sea basin. Such brief events are not singular. For instance, the last phase was represented by lowering of the Caspian Sea level by 2.5 m during the period of 1929-1956. Since then the Caspian level remained nearly stable. The presence of the same brackish species in the four cores from Pardina Depression would seem to indicate an evidence of their temporal synchronization. The sediment thickness is not significant for the correlation in the context of the similar species. However, the three cores are very close (intercalations of the brackish water level in a fresh water sequence at 5.00-5.40 m, at 4.70-7.60 m and 7.20-7.60 m), and other two, obviously, above them (at 0.93-1.00 m and at 1.10-1.15 m) (Fig. 1).

CONCLUSIONS

Beyond these many controversial questions, most important, undoubtedly, is the one about the first marine inflow from the Mediterranean Sea. The Karangatian basin is an arch of time between 125.000 and 60.000 yr. (Panin and Popescu, 2004) when the first ostracod species can unequivocally be assigned to marine species found in the Black Sea sediments.

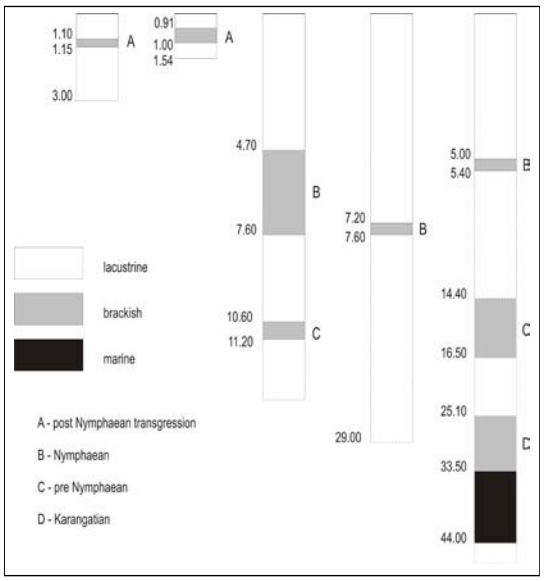

Fig. 1 The three "invassions" of the brackish water during the post-Karagatian time

The following flooding phase of the Danube Delta is characterized by the same relict brackish Pontian-type micro and macrofauna (as phylogenetical descendants of the Pontian Cycle of the fauna evolution). The recent fauna preserved just 11 brackish ostracod species from the "older reservoir" like sort of living fossils. These "invaded" twice the Danube Delta area during the historical time after the Histria time of existence.

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