Transformation of the Neoeuxinian lake into the Black Sea: Evidence from benthic foraminifera

Yanko-Hombach V.

Avalon Institute of Applied Science, 3227 Roblin Blvd, Winnipeg, MB R3R 0C2, Canada, valyan@avalon-institute.org

Introduction

This paper is focused on the reconstruction of the Black Sea level and salinity since the Last Glacial Maximum (LGM) using benthic foraminifera as the main tool (Yanko-Hombach, 2006).

Materials and methods

The data were collected since 1971 during the course of a large-scale geological survey of the Black Sea shelf. The materials on the Eastern Mediterranean, the Sea of Marmara and the Caspian Sea were used as supporting evidence of the origin of the Black Sea foraminifera. In the Black Sea, approximately 30,000 samples from 1,325 grabs, 4,000 gravity/piston cores, and 56 boreholes were investigated. The collection of the Black Sea, Caspian Sea, and Sea of Azov (155 species) foraminifera is stored in the Paleontological Museum, Odessa National University, Ukraine. The original collection of foraminifera (about 500 species) from the Eastern Mediterranean and Sea of Marmara is stored at the Avalon Institute of Applied Science.

Our ecostratigraphic technique is largely based on alternation of foraminiferal assemblages and their ecological characteristics in geological sections supported by ^{14}C and palynological assays. An increase of the number of Mediterranean immigrants, especially strictoeuryhaline and polyhaline species in sediment sequences indicates an increase of Mediterranean influence and salinity and *vice versa*. The complete replacement of Mediterranean immigrants by oligohaline Caspian species shows separation between the Black Sea and Mediterranean, followed by desalination of the Black Sea. The classification of Tchepalyga (also spelled as Chepalyga) is used to describe the salinity of paleobasins: fresh <0.5‰, semi-fresh 0.5-5‰, brackish 5-12‰, semi-marine 12-30‰, and marine 30-40‰.

Results and interpretation

Foraminifera

Planktonic foraminifera do not live in the Ponto-Caspian basins, while they are abundant in the neighboring Sea of Marmara and the Mediterranean Sea. Benthic foraminifera live on the shelf to a maximum depth of 220 m in the Black Sea and 70 m in the Caspian Sea. In the Black Sea, they are represented by 101 species, 86% of which have Mediterranean genesis (Yanko 1989, 1990a).

The Black Sea foraminifera are dominated by ten species of *Ammonia*. The Black Sea endemic *A. novoeuxinica* together with Caspian endemics *Mayerella brotskajae* and *Elphidium caspicum capsicum* inhabit river deltas. Together with other Caspian endemics *A. caspica* and *Porosononion martkobi tchaudicus,* they indicate semi-fresh regime of the Black Sea. Euryhaline Mediterranean species A. *tepida* lives everywhere on the shelf while polyhaline *A. compacta* and *A. ammoniformis* dominate on the outer shelf where salinity is I≤18‰. Together with other Mediterranean species *A. beccarii, A. parkinsoniana* and *A. agoiensis,* they indicate a semi-marine and marine regime of the Black Sea.

There is strong variation in taxonomy and diversity of foraminiferal assemblages across the Black Sea shelf. In general, diversity of foraminifera increases from north-west to east and west reaching maximum values near the Bosphorus.

Lower Neoeuxinian beds (27-17 ky BP)

In the cores recovered below isobath 100 m, the Lower Neoeuxinian beds (27-17 ky BP) are separated from underlying sediments by an erosional unconformity, and are represented by alterations of grey silt and grey striped clays ($CaCO_3$ c. 50% and C_{org} >1%) enriched with hydrotroilite, sand (minor) and shells of *D. rostriformis distincta*. The foraminiferal assemblage consists of *A. caspica* and *Porosononion martkobi tschaudicus*. The number of specimens does not exceed 30 specimens. A similar assemblage inhabits present-day river deltas indicating a shallow semi-fresh paleoenvironment during accumulation of the Lower Neoeuxinian beds. There are no Mediterranean species among foraminifera, ostracoda, and mollusks. The Early Neoeuxinian basin was semi-fresh, aerobic, and heavily populated by benthic organisms. The Early Neoeuxinian palynological diagrams are dominated by *Artemisia, Chenopodiaceae, Adonis* and *Thalictrum* and are similar to those of the dry pine forest of Romania indicating a cold and dry climate.

Upper Neoeuxinian beds (17 - 10 ky BP)

Above isobath -100 m the Lower Neoeuxinain beds are often overlapped by subaerial loams and further on by aquatic sediments with ostracoda *Candona, Candoniella* and foraminifera *A. novoeuxinica.* This alteration indicates transformation of the bottom from erosional to a subaquatic accumulative phase at the beginning of the Late Neoeuxinian transgression.

The Upper Neoeuxinian beds cover the Black Sea floor below isobath -20 m almost everywhere: -18 m on Turkish, -30 m on Bulgarian, -20 m on north-western, -30 м on Crimean, -30 m on Caucasian shelves and -11 m in Kerch Strait. In some places (e.g., western part of the Golitsin Uplift located at the mouth of the Karkinitsky Bay) they are exposed on the sea floor. Their thickness varies up to 25 m. Lithologically the Upper Neoeuxinian beds on the shelf are rather monotonous. They are represented by light grey sandy coquina and/or bluish-grey stiff clays that fill pre-Neoeuxinian depressions and paleoriver valleys. The stiff clay has a massive structure, high density (about 2.7 g/cm^3), and low water content. The interstitial water salinity is 7‰

Mollusks are dominated by *D. polymorpha* and *D. rostriformis* on the inner and outer shelf, respectively. Other Caspian mollusks, such as *M. caspia,* are also abundant. The foraminiferal assemblage is rather uniform, being dominated by oligohaline Caspian *M. brotzkajae* and *E. capsicum,* and holeuryhaline *Black Sea* endemic *A. novoeuxinica.* The number of specimens do not exceed 100. Today, a similar foraminiferal assemblage inhabits river deltas and semi-fresh limans indicating paleosalinity of the Late Neoeuxinian lake of about 5‰ in the shallow area; it could reached 7‰ and even 11‰ in deeper parts of the basin. The Late Neoeuxinian lake was aerobic and heavily populated by organisms with carbonate shells. The Late Neoeuxinian palynological diagrams are dominated by *Quercus, Carpinus, Ulmus, Salix, Betula* with decreased concentration of *Pinus* and grass (Komarov et al., 1979). The climate became warmer during Late Neoeuxinian time as indicated by exchange of pine by broad-leaved forests.

In many places the Upper Neoeuxinian beds are overlapped by peats of c.10 ky BP and/or very coarse sediments. The maximum sampling depth (water depth plus depth in the core) of the peats is about 50 m. They were formed at the end of the Younger Dryas (ca 10.2 ky BP) when the level of the lake dropped to ca -55 m.

Holocene (10 ky BP - present)

The Bugazian beds contain the first Mediterranean immigrants, are widely distributed below the 17 m. isobath. Their thickness increases from 0.03-0.2 m on the slopes of submerged river valleys to 2.5 m on their bottom. They are represented by light grey or greenish-grey fine sand or blewish-grey clayely silt with $CaCO_3$ 31-36%, C_{org} 0.5-1.1%. The sediments have rudimentary lamination expressed as alternating light grey and dark grey microlayers of 1-2 mm thickness.

The Bugazian palynological diagrams are characterized by a sharp decrease of grassy elements (e.g., wormwood, goosefoot) and conifers (*Pinus, Picea, Juniperus*). Instead broadleaf Quercus, Corylus, Ulmus, Betula and even Beech become dominant indicating moderate climate conditions typical of the Boreal Ecozone.

On the inner shelf, Bugazian mollusk assemblages are dominated by *D. polymorpha*, but rare *C. edule* are present as well. The foraminiferal assemblage includes *M. brotzkajae, A. novoeuxinica* and *A. tepida* (up to 30 specimens per sample in total) and resembles the recent Dn-Bg assemblage distributed at depths >9 m and salinity of about 14.0‰. The interstitial water salinity is 15‰. On the outer shelf below isobath 40 m, Bugazian mollusk assemblages are dominated by *D. rostriformis distincta* but rare *C. edule* are also present. The number of foraminiferal species and specimens increases to 13 and 7000, respectively. The euryhaline *A. tepida* dominates. The similar foraminiferal assemblage lives today in Odessa Bay under a salinity of 13‰ indicating brackish/semi-marine regime of the Black Sea during accumulation of the Bugazian beds. .

The Bugazian beds overlap the Upper Neoeuxinian beds with erosional unconformity corresponding to drop of sea level from -20 m to -53 m below present. The boundary between the two is clearly seen by an appearance of the first Mediterranean immigrants among foraminifera, mollusks and ostracoda in Bugazian beds. This indicates a beginning of Mediterranean transgression that transformed the semi-fresh Late Neoeuxinian lake into the semi-marine Black Sea. This transgression has started ca 9.8 ky BP - 9.5 ky BP when sea level and salinity were about -42 m and 7‰, respectively. An increase of sea level and salinity was neither rapid nor catastrophic. Rather, it was gradual and occurred in a fluctuating manner. Due to the low amplitude of the regressive phases, they cannot be traced in cores recovered from a depth of more than 50 m, thus giving an impression of a gradual increase in sea level and salinity.

Conclusions

During the moderately warm Würm Paudorf (Middle Weichselian) Plenigalcial (prior to ca 27 ky BP), there was a brackish Tarkhankutian basin connected with the Sea of Marmara. At LGM, this connection was lost, and the level of the Tarkhankutian basin dropped to ca-100 m transforming this basin into the Early Neoeuxinian lake. The lake did not have connection with the Caspian Sea as well. In a warming climate at ca 17 ky BP, a massive water discharge most likely from the Caspian Sea via Manych Outlet increased the level of the Late Neoeuxinian lake to ca-20 m. The latter must have spilled an excess of semi-fresh to brackish water into the Sea of Marmara and from there into the Mediterranean. During the short climate cooling episode occurring at Younger Dryas, the level of the lake dropped from -20 m to -43 m and than rose again to ca -20 m. After ca 10 ky BP, the level of the Black Sea never again dropped below ca 40 m iosobath, nor exhibited a maximum amplitude of fluctuation greater than ca 20 m. At ca 10 ky BP, it reached -20 m again, allowing Mediterranean waters and organisms to enter the Late Neoeuxinian lake. The re-colonization of the Black Sea occurred in an oscillating manner. It was slow at the beginning, becoming most prominent at ca 7.0 ky BP. The connection between adjacent basins was probably not through the Bosphorus Strait, but via an alternative route, e.g., Izmit Bay - Sapange Lake - Sakarya River. On average, the sea level rose gradually but in an oscillating manner to the present level, and perhaps slightly higher.

References

Yanko-Hombach V.V. 2006. Controversy over Noah's Flood in the Black Sea: geological and foraminiferal evidence from the shelf. In Yanko-Hombach V., Gilbert A.S., Panin N., Dolukhanov P. (eds), The Black Sea Flood Question: Changes in Coastline, Climate, and Human Settlement, pp. 146-203. Springer, Dordrecht, The Netherlands. (In press).