EASTERN MEDITERRANEAN MARINE ECOSYSTEM MONITORING THROUGH MORPHOLOGICALLY ABNORMAL BIO-INDICATORS

G. Kontakiotis [1], A. Antonarakou [1], H. Drinia [1], G. P. Mortyn [2] and S. Zarkogiannis [1]*
[1] National & Kapodistrian University of Athens, Faculty of Geology & Geoenvironment, Greece - stergiosz@geol.uoa.gr
[2] Institute of Environmental Science and Technology (ICTA),Universitat Autonoma de Barcelona (UAB), Spain and Department of Geography, Universitat Autonoma de Barcelona (UAB), Spain

Abstract
We investigate morphological abnormalities of recent planktonic foraminiferal tests in coastal (Aegean Sea) and open marine (Levantine Sea) environments of the eastern Mediterranean Sea. The occurrence of "twinned" *Globigerinoides ruber* specimens may be linked to stressful environmental conditions, mostly associated with the hypersaline, oligotrophic and oxygen-depleted nature of the Mediterranean water column. Therefore their relative abundance can be a useful proxy for the reconstruction of paleoecological changes in stressed environments, and furthermore as an alternative to population dynamics in studying and monitoring natural population ecology.

Keywords: Bio-indicators, Paleoceanography, Salinity, Temperature, Mediterranean Sea

Morphological abnormalities of both benthic and planktonic (less frequent) foraminiferal tests have long been documented and various hypotheses relating to either natural ecological causes (wide salinity fluctuations, water acidification, oxygen depletion, increased terrigenous input, nutrification, and high energy hydrodynamics) or human activities (pollution by heavy metals, and organic matter produced by eutrophication) have been proposed to explain their occurrence [1-4]. Especially the particular type of abnormality manifested by the so-called "double tests" usually arise due to abnormal growth originating mainly from twinning, but may also be caused by irregularities in the early chambers and by regeneration after test injury that modifies the direction of growth. Application of this information to a suite of modern core-top samples in the eastern Mediterranean Sea [5] spanning strong sea surface environmental (temperature, salinity, dissolved oxygen and productivity) gradients, along a North-South transect shows the presence of twinned *Globigerinoides ruber* specimens for the first time, and furthermore highlights the possible connection between this mode of deformation and environmental parameters. Scanning Electron Microscopy (SEM) observations on *G. ruber* tests indicate a range of malformations and aberrant morphologies from slight deformity with smaller or overdeveloped chambers to more severe deformity with misplaced chambers, distorted spirals, irregular sutures, double apertures, or double tests forming twinned individuals. The test abnormalities, carried out on total assemblages, show that the Foraminiferal Abnormality Index (FAI) values range from 0% to 5%. In the North Aegean no abnormality events were found, while in the Central Aegean they were relatively rare, with percentages not exceeding 1% of the total assemblage. The highest percentage of abnormal tests occurred in the South Aegean and Levantine regions and reached ~5%. Although it is difficult to distinguish between the effect of natural stress and anthropogenic impact, their similar occurrence in both the coastal environment of the South Aegean and the open Levantine Sea lead us to carefully look at different aspects of the environment (e.g. salinity, eutrophication, oxygen levels) before concluding that anthropogenic pollution is the only cause of deformations of both benthic and planktonic foraminifera. The combined interplay of local environmental stressors acting on this oligotrophic, oxygen-depleted and hypersaline sector of the Mediterranean Sea is the most likely explanation for the observed morphological abnormalities. Regardless of the exact mechanism producing test abnormalities, our results clearly support the current use of the relative abundance of abnormal tests as a bio-indicator for monitoring natural stress, and further illustrate the necessity to map both their spatial and temporal distribution for accurate paleoenvironmental reconstructions. However, further investigations should extend this approach to test the robustness of our findings in a number of similar oceanic settings.

References

1 - Stouff V., Debenay J.P., Lesourd M., 1999. Origin of double and multiple shells in benthic foraminifera: observations in laboratory cultures. *Mar. Micropal.* 36 (4): 189–204.
2 - Geslin E., Stouff V., Debenay J.P., Lesourd M., 2000. In: Martin, R.E. (Ed.), Environmental variation and foraminiferal test abnormalities. Environmental Micropaleontology, vol. 15 of Topics in Geobiology. Kluer Academic, pp 191–215.
3 - Frontalini F. and Coccioni R., 2008. Benthic foraminifera for heavy metal pollution monitoring: a case study from the central Adriatic Sea coast of Italy. *Estuar. Coast. Shelf Sci.* 76: 404–417.
4 - Mancin N. and Darling K., 2015. Morphological abnormalities of planktonic foraminiferal tests in the SW Pacific Ocean over the last 550 ky. *Mar. Micropal.* 120: 1-19.
5 - Kontakiotis G., Mortyn P.G., Antonarakou A., Martínez-Botí M.À., Triantaphyllou M.V., 2011. Field-based validation of a diagenetic effect on *G. ruber* Mg/Ca paleothermometry: Core top results from the Aegean Sea (eastern Mediterranean). *Geochem. Geophys. Geosyst.* 12 (9), Q09004. doi:10.1029/2011GC003692.