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Bathymetric zonation of modern shelf benthic foraminifera in the Levantine Basin, eastern Mediterranean Sea

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ABSTRACT

Siliciclastic carbonate-poor sediments are common in southern and central parts of the inner Israeli shelf, part of the Nile littoral cell and in deeper water along the entire coast, while carbonate rich sediments occur in northern Israel and in submerged rocky environments. The distribution of benthic foraminifera, common components of these environments, was studied in surface sediment samples in order to identify their bathymetric zonation using multivariate statistical analyses. The dead foraminiferal assemblages exhibit a clear bathymetric zonation directly related to substrate type. A distinct faunal change has been found at approximately 40 m water depth coinciding with the shift from the shallow-water sand belt, distributed parallel to the Israeli coast up to Haifa Bay, to a silty–clayey belt relatively rich with organic matter extending westward along the entire SE Mediterranean shelf. *Ammonia parkinsoniana*, *Ammonia* sp. 1, *Buccella granulata*, *Nubeculina divaricata* and *Adelosina* sp. 1 predominating the shallow-water depths are positively related to sand content and negatively related to water depth. Other species, such as *Asterigerinata mamilla*, *Hanzawaia rhodiensis*, *Reussella spinulosa*, *Triloculina marioni* and *Valvulineria bradyana*, occurring between 40 and 100 m, exhibit a positive relationship with total organic carbon content and water depth. Beyond the Nile littoral cell and partly in its distal part *Amphistegina lessonii*, *Peneroplis pertusus*, *Pseudoschlumbergerina ovata*, *Pseudoschlumbergerina* sp. 1 and *Quinqueloculina ungeriana* dominate the rocky and coarse sand substrate, exhibiting a more positive relationship with higher carbonate content values. The distinct bathymetric zonation established in this study may prove to be useful in fossil records for accurate paleo-bathymetry reconstruction of Quaternary records in this dynamic system prone to frequent sea level fluctuations.

1. Introduction

Benthic foraminifera have been extensively used as sensitive indicators for reconstructing paleoenvironmental, paleoceanographic and paleobathymetric changes in different marine environments around the world including the Mediterranean Sea (e.g., Avnaim-Katav et al., 2013; Murray, 2006; Sen Gupta, 1999). In fine sediments of deep sea or continental shelf environments, benthic foraminifera respond mainly to variations in organic matter content and dissolved oxygen concentration (e.g., de Rijk et al., 1999, 2000; Jorissen et al., 1992, 1995; Mojtahid et al., 2009; Murray, 2001). In shallow shelf environments of the Mediterranean Sea, temperature, salinity and substrate type are the main environmental parameters influencing the distribution pattern of the benthic foraminifera (Basso and Spezzaferri, 2000; de Stigter et al., 1998; Hyams-Kaphzan et al., 2008; Jannink, 2001; Jorissen, 1987, 1988; Milker et al., 2009; Samir et al., 2003). Several ecological studies have demonstrated that the environmental variables controlling the distribution pattern of benthic foraminiferal assemblages vary with water depth (e.g., De Rijk et al., 2000; Rossi and Horton, 2009, and references therein). De Stigter et al. (1998) and Milker et al. (2009) showed distinct benthic foraminifera bathymetric zonation linked to substrate, water turbulence and food availability at the sea floor. Water depth by itself doesn't influence benthic foraminiferal distribution rather than other parameters cited above. Nonetheless in cases where water depth is shown to be indirectly influencing benthic foraminiferal distribution (e.g., Jorissen et al., 1995), they can be used for quantitative paleo-depth estimates as shown by Rossi and Horton (2009) and Milker et al. (2010) for shelf environments of the Western Mediterranean.

Hyams-Kaphzan et al. (2008) showed that the recent benthic foraminiferal assemblages in the southeastern Mediterranean inner-shelf depend primarily on substrate type, which is linked to its position along the Nile littoral cell and to bathymetry. Moreover, the Israeli benthic foraminiferal ecosystems have been lately invaded by some Lessepsian taxa introduced to the eastern Mediterranean from the Red

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Sea through the Suez Canal (Hyams et al., 2002; Hyams-Kaphzan et al., 2008; Langer and Hottinger, 2000; Zenetos et al., 2012).

Avnaim-Katav et al. (2013) studied lately the distribution of recent foraminiferal assemblages in Haifa Bay seafloor (Fig. 1). These assemblages were integrated with some proxy data and utilized as a modern analog for general characterization of past environmental changes that occur in three 120 m long cores that span the last million years. In order to better constrain and refine the paleo-water depth reconstructions of the subsurface successions of Avnaim-Katav et al. (2012) by a more quantitative approach, there is a need for a larger and comprehensive regional reference dataset for a proper statistical evaluation. Moreover this dataset can be applied to a wide range of scientific questions in quantitative environmental and climate studies.

In the current study, the results of Avnaim-Katav et al. (2013) were merged with those of Hyams-Kaphzan et al. (2008) and additionally, total organic carbon (TOC) in the sediment samples were analyzed in order to determine the most important factors influencing the foraminiferal distribution in the study area. Species distribution and composition of recent benthic foraminifera (thanatocoenosis) of the Levantine continental shelf were investigated for the first time via various multivariate analyses. Hence, this study is designed to create a robust and extensive regional reference dataset covering a wide range of environmental conditions (as opposed to the local information shown by Avnaim-Katav et al., 2013). By adding new information on the distribution patterns of the recent eastern Mediterranean foraminiferal census constrained by quantitative ordination methods (e.g., Redundancy Analysis), we intend to explain the species composition variability in relation to the environmental variables and specifically to examine whether the recent assemblages of the SE Mediterranean shelf show a distinct bathymetric zonation. This study provides an essential step for any future paleoenvironmental, paleoceanographic and quantitative paleowater depth reconstructions.

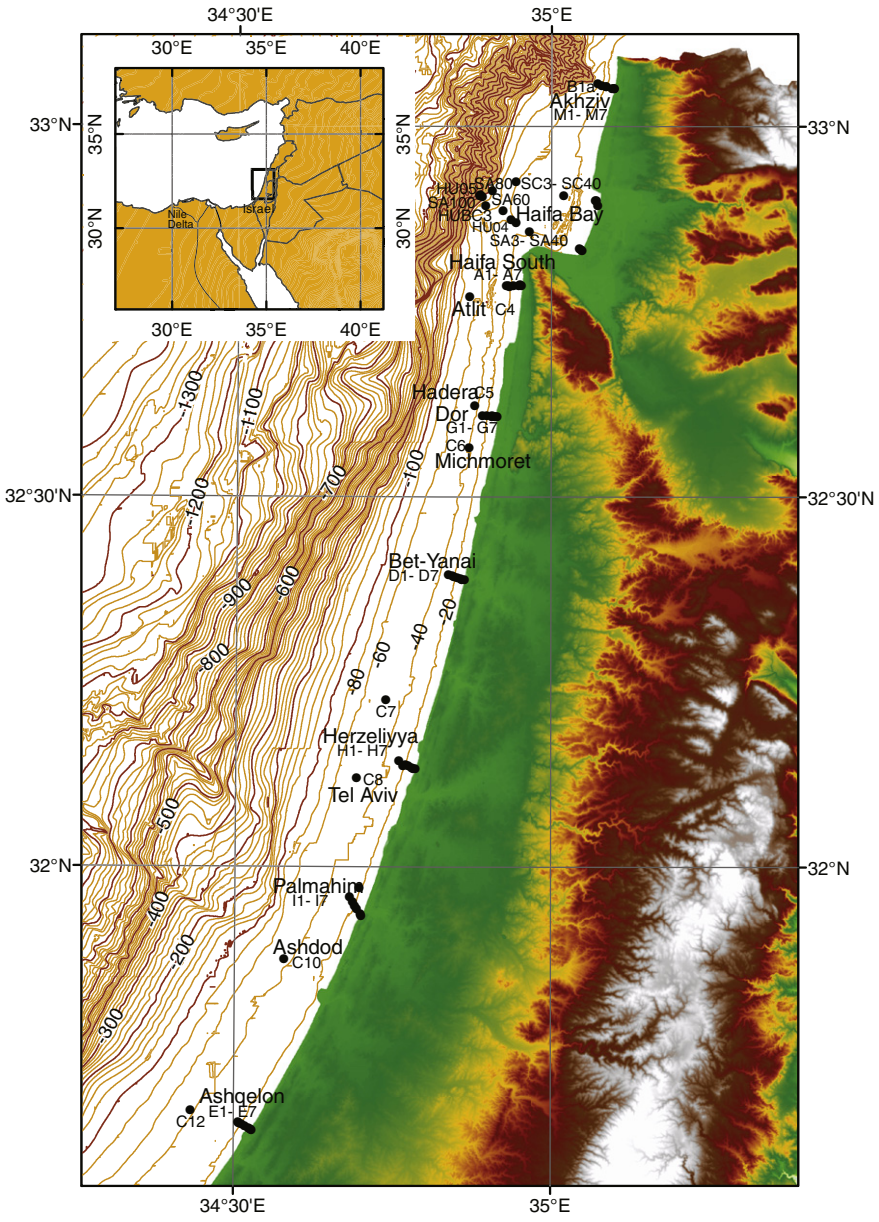

Fig. 1. Bathymetric map (contours at 20 m step) following Sade et al. (2006) showing the location of the studied sampling stations along the Israeli coast in the eastern Mediterranean (upper left corner). See also Table 1.