# Benthic foraminifera contribution to the stratigraphic and paleoenvironmental evolution of the coastal area of Farasan Al-Kabir Island (Saudi Arabia)

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Holocene environmental changes of coastal areas with a high temporal resolution, can be derived by the multi-proxy analysis of sediment cores (e.g., Morhange *et al.*, 2000; Triantaphyllou *et al.*, 2010; Di Rita *et al.*, 2011), while the study of benthic foraminifera assemblages together with radiocarbon dating is evidently the best tool to reveal the succession of past environmental conditions and, therefore, the alteration of physiographical settings (e.g., Cann *et al.*, 2000; Horton *et al.*, 2007; Koukousioura *et al.*, 2012; Xiang *et al.*, 2008).

The Farasan Al Kabir island is one of the two main islands of the Farasan Bank, which lies in the southeastern part of the Red Sea, offshore the southwest Saudi Arabian coast (Fig. 1A), and consists of more than 128 islands covering a total land area of approximately 600 $km^2$ (Khalil, 2012).

In order to reconstruct the coastal paleoenvironments since the mid Holocene, a 3.3-m long sediment core sampling, was conducted and Matar-1 core was analyzed. A multidisciplinary approach was selected to reveal short-term changes, combining micropalaeontological (benthic foraminifera), stratigraphical, lithological, element geochemical, bulk mineralogical, and isotopic dating ($^{14}C$) analyses. Thirty nine (39) samples were used for micropaleontological analysis and over than forty foraminiferal species were identified. Benthic foraminiferal assemblages of the studied core samples were generally rich, but a lot of broken specimens were observed. Thus, the broken-reworked ratio was calculated.

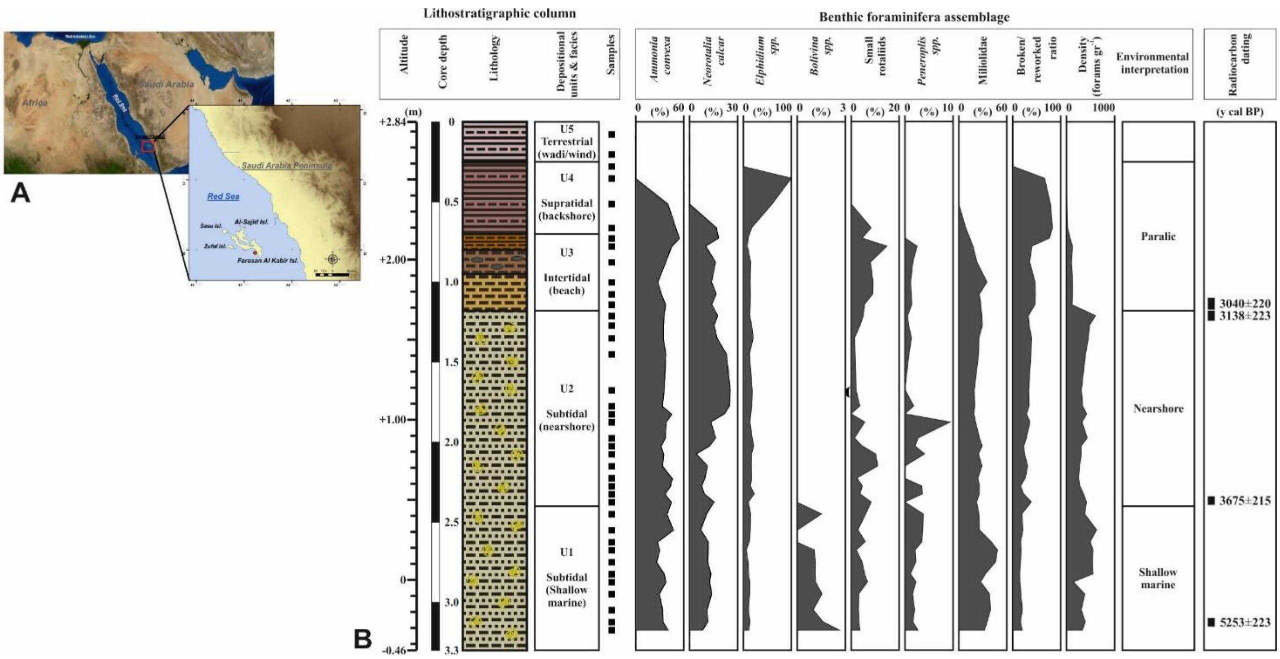


**Figure 1. A) Location map of Farasan Al-Kabir Island, B) stratigraphy and benthic foraminiferal assemblages of Matar-1 core (modified from Pavlopoulos *et al.*, 2018).**

The southeast coast of the Farasan Al Kabir Island is formed from uplifted reefal limestone. The arid low-lying topography includes hard rock formations, such as coral limestone plateau, cliffs and pediments, as well as soft-sediment formations, such as playa-like depressions located on plateau surfaces, alluvial fans and bajada, and sandy beaches.

The mid Holocene evolution of the borehole area is resulted from the detailed analysis of five sedimentary units detected along the core Matar-1, and includes three distinct stages:

(a) from 5253 ± 223 y cal BP to 3138 ± 223 y cal BP, carbonate coarse-grained material consisting of coral fragments, molluscs, calcareous algae and benthic foraminifera are deposited on a shallow marine fringing reefal platform.

Foraminiferal density presents high values, while the fauna is characterized by the dominant *Ammonia convexa* and miliolids, along with the small rotaliids, elphidiids and *Bolivina* spp. (Fig. 1B). Faunal composition varies at around 3675 ± 215 y cal BP, consisting mainly by *Neorotalia calcar* and *A. convexa* and by fluctuating percentages of small rotaliids, *Peneroplis* spp. and miliolids. Density reaches high values and broken-reworked tests increase significantly suggesting a high energy environment, in accordance with the Farasan modern analogue (Abu-Zied et al., 2011), pointing to a nearshore backreef, and later (around 3138 ± 223 y cal BP) a reef ramp.

(b) since 3040 ± 220 y cal BP foraminiferal density decreases abruptly, with broken-reworked tests presenting their highest values, suggesting that the borehole area obtains the characteristics of a high-energy beach that receives increasing inputs of terrigenous material;

(c) subsequently, a supratidal backshore setting is established influenced mostly by terrestrial processes and occasionally by marine processes, as it is indicated by the decreasing and sometimes sporadic presence of benthic foraminifera, and recently, a sedimentary veneer consisting of terrigenous, carbonate and evaporite material is formed by terrestrial, mainly wadi and aeolian, processes.

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## References

Cann, J.H., Bourman, R.P., Barnett, E.J., 2000. Holocene foraminifera as indicators of relative estuarine-lagoonal and oceanic influences in estuarine sediments of the River Murray, South Australia. Quaternary Research 53(3), 378-391.

Di Rita, F., Simone, O., Caldara, M., Gehrels, W.R., Magri, D., 2011. Holocene environmental changes in the coastal Tavoliere Plain (Apulia, southern Italy): a multiproxy approach. Palaeogeography, Palaeoclimatology, Palaeoecology 310(3), 139-151.

Horton, B.P., Culver, S.J., Hardbattle, M.I., Larcombe, P., Milne, G.A., Morigi, C., Whittaker, J.E., Woodroffe, S.A., 2007. Reconstructing Holocene sea-level change for the central Great Barrier Reef (Australia) using subtidal foraminifera. Journal of Foraminiferal Research 37(4), 327-343.

Khalil, H.M., 2012. Pliocene-Pleistocene stratigraphy and macrofauna of the Farasan islands, south East Red Sea, Saudi Arabia. Arabian Journal of Geosciences 5(6), 1223-1245.

Koukousioura, O., Triantaphyllou, M.V., Dimiza, M.D., Pavlopoulos, K., Syrides, G., Vouvalidis, K., 2012. Benthic foraminiferal evidence and paleoenvironmental evolution of Holocene coastal plains in the Aegean Sea (Greece). Quaternary International 261, 105-117.

Morhange, C., Goiran, J.P., Bourcier, M., Carbonel, P., Le Campion, J., Rouchy, J.M., Yon, M., 2000. Recent holocene paleo-environmental evolution and coastline changes of Kition, Larnaca, Cyprus, Mediterranean sea. Marine Geology 170(1), 205-230.

Pavlopoulos, K., Koukousioura, O., Triantaphyllou, M., Vandarakis, D., Marion de Procé, S., Chondraki, V., Fouache, E., Kapsimalis, V., 2018. Geomorphological changes in the coastal area of Farasan Al-Kabir Island (Saudi Arabia) since mid Holocene based on a multi-proxy approach. Quaternary International 493, 198-211.

Triantaphyllou, M.V., Kouli, K., Tsourou, T., Koukousioura, O., Pavlopoulos, K., Dermitzakis, M.D., 2010. Paleoenvironmental changes since 3000 BC in the coastal marsh of Vravron (Attica, SE Greece). Quaternary International 216(1), 14-22.

Xiang, R., Yang, Z., Saito, Y., Fan, D., Chen, M., Guo, Z., Chen, Z., 2008. Paleoenvironmental changes during the last 8400 years in the southern Yellow Sea: benthic foraminiferal and stable isotopic evidence. Marine Micropaleontology 67(1), 104-119.