Neoichnological Characteristics of Hypersaline Environments: Insights from the East Coast of Saudi Arabia

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Abstract

Neoichnology is a powerful tool for establishing the effects of environmental stress on trace-making organisms and these correlations then facilitate robust paleoenvironmental reconstructions. A wide variety of modern systems have been assessed for their neoichnological characteristics, although hypersaline environments have largely been ignored due to their limited worldwide distribution. Hypersaline conditions along the east coast of Saudi Arabia serve as an unparalleled natural laboratory to test trace-maker responses to extreme salinity conditions.

This study focuses on a tidal flat situated within a semi-enclosed embayment. The tidal flat no longer receives sediment and is covered by a relatively thin microbial mat, which enhances the preservation of underlying physical and biological structures. Over ten months (May 2021-June 2022), salinity values reached up to 59.2 psu and averaged 46.8 psu, while water temperature values reached up to 39.5°C and averaged 26.5°C. Substrate temperatures on the tidal flat reach 60°C during summer. Grain size samples were collected at 30 stations along 6 transects, and at 15 stations macrobenthic organisms were counted and total organic carbon was measured. Sedimentological and neoichnological characteristics were determined using trenches and x-radiographs at six locations, along two of the transects.

Observation of the near-surface sediment record reveals the presence of bi-directional current ripples, planar- parallel lamination, and mud drapes. Bioturbation intensity is low (BI 1–2) and is confined to the uppermost 10– 15 cm. Trace assemblages include simple vertical structures (e.g., Skolithos, Arenicolites) primarily constructed by modern larvae above the high tide water level. Layers below 15 cm depth exhibit well-preserved primary structures and are devoid of traces. Total organic carbon content is relatively high (maximum 5.7 wt%; average 1.8 wt%) suggesting sufficient nutrient availability. However, organic matter decay would limit the dissolved oxygen of pore water, which would inhibit infaunal activity without an open connection to the seafloor.

In conclusion, the studied tidal flat is subject to extreme environmental stress on infaunal organisms, primarily attributed to high salinity, with seasonal temperature fluctuations and possible oxygen depletion posing secondary stresses. Sedimentary structures are well-preserved with only minor bioturbation caused by very recent modification of the system. These insights contribute to building a robust ichnological model for hypersaline environments, which can be applied to similar systems globally and in the geological record.