RIFT CARBONATES, BRINE POOLS, AND DEEP SEA MICROBIALITES IN THE RED SEA – PART III

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PROJECT OBJECTIVES

- To characterize rift basin carbonates in an active maritime rift setting.
- To analyze a new dataset acquired in 2023 from the NEOM Brine Pool (Gulf of Aqaba) to evaluate the genomics and geochemistry of deep-sea extremophile microbial mat-forming communities.

PROJECT RATIONALE

The Red Sea and Gulf of Aqaba sedimentary basins are developed along the African and Arabian conjugate margins and are characterized by Late Tertiary rifts filled with siliciclastic, carbonate, and thick evaporite successions. In collaboration with OceanX, we have now conducted three research cruises to explore these basins, the first in 2020, the second in 2022, and now most recently, in 2023. All three cruises used the R/V OceanXplorer and had the common objective of exploring and further detailing the deep Red Sea rift offshore Saudi Arabia.

This project assembles a unique dataset spanning swath multibeam bathymetry, sub-bottom profiles, sample collections from submersible and ROV, and deep-sea coring. Work to date has focused on margin stability of the rift shoulders (Purkis et al., 2022a) and description of a complex of brine pools that we discovered at a depth of 1,770 m in the Gulf of Aqaba (Purkis et al., 2022b). Having had the opportunity to collect new cores in these pools, we are now using geochemical and genetic analyses to understand the sedimentary record preserved in these anoxic (and therefore not-bioturbated) settings and the geological relevance of the diverse and expansive extremophile microbial communities that they host.

APPROACH

The Red Sea is the youngest actively rifting marine basin in the world and it is also one of the few giant salt basins that is still evolving. Our overarching goal of this project is to use the Red Sea rift as a present-day analogue for rifted continental margins with adjacent “Atlantic-type” sedimentary basins. The Red Sea facilitates an examination of carbonate deposition in an active rift setting. In particular, the basin allows the interaction of shallow-water carbonates atop fault–bounded syn-rift highs to be studied. The analog is of broad interest because syn-rift carbonate platform strata can form important petroleum reservoirs within rift basin systems.

Our dataset allows the interaction between flowing sub-seabed Miocene evaporites and shallow-water carbonates to be examined in a nascent oceanic basin. At the present time, the Miocene evaporites of the Red Sea are covered by 200-300 m of hemipelagic Pliocene-Quaternary (PQ) overburden sediments, which appear to do a good job of preventing the halite within the evaporites from re-dissolving, except where exposed by faults or slumps. The PQ overburden would, however, have been much thinner or absent in the early Pliocene. Our dataset is interesting as it provides an analog for the likely seabed environment that occurred in the early Pliocene Red Sea and in early stages of other salt giants shortly after reflooding of their basins by seawater. Presumably, they were floored by patchy brine pools accompanied by exotic fauna, as seen at the NEOM brine pools. This kind of detail is hard to work out for the older margins such as off Brazil, though our observations hint at things to look for in those areas, such as evidence of undisturbed sediments within brine pools immediately or closely above the salt deposits. Why did those salt deposits not simply re-dissolve once those basins become reflooded with seawater after the desiccation phase? Seemingly the answer to that might partly in the stability of brine pools if diffusion is slow.

SIGNIFICANCE

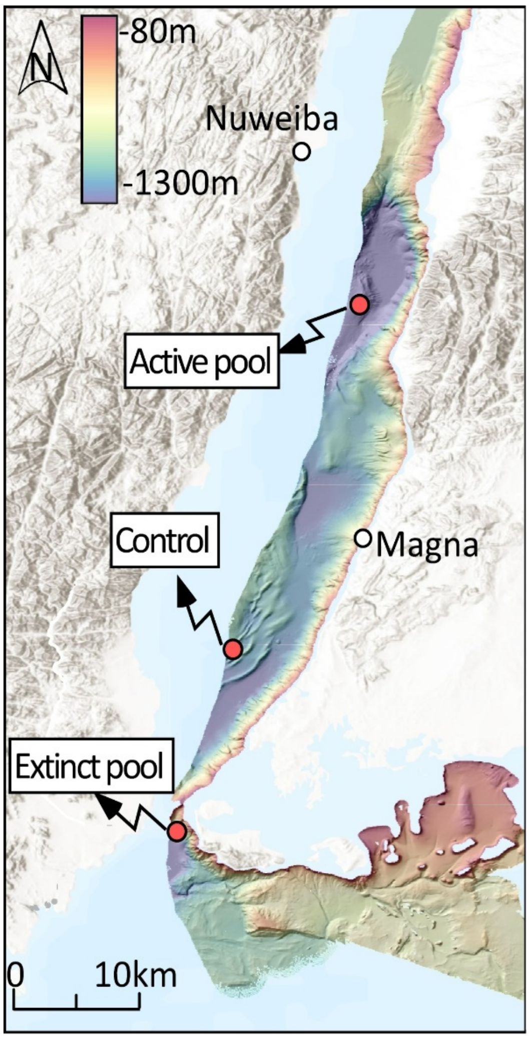

Figure 1: Multibeam data in the Gulf of Aqaba, Red Sea. Sample areas located in red.

The multibeam data assembled for this project allows for the direct imaging of the seabed structures generated by evaporite flowage, displacement, and withdrawal. Submersible and ROV dives have allowed direct sampling of the seabed structures associated with this movement. Discovery of the NEOM brine pools shows how sub-seabed evaporites can be dissolved by seawater penetrating along faults combined with hydrothermal circulation. Geologists commonly study microbialites but rarely in a deep-sea context as they are generally thought to be a shallow-marine phenomenon (Sprachta et al., 2001). The microbial fauna of the NEOM brine pool, however, implicates the potential formation of microbialites in bathyal-to-abyssal environments too. Further analyses will seek to determine if this microbial assemblage is actively trapping and binding sediments or precipitating new minerals. Preliminary genomic analyses reveal that the sediments surrounding the brine pool are just as diverse as the brine pool itself, while also harboring a distinctly different microbial assemblage (Fig 2). Thus, the biodiversity present in brine pool communities is even higher than previously thought, potentially opening the door for new research avenues in these extremophile environments.

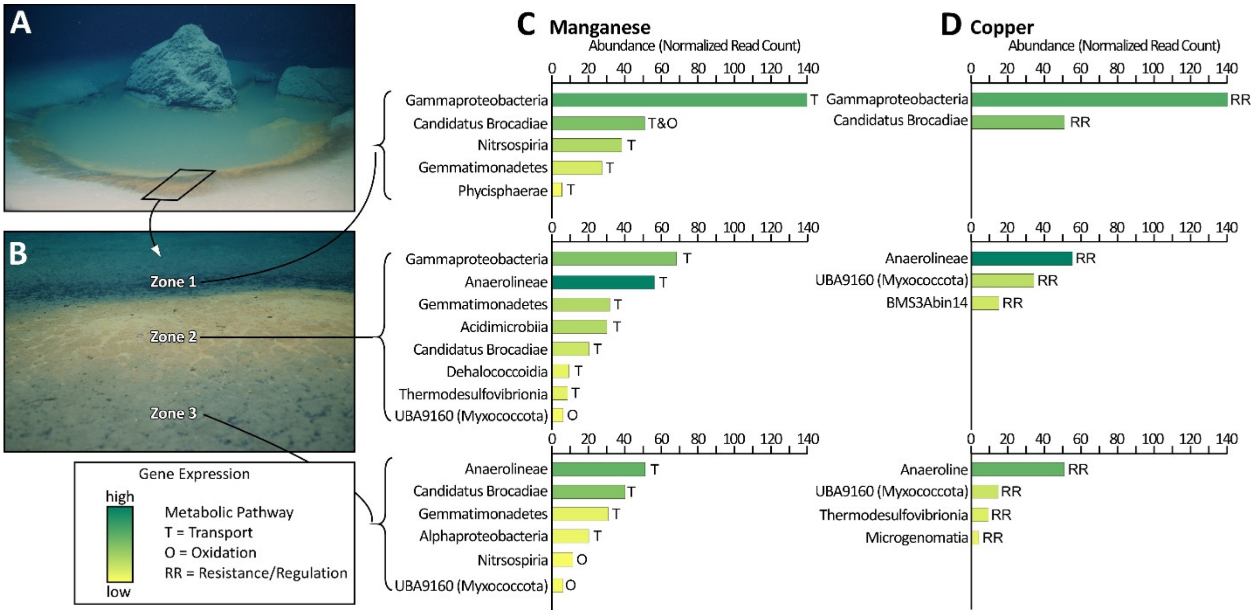

Figure 2: Expression versus abundance plots of microbes in the different microbial zones surrounding the NEOM Brine Pool, and their associated metabolic function. (B) The three microbial zones surrounding the brine pool. (C) Microbes present in the three zones utilizing Manganese. They are ordered based on abundance and shaded based on expression. Metabolic pathway stated on the end of the bar. (D) Microbes in the three zones utilizing Copper.

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