UNUSUAL CARBONATE SLOPES IN THE GULF OF AQABA

Ellie Barkyoumb, Gregor P. Eberli*, Morgan I. Chakraborty, Mara R. Diaz,
Peter K. Swart, Michael. G. Grammer, and Sam J. Purkis

KEY FINDINGS

- The very steep slopes in the Gulf of Aqaba are unusual: they have a wide mesophotic reef zone down to -150m followed downslope by undulating ledges with a regular spacing.
- These ledges consist of micritic limestone with fossils; with their hardness, their iron stained and borings by sponges and *lithophaga* they are reminiscent of hardgrounds.
- SEM images reveal a microbes, indicating that most of the micritic cement is microbially induced.

BACKGROUND

The Gulf of Aqaba is part of a nascent actively rifting ocean basin that is considered the most seismologically active region in the Middle East. As a result, submarine landslides big enough to generate tsunamis are common in the Gulf (Purkis et al., 2022). The waters in the Gulf are unique; the temperature and salinity are abnormally high and consistent throughout the water column.

Water temperatures do not significantly decrease with depth but are above 21°Celsius, even at depths of 1,700 meters (Fig. 1). Due to the restricted nature of the basin, the Gulf of Aqaba is slightly hypersaline, with an average salinity of 40 psu (Purkis et al., 2022). These conditions dictate not only the faunal assemblages that build frameworks and create sediment but might also influence the diagenetic processes that lithify the sediments in the shallow-water and the slopes. In a depth profile, the high diversity reefs in the shallow water give way to a luxurious mesophotic zone where corals coexist with foraminiferal-algal nodules (Bracchi et al., 2023). Below the mesophotic zone, the slope is very steep, in places near vertical. It consists of fine-grained wackestone and packstones that are

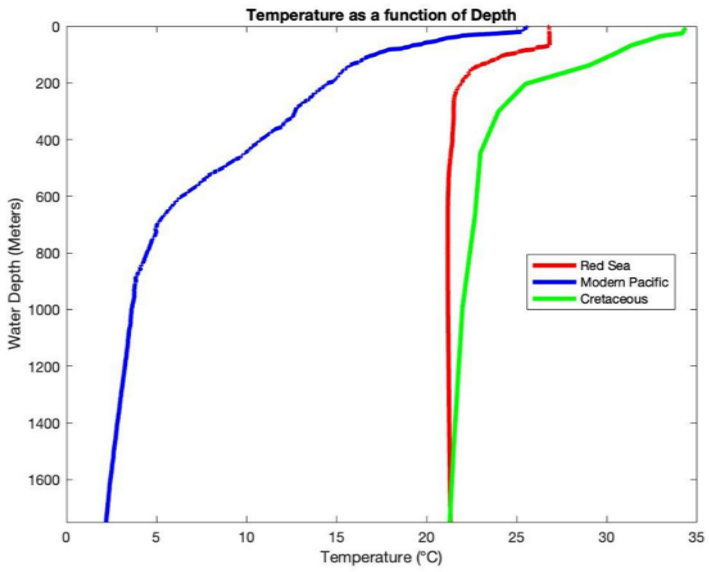


Figure 1: Temperature profile of the Red Sea, Modern Pacific and the Cretaceous. The Red Sea profile is unusual as temperature remains warm to great depth, while in most modern ocean basins temperatures decrease rapidly with depth.

arranged in a regular pattern of small cushion-like ledges. Their hard surface is reminiscent of a hardground. Here we report on the petrographic and geochemical analysis of slope carbonates taken at different water depths.

DATA SET AND METHODS

The data set consists of blocks retrieved from the carbonate slopes of the Gulf of Aqaba that were collected in collaboration with OceanX, aboard the R/V OceanXplorer during two cruises in 2020 and 2022. Remotely Operated Vehicles (ROVs) as well as human-occupied submersibles were used to be able to collect samples of the slope wall at a variety of depths, ranging from 0 to 800 meters water depth. After collection, samples were labeled, given initial descriptions, and organized along a depth transect. Visual inspection and description of 32 samples were followed by analyzing thin sections under a petrographic microscope to determine grain composition and diagenetic alterations. A portion of the sample was powdered and used for X-Ray diffraction (XRD) and stable isotope analysis of carbon and oxygen. XRD analysis was conducted in collaboration with Dr. G. Michael Grammer at the Boone Pickens School of Geology, Oklahoma State University.

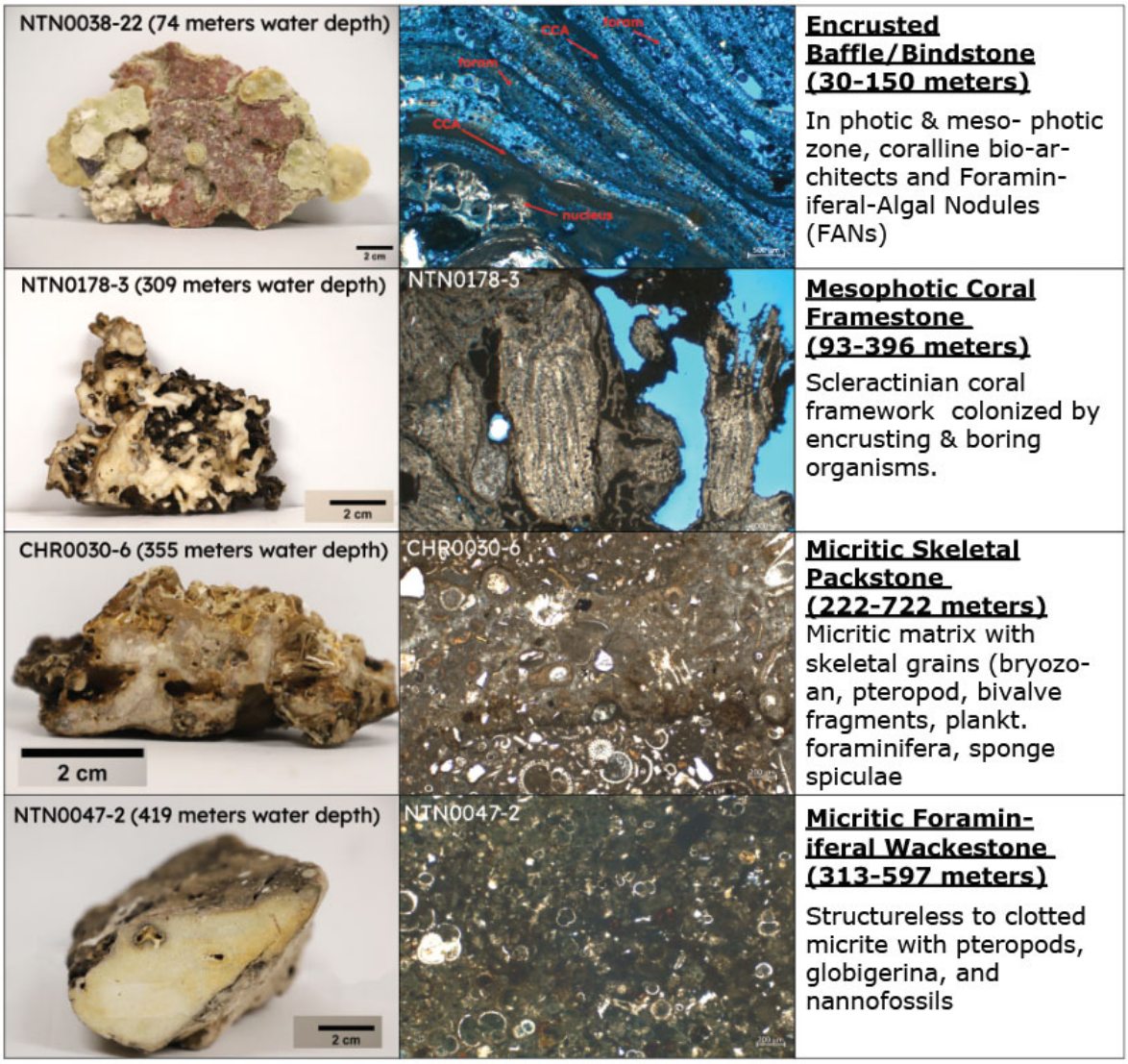
Fig.2 Submersible in front the micritic crusts below the mesophotoic reefs in the Gulf of Aqaba. The regular spaced, cushion-like ledges that are covered by a dust of sediment.

MORPHOLOGY AND COMPOSITION OF THE SLOPE

The morphology of the Gulf of Aqaba slopes is dictated by the rift tectonics that produces very steep slopes, punctuated by terraces and near vertical cliffs. Along the coastline of the Gulf of Aqaba, coral ecosystems flourish with a high coral species diversity peaking around 30 m depth. In addition to shallow water reefs, there are extensive frameworks of deep warm water azooxanthellate

corals in the aphotic zone of the Gulf of Aqaba. Dullo et al. (1990) defines the forereef slope sequence of the Red Sea as consisting of scleractinian corals, followed by hermatypic *Leptoseris* reefs, and micritic crusts. These micritic crusts protrude from the slope, producing layered ledges (Figure 2). In this study, we grouped the facies on the slope into four categories (Plate 1). The encrusted Bind/Bafflestone facies collected at shallow depths contain photosynthetic encrusting organisms. These organisms include Crustose Coralline Algae (CCA), zooxanthellate corals, sponges, and encrusting foraminifera. This facies also includes the free living foraminiferal-algal nodules that form an unexpected benthic ecosystem in mesophotic water depths. They are often transported into the deep water of the basin, where they stop accreting (Bracchi et al., 2023).

Plate 1: Facies Groups of the slope carbonates in the Gulf of Aqaba



MINERALOGY AND CEMENTATION

The most abundant mineral of the slope carbonates is high magnesium calcite (HMC). It ranged from 0 to 93% and was detected in all but one of the samples. Aragonite is the second most abundant, with higher percentage composition values within both the encrusted baffle/bindstone and mesophotic coral framestone group. Small amounts of dolomite and quartz grains were detected in some samples.

The majority of samples are well-cemented with microbially-induced micrite and large acicular splays as the dominant cement type (Fig. 3). In general, the microbially-mediated micrite is the initial cement, with the acicular aragonite as second generation of cements. In some instances, a second phase of micritic cement can cover the aragonite splay.

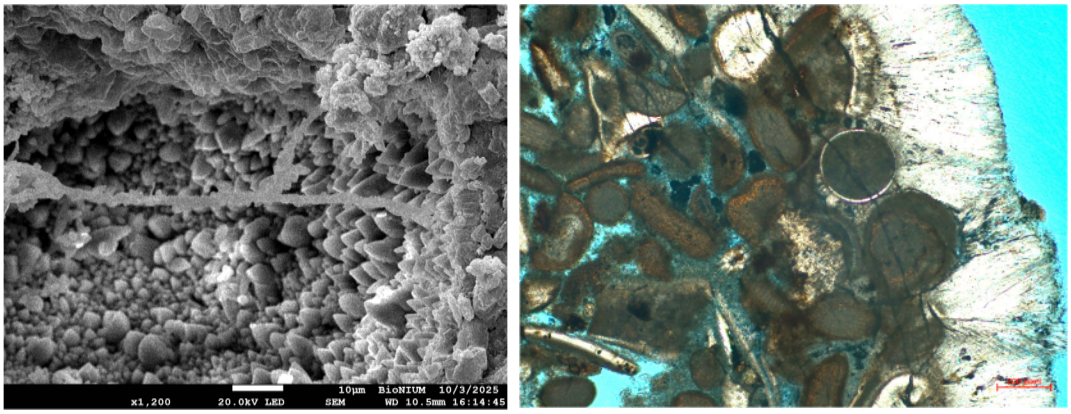


Figure 3: Left: Calcareous filament and micropeloids in the micritic crust. Right: Grainstone cemented by micritic contact cement and acicular aragonite splay on the outside of the clast.

SIGNIFICANCE AND IMPLICATIONS

The steep slopes in the Gulf of Aqaba harbor a highly diverse reefal ecosystem in the shallow water and deeper the mesophotic reef zone that with depth give way to ledges of the micritic crusts. The initial cementation along the entire transect is microbially induced micritic cement. Spectacular aragonite splays are late cements and most likely do not contribute much to slope stability. Altogether, the deep slopes in the Gulf of Aqaba can be consider an actively growing microbial slope. The undulating ledge morphology and the micritic crusts are reminiscent of the vertical wall at Chub Cay (Bahamas) and the Belize Barrier Reef.

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