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Sabkhas of Qatar: Extreme Environments Supporting Biological Activity and Mineral Formation

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The arid sabkhas (tidal salt flats) of Qatar are extreme biogeochemical environments, hosting hyper-saline conditions ideal for the formation of calcium-carbonates (dolomite, aragonite), -phosphorites (apatite) & -sulfates (gypsum, anhydrite) within the sedimentary column and on the surface as evaporites. These minerals form in close association with photosynthetic microbial mats residing at the sediment-water interface (SWI), and with degraded organic matter and microbes in the sediment below. Since the above minerals can form both authigenically and by biological means, the mineralization mechanisms and the consortia of microbes involved are unclear. Controlled recycling of phosphorites is of interest due to their economic importance in fertilizer production.

This study examines geochemical conditions at the SWI in the coastal environments of Qatar. We collected the sediment cores in December 2021 from diverse Sabkhas around Qatar (in-land sea, mangrove pond, salt pond, gypsum flat). The depth profiles sub-samples were analysed on methane content and isotopic composition, dry weight, total organic carbon, metal composition, alkalinity, and microbial community composition. Micro-profiling of the pH, redox potential, oxygenation, and sulfide concentrations were performed using a Unisense microsensor system with up to 1 mm spatial resolution. Electron microscopy imaging, Raman microspectroscopy, and X-ray diffractometry analysis were used to analyze morphology, chemical composition at high spatial resolution. The sediment core sampling profiles reveal major changes in all studied variables with sediment depth. Microsensor profiles of the microbial mats show increased oxygenation at the SWI, as well as increased sulfide concentrations and negative reduction potential directly below the mat surface. Characterizing the biogeochemical conditions in the sabkhas informs our future experiments involving the nanoscale *in situ* imaging of organo-mineralization mechanisms in microbial mats and their potential application in phosphorite bioremediation.

Figure 1: Microsensor profiling of H2S, O2, redox and pH levels and analysis of total organic carbon (TOC) in sabkha sedimentary columns. A) Microprofile obtained from the surface water and sediment of a mangrove pond near Al Thakhira, Qatar. Red dotted line shows the sediment-water interface. B) A microbial mat in the in-land sea Khor Al-Adaid. Inset: Microsensor apparatus. C) TOC profiles at the sabkha sites in the study.