Gypsum Stromatolites From Sawda Nathil: A Geological Relict From Salinas Along the Fourth Coastline of Qatar*

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Abstract

Sawda Nathil is one of a series of inland depressions (inland sabkhas and salinas) that extend nearly continuously along the Southern Qatar border with Saudi Arabia. Six to eight thousand years ago, these depressions were marine embayments that separated the peninsula of Qatar from the mainland. These embayments in-filled rapidly with marine sediments and dune sands, blown southeastward across Qatar. Since then, they have become progressively more evaporitic. Inland depressions like Sawda Nathil host a set of unique environments within Qatar. Most depressions are close to or below sea level, resulting in near-surface water tables in the driest parts of Qatar. Evaporation to salt saturation creates thick gypsum and salt crusts (sabkhas), as well as shallow hypersaline ponds (salinas) with spectacular domal microbial gypsum stromatolites. The present ground surface is a mosaic of relict marine facies, deflated dune sands, and inland sabkhas and salinas. Sediment from four short push cores was photographed, described, and sampled for petrographic thin-section and X-ray diffraction (XRD) analyses. Radiocarbon (AMS) as well as optically stimulated luminescence (OSL) age-dating were carried out on three samples. Scanning electron microscopy (SEM) was used to resolve the microbial-influence on gypsum precipitation. Radiocarbon dating of marine shells provides ages of approximately 6,600 un-calibrated ¹⁴C years before present (yr BP), coinciding with a well-documented sea-level highstand, approximately 2 to 4 meters higher than present. During that time, Qatar was mostly an island, only connected in the south to the Arabian Peninsula by narrow isthmuses. SEM examinations of gypsum stromatolites show gypsum crystals developing in close spatial association with microbial biofilms. Whether this is a purely passive microbial-influenced gypsum mineralization process or an example where microorganisms actively control the gypsum crystal morphology in order to obtain ecological advantages, remains to be evaluated. Studying and documenting different types of microbial sedimentary structures preserved in gypsum is of particular interest, not only in the field of petroleum geology, but also in the field of exobiology. Whereas carbonate minerals quantitatively form the most important sediments for preserving morphological bi-signatures on Earth, the most relevant chemical sediments on Mars are likely formed by sulfate minerals, such as gypsum.
Abstract

Sawda Nathil is one of a series of inland depressions (inland sabkhas and salinas) that existed near the coastline along the Fourth Coastline of Qatar. In the last thousand years, these depressions were marine embayments that expanded the peninsulas of Qatar from the mainland. These embayments filled rapidly with marine sediments and dune sands, leading seaward across Qatar. Since then, they have become ephemeral lakes with interdune salinas and inland sabkhas.

Inland depressions like Sawda Nathil are a sort of unique environments within Qatar. Most depressions are close to or above sea level, resulting in near-surface water tables in the deep parts of Qatar. Evaporation to salt saturation creates thick gypsum and salt crusts (inland sabkhas), as well as shallow hypersaline ponds (salinas) with spectacular domal microbial gypsum stromatolites. The present ground surface is a mosaic of relict marine facies, deflated dune sands, and inland sabkhas and salinas.

Sediment from four short push cones was photographed, described, and sampled for petrographic thin section and x-ray diffraction (XRD) analysis. Radiocarbon (AMS) as well as optically stimulated luminescence (OSL) age-dating were carried out on three samples, forming microbeads (MBM) was used to isolate the microfossil traces on gypsum crystals.

Radiocarbon dating of marine shells provides ages of approximately 6,600 un-calibrated yr B.P. (6,500 ± 70 yr B.P.) at Sawda Nathil, which is most likely an age equivalent to the fauna (Late Holocene) of the Northern Arabian Peninsula.

GBMR: Stratigraphic and mineralogical controls on the distribution of microbial biofilms associated with microbial stromatolites. Whether this is a purely passive microbial-influenced gypsum mineralization process or an example where microorganisms actively control the gypsum crystal morphology in order to obtain ecological advantages, remains to be evaluated.

Studying and documenting different types of microbial sedimentary structures preserved in gypsum is of particular interest, not only in the field of petroleum geology, but also in the field of exobiology. Whereas carbonate minerals quantitatively form the most important sediments for preserving morphological bio-signatures on Earth, the most relevant chemical sediments on Mars are likely formed by sulfate minerals, such as gypsum.

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Photographs showing saltina (SA) with water-covered gypsum stromatolites, temporarily exposed gypsum stromatolites covered by halite crust ("whitish" area, black arrows), and desiccated saltina / sabkha (DSA / SK), displaying buckled gypsum-halite surface crust (brownish area), tinged by sabkha (SK). Buckled gypsum-halite surface crust. Topographic highs in background are Eocene bedrock (EB).

Photographs showing subaqueous precipitated gypsum crust and gypsum encrustation.
A: Prismatic gypsum crystals (swallow-tails) forming multi-layered gypsum crust, covering salina floor. Gypsum growth seems to be triggered / mediated by cyanobacteria-rich, greenish layers (close-up, red box).
B: Prismatic gypsum crystals encrusting plant material.

Partly crossed polarized light.

Core photograph (SN-4), mineralogical composition determined by X-ray diffraction (XRD), reported as cumulative weight percentage, and thin section photomicrographs.

Photographs showing different types of single, mushroom-like looking, gypsum stromatolite.
A: Side view.
B: Side view.
C: Top view.
D: Cross-section through stromatolite showing gypsum-encapsulated green cyanobacteria, indicating photosynthesis.
Photograph showing Holocene beach bar / tidal bar (HB; foreground, "whitish" area) dipping towards back bar desiccated salt pan (DSP, background, "whitish" area), displaying warped-up halite polygons.

Transition between beach bar / tidal bar and salt pan (salina) shows darker, brownish sabkha (SK) area, displaying buckled gypsum-halite surface crust.

Photographs showing close ups of salt pan and Holocene beach bar / tidal bar area.
A: Dry (desiccated) salt pan (DSP) displaying halite crust polygons with upturned edges.
B: Deflated Holocene beach bar / tidal bar (HB) showing predominantly cardiid bivalves and cerithid gastropods.
C: Deflated Holocene beach bar / tidal bar (HB) trench showing intertidal to shallow subtidal bivalves, gastropods (cerithids), and vertical Skolithos-type burrows.

Cross-section, correlating push cores SN-12, SN-4, SN-10, and SN-9. Shown is lithology, sedimentary structures, major grain types, and vertical facies successions for each push core. Also shown are interpreted lateral and vertical environment of deposition (facies) transitions between push cores (not to scale). Radiocarbon age-dating results show un-calibrated conventional 14C ages of approx. 6,600 yr BP.

Photographs showing close ups of salt pan and Holocene beach bar / tidal bar area:
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Defined Holocene beach bar / tidal bar (HB) showing predominantly cardiid bivalves and cerithid gastropods.

Photograph showing Holocene beach bar / tidal bar (HB) fronting ETR - surface morphology and vertical Skolithos-type burrows.