Sea-Level Controlled Low-Energy Shoreline Progradation and Facies Successions along the Southwestern Coastline of Qatar (Al-Zareq Area, Gulf of Salwa)*

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Abstract

Qatar is a north-south oriented peninsula that protrudes into the southern Arabian Gulf. Its western coastline is characterized by low-energy beach systems that form in a narrow embayment (Gulf of Salwa), protected from high wave energy associated with the predominant northwestern Shamal winds by the Bahrain-Qatar high. Globally, the Holocene transgression started about 18,000 years ago. The Bahrain-Qatar high acted as a barrier between the Gulf of Salwa and the Arabian Gulf, preventing flooding of the Gulf of Salwa until about 9,000 years before present (yr BP). Sea level reached a highstand of 2 to 4 m above present day about 6,000 yr BP. The subsequent regression of sea level caused several kilometers of seaward progradation and the stranding of previous Holocene shorelines.

The present study aims to illustrate facies changes and coastal evolution in the area of Al-Zareq, situated along the southwestern coastline of Qatar. Twelve sediment cores, ranging in thickness between 5 and 20 meters, were recovered and sampled, and several trench profiles were described; representative of the entire transgression-regression cycle. Our investigation entailed general sedimentologic and stratigraphic description, grain size and shape distribution, petrographic thin section analyses, XRD for semi-quantitative determination of mineral assemblage, as well as microfaunal classification. Additionally, more than thirty samples were radiocarbon-dated, and five samples are currently being dated by optically stimulated luminescence. Distinct facies types, formed by the interplay between siliciclastic, carbonate, and evaporite deposition and precipitation, and related to paleobathymetry controlled by pre-flooding Pleistocene dune fields and sea-level variations, are indicative of different depositional environments. Interpreted environments of deposition include open-lagoon (coarse bioclastic carbonate), protected (fine bioclastic carbonate) and restricted (salina-type evaporite) shallow subtidal to intertidal lagoons, higher energy intertidal beaches (gastropods and ooids), as well as supratidal coastal sabkha and dune environments. Dense sampling for radiocarbon dating chronologically pinpoints facies changes and coastal dynamics and evolution. Over time, the Pleistocene and Early Holocene terrestrial dune environment transitioned to subtidal marine conditions during the Middle Holocene sea-level highstand. This was followed by Late Holocene beach migration/progradation, causing gradual restriction and closing of lagoons, and the eventual formation of sabkha conditions.

The described sea-level-controlled facies successions observed at Al-Zareq represent low-energy beach environments that can be used for conditioning geological and reservoir models of arid climate reservoirs like the Jurassic Arab and the Permo-Triassic Khuff formations.

Selected Reference

Lambeck, K., 1996, Shoreline reconstructions for the Persian Gulf since the last glacial maximum: Earth and Planetary Science Letters, v. 142, p. 43-57.

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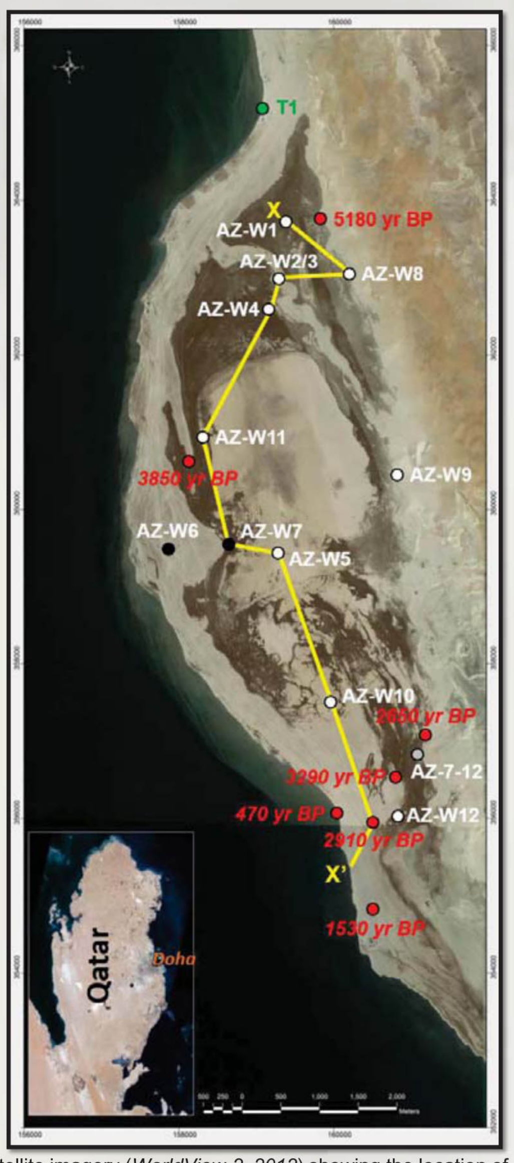
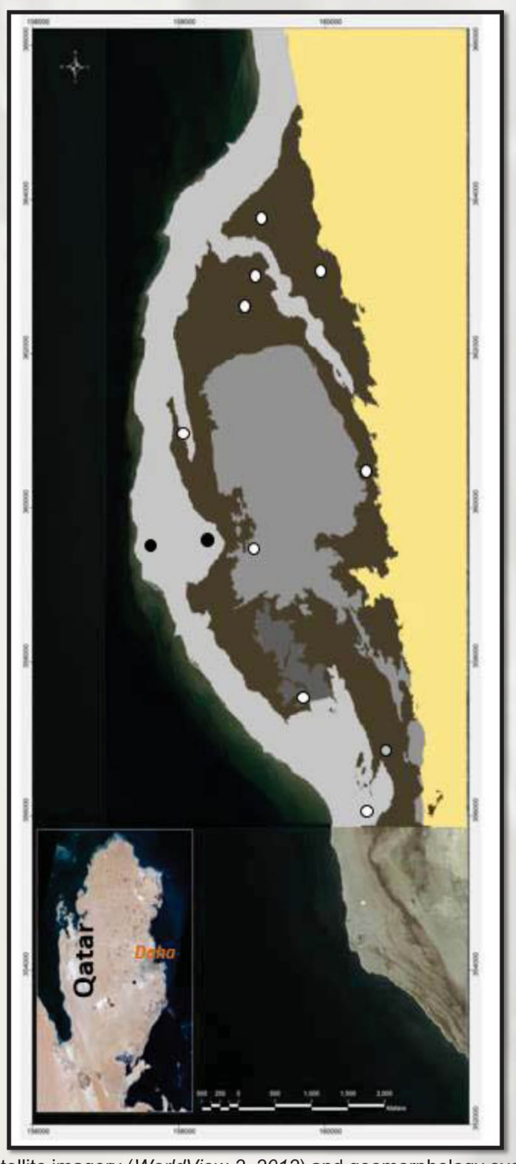
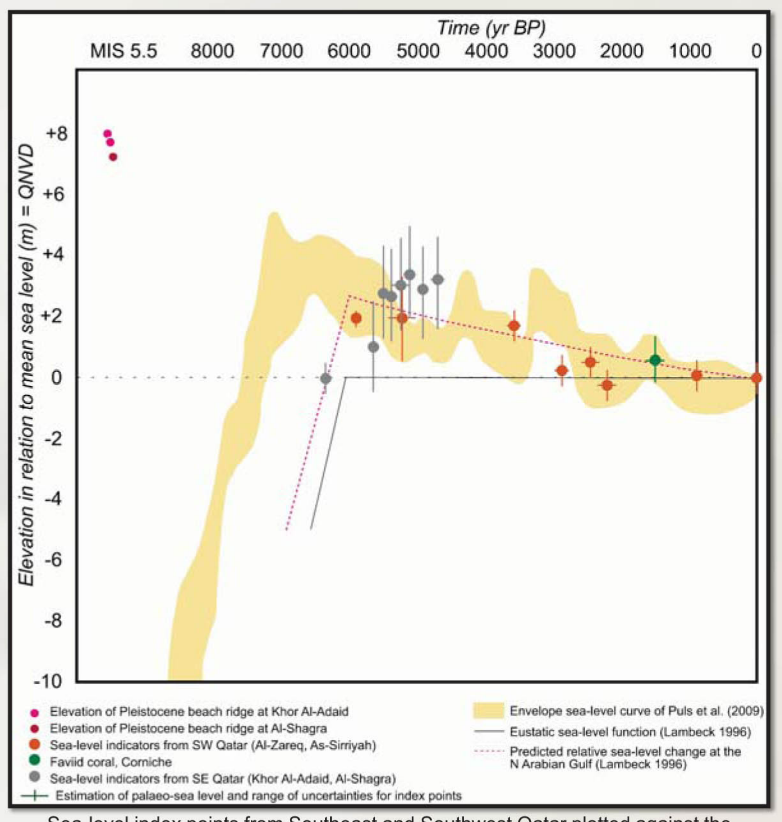


Satellite imagery (*WorldView-2, 2012*) showing the location of 10 vibracored wells (white dots), 1 shallow core (gray dot), 2 deep wells (up to 20.5 m; black dots), and 1 trench (green dot). Also displayed are un-calibrated ^{14}C surfaces ages (red), as well as the position of the North-South cross-section X-X'.



Satellite imagery (*WorldView-2, 2012*) and geomorphology overlay. See legend directly to right.



Sea-level index points from Southeast and Southwest Qatar plotted against the relative sea-level curve of Puls et al. (2009) and the eustatic sea-level function and predicted relative sea-level curve for the northern Arabian Gulf (Lambeck 1996). Most sea-level indicators are represented by radiocarbon-dated shell material.

- Soft gypsum-halite crust
- Buckled, polygonal lagoonal sediments
- Buckled-polygonal gypsum-bassanite-halite crust
- Beach
- Dune

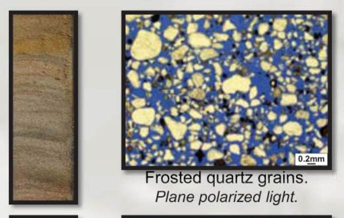
Environment of Deposition

Core Photographs | **Thin Section Photomicrographs**

1. Aeolian Dune and Interdune Environment

1a. Aeolian Dune

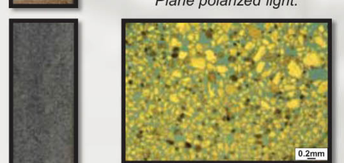
- Dune foresets to toesets
- Low-angle cross-bedded to parallel-bedded
- Frosted quartz grains, moderately rounded



Frosted quartz grains. *Plane polarized light.*

1b. Reworked Dune

- Wavy-bedded to non-bedded
- Variable structures due to reworking
- Minor coatings around quartz grains
- Minor amounts of carbonate material (peloids, coated grains, and skeletal grains)



Frosted quartz grains and coated grains. *Plane polarized light.*

2. Coastal Sabkha (Diagenetic) Environment

- Supratidal environment
- Non-bedded
- Very rich in quartz
- Minor amounts of carbonate material (peloids, skeletal grains, ooids and/or coated-grains)
- Rich in lenticular and minor prismatic gypsum

3. Saline Lake (Salina) Environment

- Restricted lagoon, shallow subtidal to intertidal environment
- Prismatic, swallow-tail gypsum crystals
- Minor halite crystals

Lenticular gypsum crystals. *Partly crossed polarized light.*

Prismatic gypsum crystal. *Partly crossed polarized light.*

4. Protected Lagoon Environment

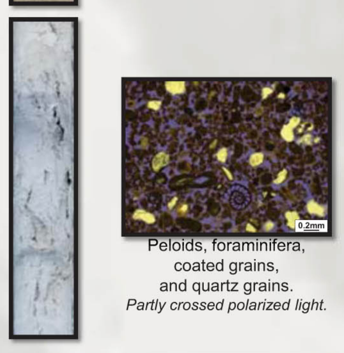
4a. Sand-Dominated Protected Lagoon

- Low-energy, shallow subtidal to intertidal environment
- High amounts of quartz
- Minor amounts of carbonate material (peloids, gastropods, and bivalves)
- Bivalves in live position
- Non-bedded to bioturbated
- Various amounts of lenticular gypsum

Foraminifera, shell fragments, and predominantly quartz grains. *Plane polarized light.*

4b. Carbonate-Dominated Protected Lagoon

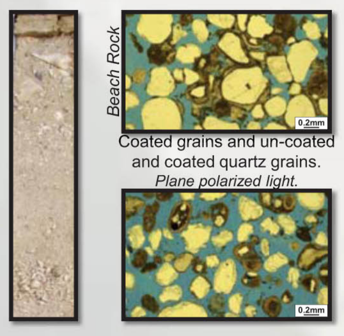
- Fine-grained peloid-skeletal packstone
- Rich in Cerithid gastropods
- Rich in foraminifera (etc., *Peneroplis* sp.)
- Common ostracods
- Rare ooids/coated grains
- Rare microbial lamination
- Non-bedded to bioturbated
- Minor amounts of quartz
- Various amounts of lenticular gypsum



Peloids, foraminifera, coated grains, and quartz grains. *Partly crossed polarized light.*

5. Beach and Beach Spit Environment

- Higher-energy, intertidal foreshore environment
- Beach rock, displaying fenestral structures and pelagosite-type aragonite coatings
- Low-angle cross-bedded to parallel-bedded
- Gastropod-ooid/coated-grain grainstone
- Rich in ooids and coated quartz-grains
- Rich in Cerithid gastropods
- Rich in quartz



Coated grains and un-coated and coated quartz grains. *Plane polarized light.*

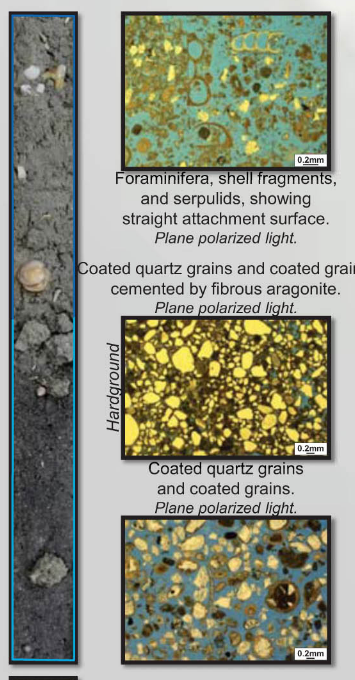
6. Open Lagoon Environment

6a. Low-Energy, Shallow-Subtidal Lagoon

- Non-bedded to bioturbated
- Coarse-grained skeletal-peloid packstone
- Rich in serpulids, often showing straight attachment surfaces, indicating growth on sea-grass leaves
- Rich in foraminifera (etc., *Peneroplis* sp.)
- Rich in *Cerithid* gastropods and bivalves
- Intercalated hardgrounds or reworked hardground clasts

6b. High-Energy, Tidal Channel and Tidal Bar Environment

- High-energy, shallow-subtidal environment
- Non-bedded
- Coarse quartz sand with lesser amounts of skeletal grains
- Quartz grains typically carbonate-coated (superficial ooids)
- Minor foraminifera (etc., *Peneroplis* sp.)
- Cerithid gastropods and bivalves present
- Intercalated hardgrounds or reworked hardground clasts



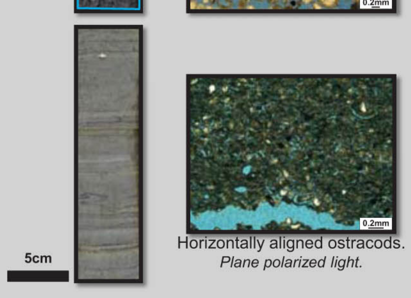
Foraminifera, shell fragments, and serpulids, showing straight attachment surface. *Plane polarized light.*

Coated quartz grains and coated grains, cemented by fibrous aragonite. *Plane polarized light.*

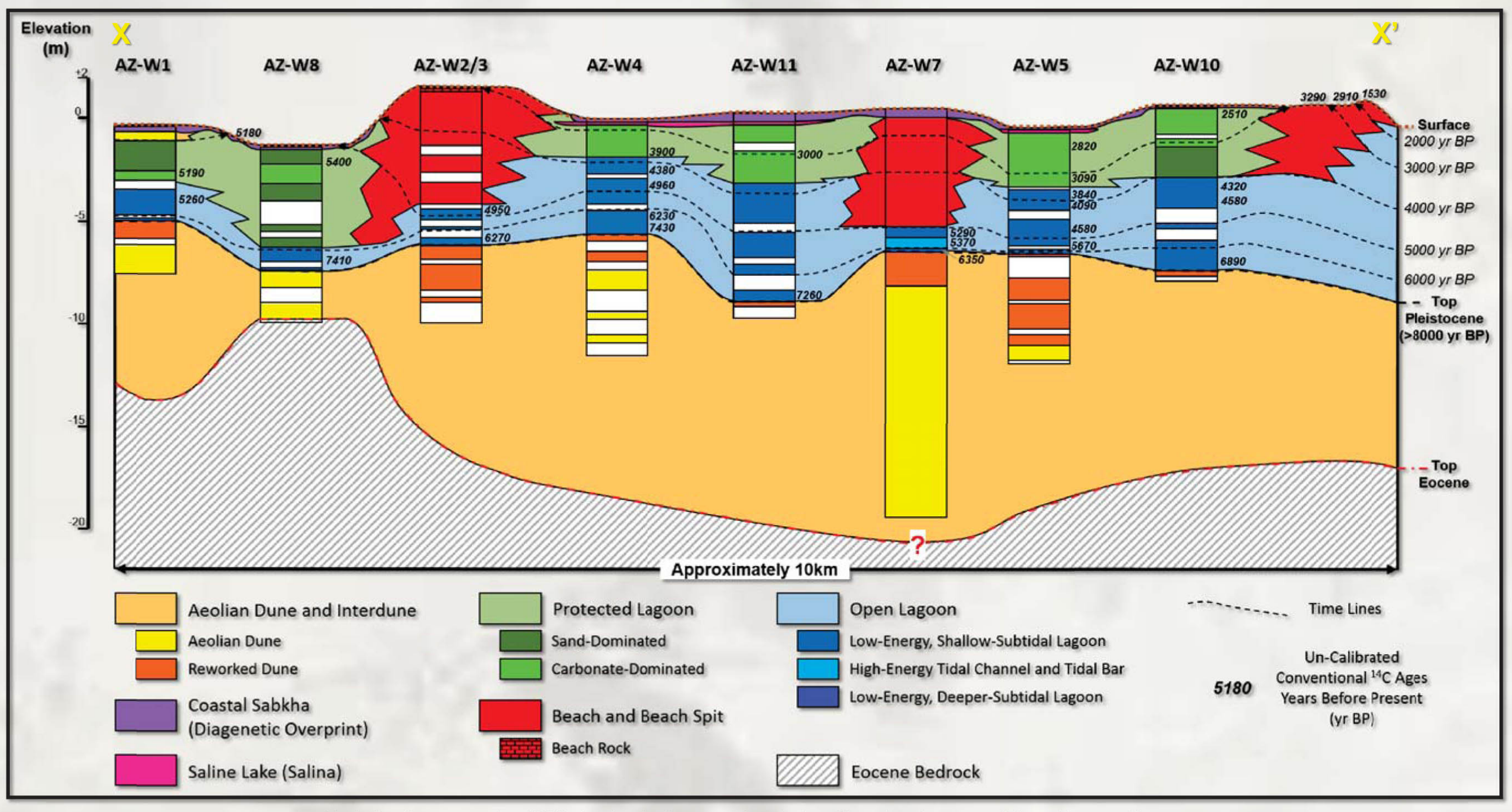
Coated quartz grains and coated grains. *Plane polarized light.*

6c. Low Energy, Deeper-Subtidal Environment

- Millimeter-bedded
- Fine-grained peloid-skeletal packstone
- Rich in quartz
- Rich in ostracods
- Rich in foraminifera (etc., *Peneroplis* sp.)
- Gastropods and bivalves present5
- Intercalated hardgrounds or reworked hardground clasts



Horizontally aligned ostracods. *Plane polarized light.*



North-South cross-section (X-X') showing the interpreted vertical and lateral environment of deposition transitions. Also shown are interpreted time-lines, based on radiocarbon age dating results. See satellite imagery for location of cross-section X-X'.

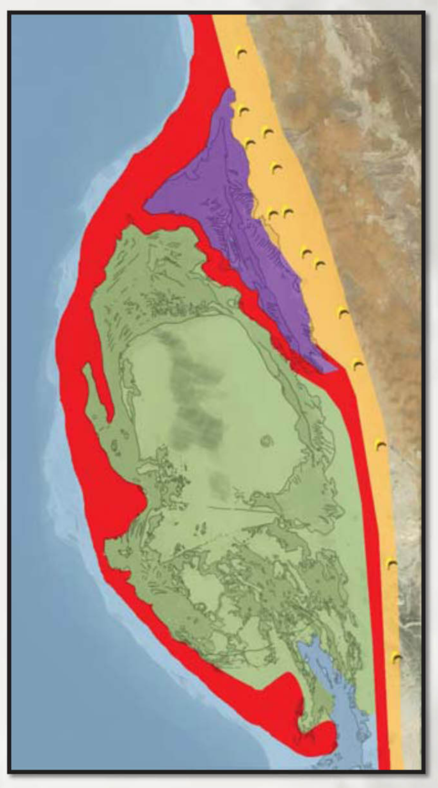
Environment of Deposition Maps along Time Lines Shown on North-South Cross-Section X – X'

Top Pleistocene (> 8000 yr BP)

6000 yr BP

5000 yr BP

4000 yr BP



3000 yr BP

2000 yr BP