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**

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Abstract

Qatar is a north-west oriented peninsula that protrudes into the southern Arabian Gulf. Its western coastline is characterized by low-energy beach systems that form in a narrow environment (Gulf of Salwa). These areas are prone to high wave-energy associated with the predominant north-western to south-western winds driven 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 1 to 3 m above present day about 6,000 yr BP. The subsequent regression of sea level caused several kilometers of seaward progradation and the formation 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 0.5 and 20 meters, were recovered and sampled, and several trench profiles were described. The results of the entire study are represented in the form of a transect showing the evolution of the coastal systems. Our investigation resulted in general sedimentological and stratigraphic description, grain-size and shape distribution, paleontological analysis, XRD for semi-quantitative determination of mineral assemblages, as well as micropaleontological 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 alluvial, carbonate, and aeolian deposits and their associations, are excellently exposed and well-preserved in the Foreland plains and associated depositional environments. In particular, the Holocene environments of deposition include: (1) coastal sequences (coastal tidal flats), (2) carbonate platforms, (3) carbonates slopes and terraces, and (4) dune environments. These facies types, represented by bioclastic, lithoclastic, and chalky deposits, are intercalated with silty sands and fine sands, and are distributed in a zonal manner along the coastline. The Holocene depositional systems are characterized by a high diversity of bioclasts, including the shell fragments of mollusks, echinoderms, and brachiopods, as well as the remains of fish and marine plants. These facies types are interpreted as having been deposited in a variety of depositional environments, ranging from coastal plain to tidal flat environments.

Facies Associations

1. Aeolian Dunes and Interdune Environment
   1a. Aeolian Dune
      - Dune foresets to foresets
      - Low-angle cross-stratified to parallel-stratified
      - Fossilized dunes, moderately rounded
   1b. Worked Dune
      - Warped dunes, interdune settings
      - Minor cross-laminated quartz sands
      - Minor amounts of carbonate material (peloids, coated grains, and algal debris)

2. Coastal Sabkha (Diagenetic) Environment
   - Supradunal environment
   - Non-bioclastic, white sands
   - Minor amounts of carbonate material (peloids, coated grains, and algal debris)
   - Rich in turriform and minor micritic pisolites

3. Saline Lake (Salina) Environment
   - Restricted lake, shallow subtidal to intertidal environment
   - Phreatic, saline, kaolinite clay pellets
   - Minor halite crystals

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, coated grains, and brachiopods)
      - Brackish to brackish
      - Non-bioclastic
      - Various amounts of turriform pisolites
   4b. Carbonate-Dominated Protected Lagoon
      - Fine-grained peloidal-skeletal carbonates
      - Rich in Centrulina gastropods
      - Rich in foraminifera (e.g., Peneroplis sp.)
      - Common ooids
      - Rare silicified ooids
      - Rare microbial laminations
      - Non-bioclastic
      - Various amounts of turriform pisolites

5. Beach and Beach Spill Environment
   - Higher-energy, intertidal environment
   - Beachrock, displaying fenestral structures and bioclastic facies
   - Low-angle cross-stratified to parallel-stratified
   - Various amounts of turriform pisolites
   - Rich in fossils and coated grains
   - Rich in Centrulina gastropods
   - Rich in quartz

6. Open Lagoon Environment
   - Low-Energy, Shallow-Subtidal Environment
     - Non-bioclastic
     - Coarse-grained peloidal-pelletated carbonates
     - Rich in sponges, oysters, and clams
     - Rich in foraminifera (e.g., Peneroplis sp.)
     - Rich in Centrulina gastropods
     - Rich in turriform pisolites

   - High-Energy, Tidal Channel and Tidal Bar Environment
     - Intercalaed peloidal carbonates with lower amounts of peloids, grains
     - Various amounts of turriform pisolites
     - Rich in turriform pisolites
     - Rich in Centrulina gastropods
     - Rich in turriform pisolites

   - Low Energy, Deeper-Subtidal Environment
     - Altered turriform pisolites
     - Various amounts of turriform pisolites
     - Rich in turriform pisolites
     - Rich in turriform pisolites

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