



# Upper Pleistocene-Holocene Coastal Depositional Sediments of the Farwah Spit, NW Libya

Ibrahim Mriheel and Mohamed Hamruni

## Abstract

This study examines sedimentary facies development of coastal deposits adjacent to the modern-day Farwah Spit in NW Libya. The modern-day coastal depositional system comprises salt marsh, tidal flat, lagoon, flood delta, and spits. Sedimentological analysis of outcrops, integrated with satellite image interpretation and comparison with equivalent deposits from neighbouring provinces, allows an understanding of the genesis and timing of the Holocene Farwah Spit Formation. The Holocene sediments unconformably overlie sediments of the Late Pleistocene age. This sequence boundary is represented by an exposed and weathered surface with Late Pleistocene marginal marine bioclastic and bioturbated sandy coastal sediments. The Holocene Farwah Spit Formation comprises bioclastic sands interpreted to record transgressive marginal shallow marine facies. These change laterally to grey muds, rich in organic matter (TOC up to 3.05%), deposited within a lagoon, and protected from the sea by Holocene sand spits. Locally, close to the eastern inlet, the lagoonal facies pass into rippled sands, interpreted to record flood delta deposits. Landward, the cycle is represented by supratidal sand and mudstones deposited in a salt marsh with characteristic halophile plants. Locally, a thin salt crust cover has occasional microbially induced sedimentary structures and/or yellow sands of aeolian origin. Mapping lateral facies changes allows identification of prograding succession, resembling sixth-order sedimentary cycles that extend for 13 km E-W along strike and vary from 100 m to a few km in width. The distribution of coastal depositional facies, particularly the spatial distribution of the Holocene prograding spits and the associated lagoonal-tidal flat

sediments, records the progressive infilling of the lagoon. Progradation of the spit is interpreted to have developed within a highstand systems tract, following sea-level rise after the last glacial maximum. The main factors controlling facies development are local topography, sea-floor morphology, sedimentation rate, relative sea-level fluctuation, and climate change following the last glacial maximum. The response to sea-level rise offers insight into long-term changes in coastal morphology that are relevant to impact studies of future sea-level rise associated with climate change.

## Keywords

Upper Pleistocene-Holocene • Coastal deposition • Farwah • NW Libya

## 1 Introduction

This study records the sedimentary facies development of Holocene coastal deposits adjacent to Farwah Spit in NW Libya (Fig. 1). No previous work has interpreted the sedimentological features of the Holocene Farwah coastal system on the southern margin of the Mediterranean Sea. This contribution examines macroscopic and microscopic features within these tidal flat sediments. Supratidal-subtidal lithofacies and associated sedimentary structures are described. These are interpreted to record coastal depositional systems (salt marshes, tidal flats, lagoon, flood delta, and spit), and a model is presented.

## 2 Methods

The different lithofacies were described and mapped locally using field observations. The areal extent was interpreted by utilizing Google Earth images (Fig. 1). To examine the tidal

I. Mriheel (✉)

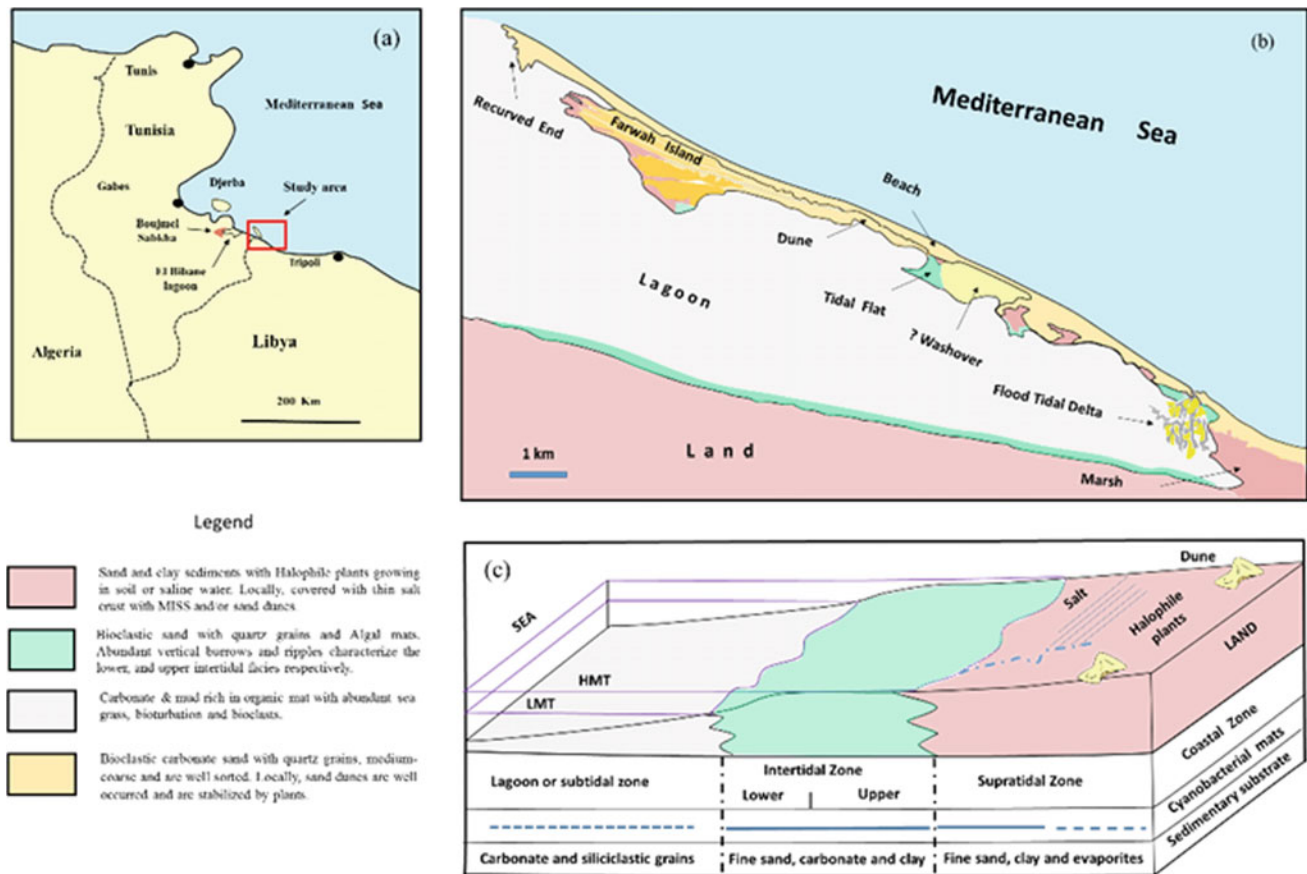
National Oil Corporation, P. O. Box 2655 Tripoli, Libya  
e-mail: [imriheel@noc.ly](mailto:imriheel@noc.ly)

M. Hamruni

Earth Science Department, Tripoli University, Tripoli, Libya

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2023

A. Çiner et al. (eds.), *Recent Research on Sedimentology, Stratigraphy, Paleontology, Tectonics, Geochemistry, Volcanology and Petroleum Geology*, Advances in Science, Technology & Innovation, [https://doi.org/10.1007/978-3-031-43222-4\\_3](https://doi.org/10.1007/978-3-031-43222-4_3)



**Fig. 1** a Location map of the study area, b interpretation of the depositional environment of the Farwah coastal system, and c a model of the peritidal-shallow lagoonal depositional facies, similar to the

hypothetical profile proposed after Lakhdar et al. (2020) for the southeastern coast of Tunisia

changes through time, several visits were made during spring and neap tides. Facies belts were mapped based on satellite images covering the study area. Representative samples were collected from both surface and subaqueous depositional sites. Both macro-structure and micro-texture examinations of samples were conducted during field and laboratory microscopic studies. Several 30–50 cm excavations were dug using a shovel to observe near-surface sedimentary structures within the tidal flat sediments. The TOC of mud deposited within the Farwah lagoon was determined using Rock–Eval pyrolysis.

### 3 Results

The Holocene sediments comprise bioclastic sands, organic-rich muds, rippled bioclastic sand, and massive to cross-bedded sand, unconformably overlying marginal marine bioclastic and bioturbated sandy deposit of Late Pleistocene age. The lithofacies record the transgression of marginal shallow marine tidal facies. Seaward, the facies change laterally to lagoonal grey muds, rich in organic

matter and locally bioturbated. Landward, the facies is covered with thin salt crust with many microbially induced sedimentary structures and/or yellowish sands of aeolian origin. These are interpreted to have been deposited within a lagoon, protected from the sea by a sand spit. Landward, the sand, clay, and evaporite sediments record a supratidal flat with salt marshes. A model for the coastal depositional system is proposed (Fig. 1).

Satellite imagery has been interpreted to extend the field observations, and the recent coastal systems can be observed that also reveal the present-day provenance of the barrier sediments along the Northern Africa continent (i.e., erosion of the Libyan Farwah and Ras Ejdeir headlands that form an essential source for the El Bibane barrier in Tunisia).

### 4 Discussion

The Holocene Farwah coastal sequence was formed during the last glacio-eustatic cycle, and the exposed prograding surfaces mark the last highstand systems tract (HST) development over the southern Mediterranean Sea that post-dated

the last glacial maximum. The marine flooding surface, which separates the transgressive systems tract (TST) from the overlying HST, occurs within submerged strata and has no exposure in the region.

Correlation with the adjacent Tunisian Boujmel Sabkha and Al Bibane lagoon (up to 6.8 ka BP) (Lakhdar et al., 2006, 2020), influenced by similar climatic events, sea-level changes (Hansen et al., 2013) and Mediterranean Sea influence (i.e., Adriatic Sea, SE Italy), reveals that the Farwah facies are prograding spit. The spit and its associated tidal flat and lagoonal facies belts developed within the HST followed postglacial sea-level rise after  $22.1 \pm 4.3$  ka (Shakun & Carlson, 2010). The prograding spit consists almost entirely of a regressive succession emplaced during postglacial sea-level transgression between the latest Pleistocene (14 ka BP) and early Holocene (8 ka BP). Lateral facies changes within the spit allow for identification and lateral tracing of six stacked, prograding successions, which may resemble stacked sixth-order cycles.

---

## 5 Conclusions

The Holocene sedimentary succession of the Farwah coastal system records the short duration (approximately  $10 \pm 2$  ka) progradation of spits and associated lagoonal and tidal flat sequences. Facies and environmental analyses, together with the reconstructed stratigraphic architecture of this succession, allow a sequence-stratigraphic interpretation, with the identification of a sequence boundary on the underlying Pleistocene and places most of the Farwah Formation into the HST. The maximum flooding surface, which separates

the underlying TST from the overlying HST, occurs within submerged strata and has no apparent exposure in the region.

Correlation with the adjacent Tunisian Boujmel Sabkha and Al Bibane lagoon suggests coeval deposition influenced by the same climatic event and global sea-level change following the last glacial maximum ( $\sim 14$  to 8 ka).

Our study documents the stratigraphic organization of the Farwah coastal facies. It records the interaction between global eustatic variations and sediment supply, both processes under the control of climatic change. Changes in sediment input, climatic variations, and, more recently, human activities close to the eastern opening (inlet) have played an essential role in the development of the flooded delta during the last century.

---

## References

- Lakhdar, R., Soussi, M., Ben Ismail, M. H., & M'Rabet, A. (2006). A Mediterranean Holocene restricted coastal lagoon under arid climate: Case of the sedimentary record of Sabkha Boujmel (SE Tunisia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 241, 177–191.
- Lakhdar, R., Soussi, M., & Rachida, T. (2020). Modern and Holocene microbial mats and associated microbially induced sedimentary structures (MISS) on the southeastern coast of Tunisia (Mediterranean Sea). *Quaternary Research*, 100, 1–21.
- Hansen, J., Sato, M., Russell, G., & Kharecha, P. (2013). Climate sensitivity, sea level and atmospheric carbon dioxide. *Philosophical Transactions of the Royal Society Series A*, 371, 20120294, <https://doi.org/10.1098/rsta.2012.0294>
- Shakun, J. D., & Carlson, A. E. (2010). A global perspective on last glacial maximum to Holocene climate change. *Quaternary Science Reviews*, 29, 1801–1816.