[PS]The Enjefa Beach Exposure in Kuwait, Northern Gulf: Evidence of Late Holocene Regression*

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Abstract

Four sedimentary facies were recognized in exposures along Enjefa Beach, Salwa, Kuwait. They are: a) Horizontally laminated, b) Trough cross bedded, c) Planar wedge shaped and ripple cross bedded, and d) Bioturbated calcareous sandstone. Facies "a" consists of horizontally laminated beds which generally display a coarsening upward trend. These beds resulted from stacking of beach faces, with top of the beds marking the shelly beach top. A fining upward gradation in a few beds is also observed, which attests to the occurrence of more than normal energy events. The trough cross bedded facies makes up the middle part of the exposure and is interpreted to be tidal channel or tidal inlet deposits. The planar wedge shaped and ripple cross bedded facies display variable orientation with a northward dominated current direction. It was likely formed in the shallower part of the channel with relatively lower energy levels, or is the ebb tidal delta deposits. The uppermost facies "d" consists of a large network of Ophiomorpha burrows and is interpreted as coastal sand flat deposits.

Following Walther's Law, the vertical sequence observed in this exposure from facies "a" to "d" was formed in laterally adjacent coastal sub-environments. This facies stacking pattern from beach, to tidal channel, to sand flat reflects a seaward shift in facies and therefore progradation. Nevertheless, during Holocene time from around 20 kyr bp, the melting of ice of the Late Pleistocene resulted in eustatic transgression. The present Gulf was the result of flooding associated with this transgression. After 7 kyr to present, transgression continued globally but at a much slower pace. The Enjefa Beach exposures on the contrary depict progradation. The glacio-isostatic adjustment cannot explain it since there was no glaciation in this region during the Pleistocene. However, there is evidence of present day active tectonism associated with the northeastern movement of the Arabian Plate under the Zagros fold belt. As a consequence, Kuwait's coastal areas and interior are experiencing structuring, creating uplift. This uplift possibly outpaced transgression, resulting in regression and the development of progradational sequences in coastal areas of the northern Arabian Plate during the latter Holocene.

Geo 2012_1201916

The Enjefa Beach exposure in Kuwait, northern Gulf: *Evidence of Late Holocene regression*

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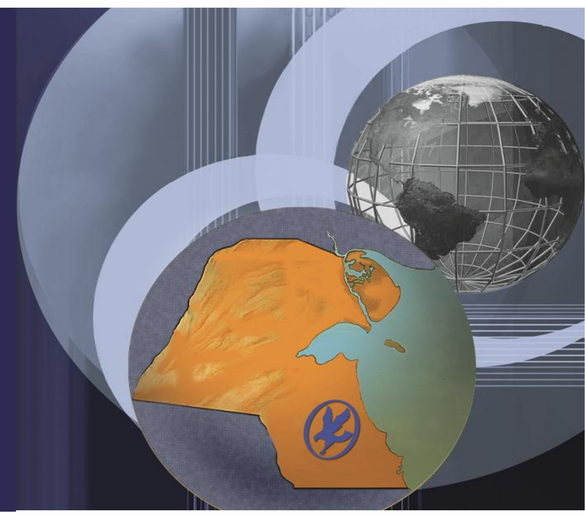

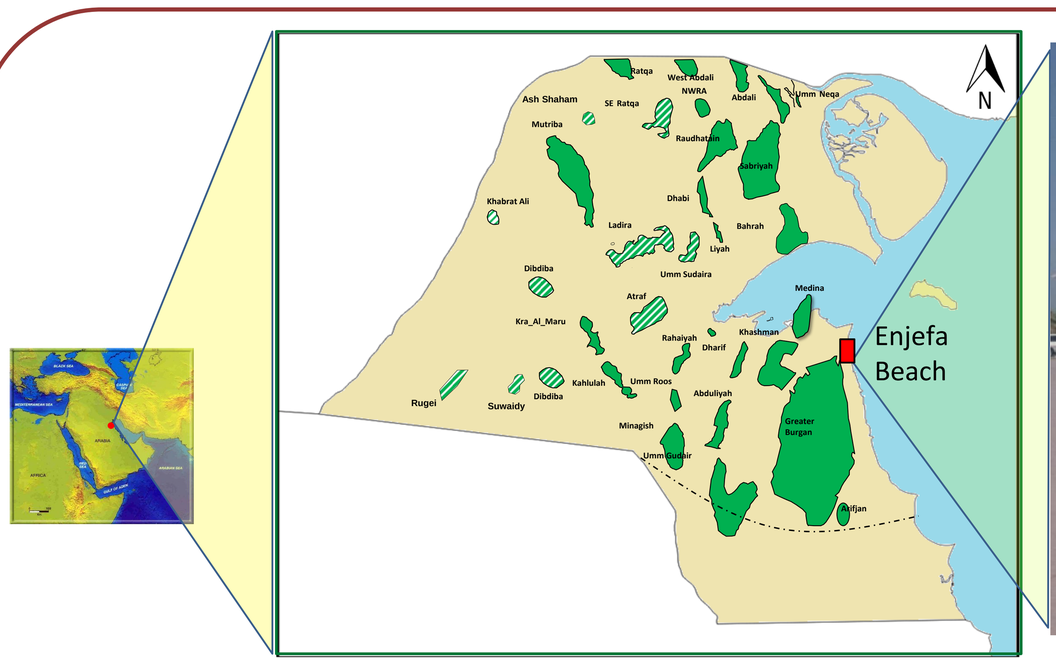

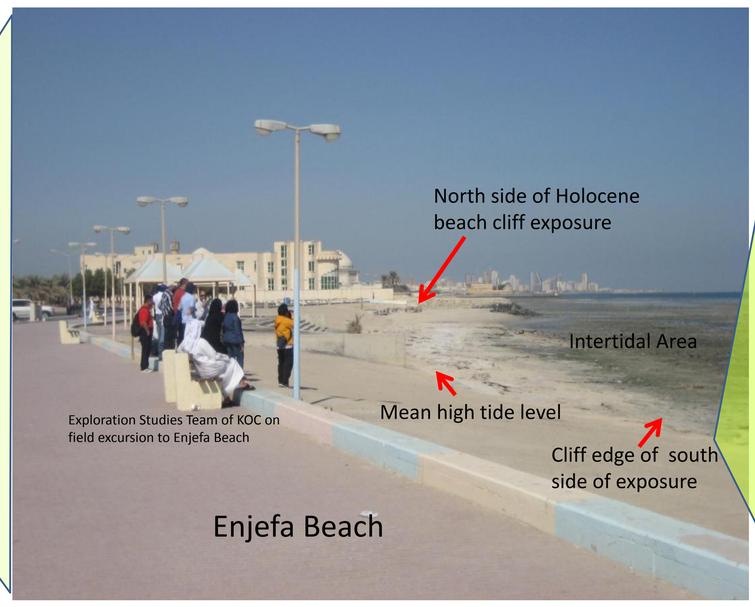

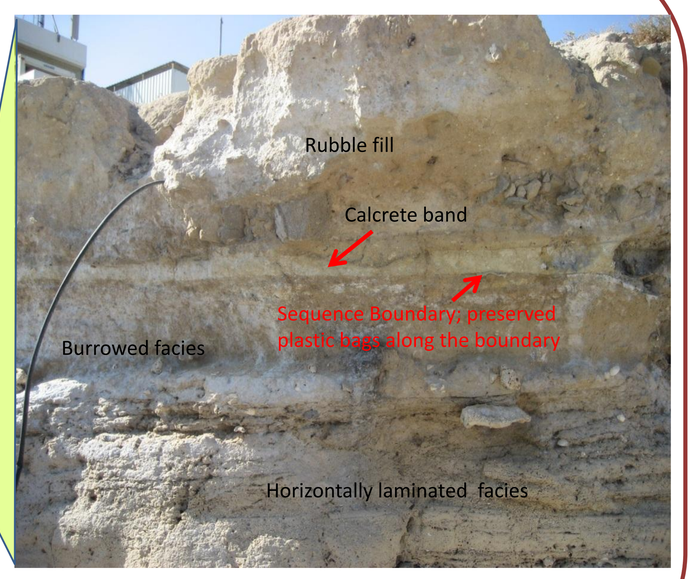

Location map of the study area

Four sedimentary facies were recognized in exposure along Enjefa Beach, Salwa, Kuwait. They are; a) horizontally laminated, b) trough cross bedded, c) planar wedge shaped and ripple cross bedded, and d) bioturbated calcareous sandstone. Facies “a” consists of horizontally laminated beds which generally display coarsening upward trend. These beds resulted due to stacking of beach faces with top of beds marking the shelly beach top. Fining upward trend in a few beds is also observed which attests to the occurrence of more than normal energy events. The trough cross bedded facies makes middle part of the exposure and is interpreted tidal channel or tidal inlet deposits. The planar wedge shaped and ripple cross bedded facies display variable orientation with northward dominated current direction. It is likely formed in shallower part of the channel with relatively lower energy levels or is the ebb tidal delta deposits. The uppermost facies “d” consists of big network of Ophiomorpha burrows and is interpreted the coastal sand flat deposits.

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Four Lithofacies:

a)Horizontally laminated

b)Trough cross-bedded

c)Ripple cross-bedded

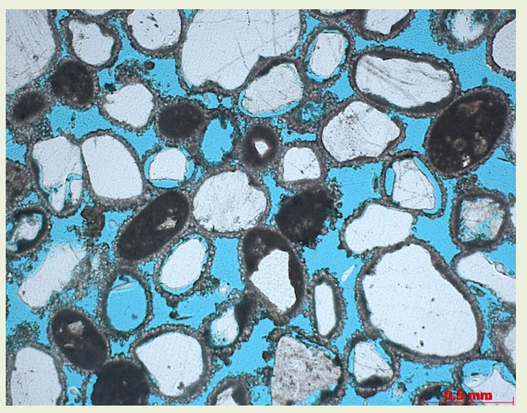
d)Bioturbated

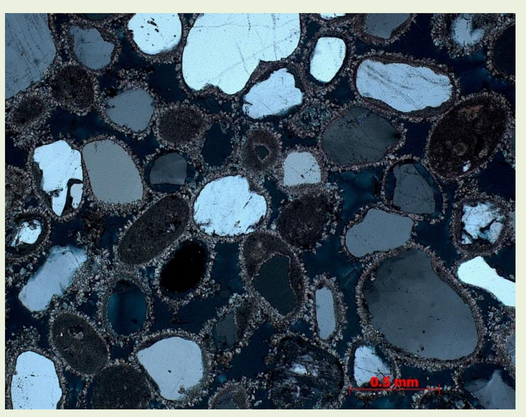
Horizontally laminated lithofacies

- Dominantly horizontally laminated
- Beds coarsen upward
- Locally fines upward
- Small cross-bedded channelized areas
- Upper shoreface to foreshore (beach) environments

Trough cross-bedded lithofacies

- Trough cross-bedded
- Dominant current NW (high angle to perpendicular to the coastline)
- Individual lamination with internal fining upward trend
- Aragonite replacement due to early diagenesis
- Tidal channel /tidal inlet environments





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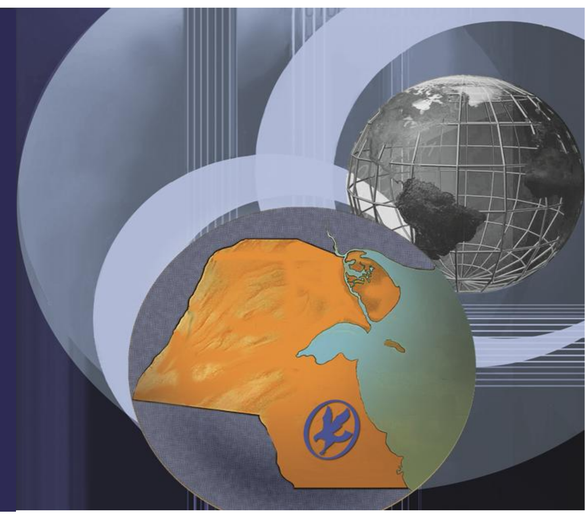
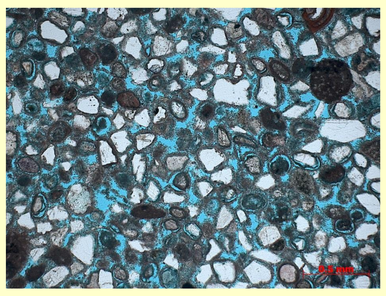
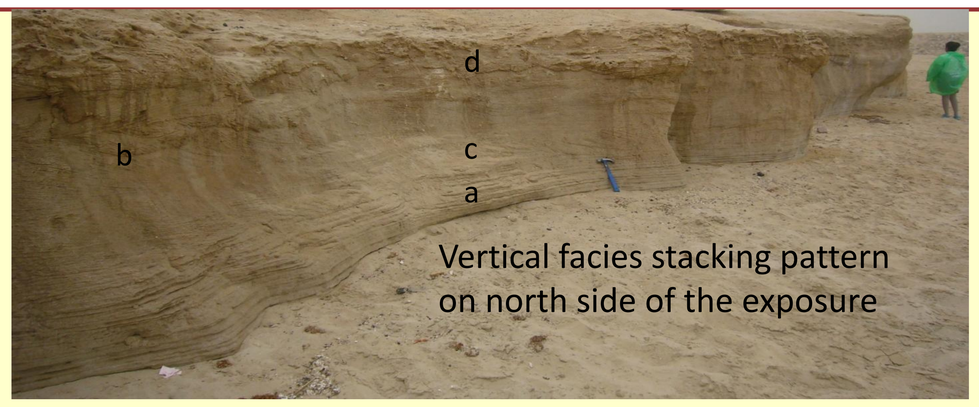
Kuwait Oil Company
إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation





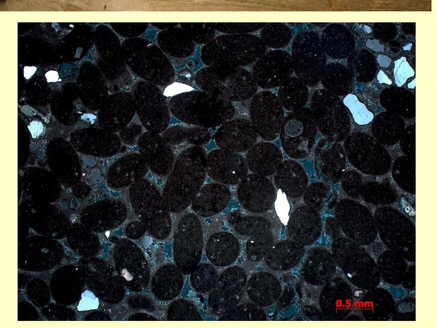


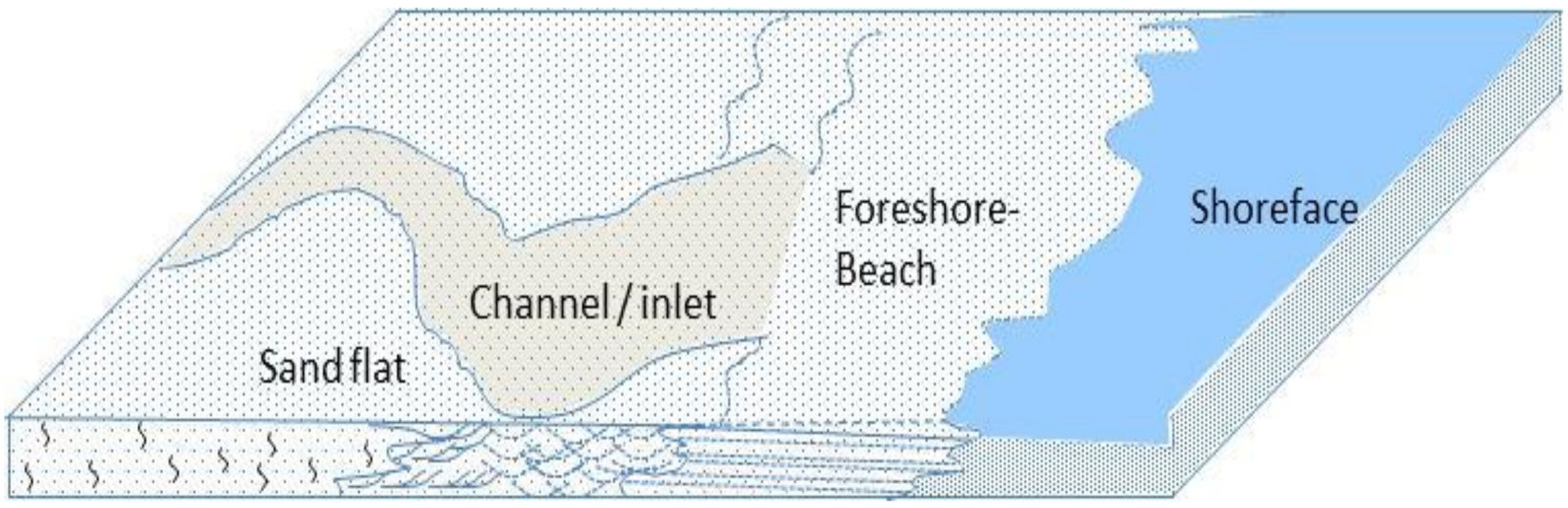
Ripple cross-bedded lithofacies

- Megaripples; planar wedge shaped cross-beds
- Dominant current Northward; parallel to the coastline
- Variable current direction
- Lithology mixed quartz and carbonate (peloids)
- Mixed or shallow tidal channel/ebb tidal delta/coastal dune environments

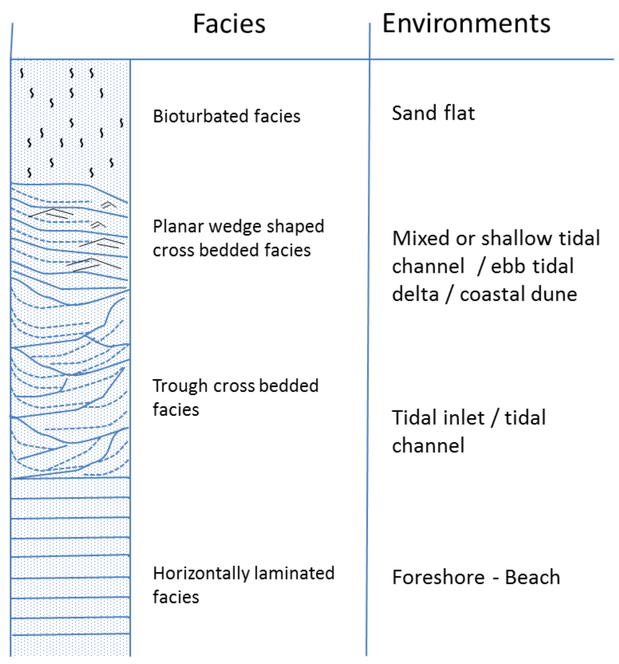
Bioturbated lithofacies

- Uppermost facies; intensely burrowed
- Locally sharply based overlies facies “c”.
- Tube network of horizontal, inclined, and rarely vertical burrows of Ophiomorpha and Parmaichnus.
- Burrow fill; fecal pellets (peloids) with intergranular miritic cement
- Protected sand flat environments

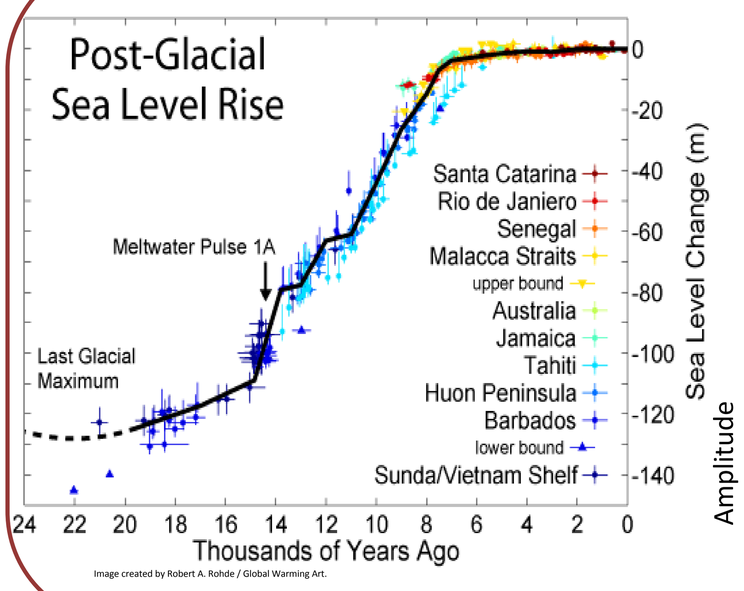


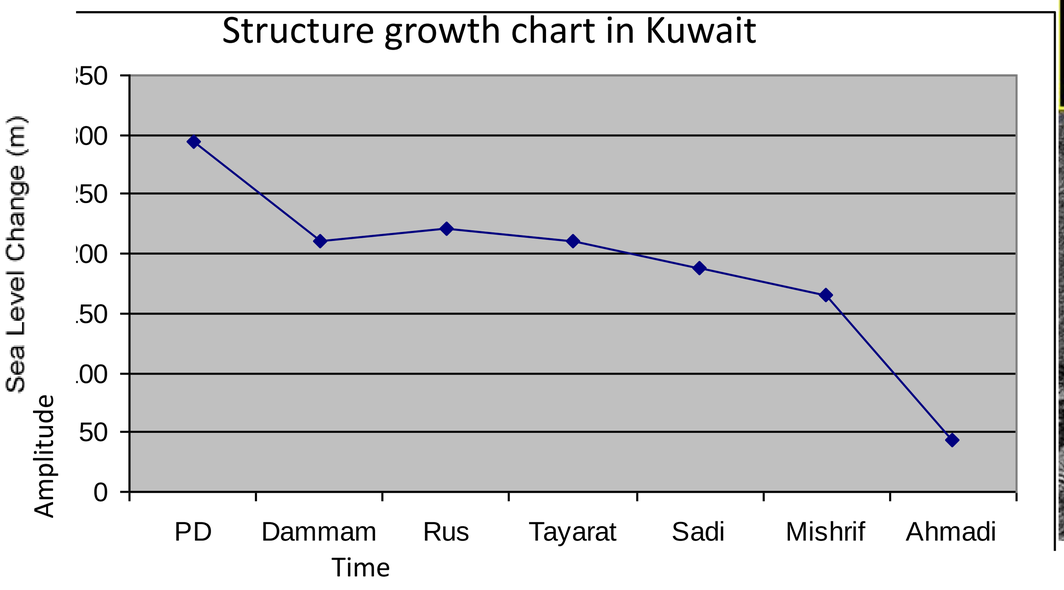


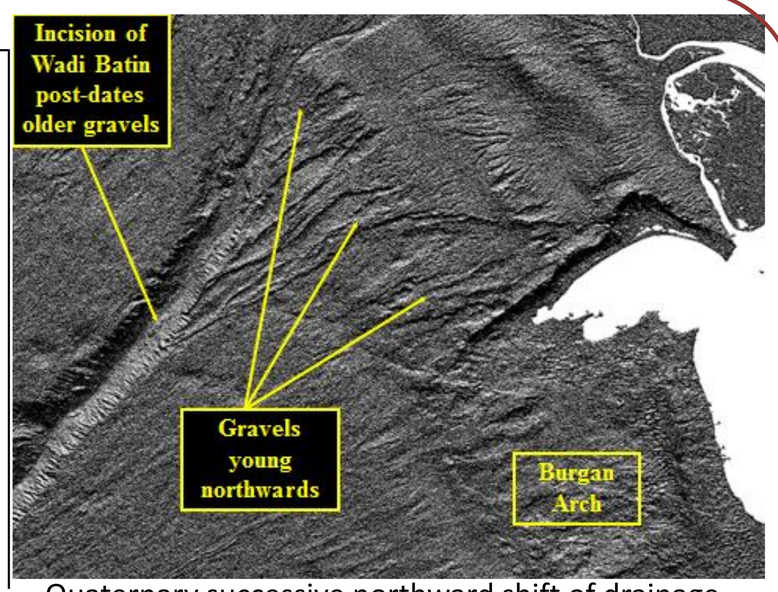
Schematic representation of the environments of deposition for the Enjefa Beach exposure.



Vertical stacking pattern of facies at Enjefa beach.

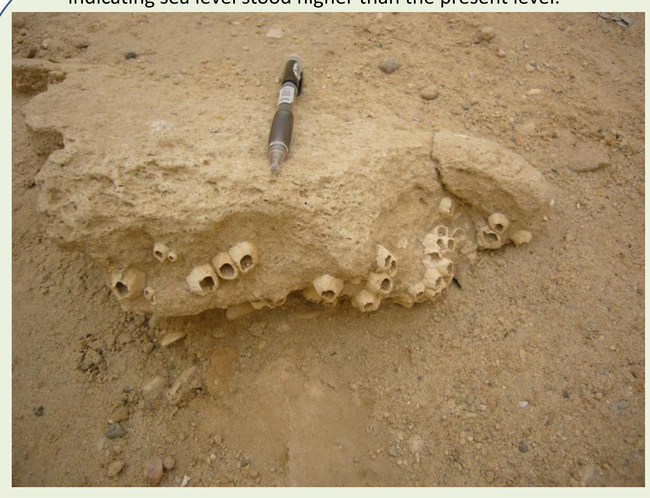






Quaternary successive northward shift of drainage in the Dibdibba Basin of North Kuwait

Fossil barnacles at Enjefa exposure (? Stromatolitic boundstone) indicating sea level stood higher than the present level.



Acknowledgements
Kuwait Ministry of Oil and the management of the Kuwait Oil Company kindly permitted presentation of this paper. Contributions from our colleagues in the Exploration Group of KOC are duly acknowledged.

Conclusions

- The Enjefa Beach exposure was deposited in foreshore-beach, tidal inlet, possibly dune and sand flat subenvironments.
- Lower part of the exposure was deposited during Holocene transgression and the upper part during late Holocene regression.
- This regression could be partly due to isostatic adjustment resulting from sea bed lowering due to the weight of access water. Local tectonics could be important contributing factor as well.
- The terrace and runnel physiography displayed in the intertidal area may suggest renewed present day transgression.

Ridge and runnel physiography in the present day intertidal area at Enjefa Beach.

Close up of a runnel cut by waves and currents in the intertidal area