A Report on a Geological Reconnaissance of Al Aryam Island, March, 2004

by Graham Evans and Anthony Kirkham

Fig 1. General location map of Al Aryam Island. (Courtesy: Google Earth)

Al Aryam Island is part of the Abu Dhabi barrier island complex. It is located at the western end of Khor Qirqishan (***Figs. 1 & 2***). It is bounded to the south-west by a tidal channel which separates it from Al Dabb'iya and divides into smaller channels which flow around the southern side of Al Aryam and ultimately link with Khor Qirqishan. Another tidal channel on Al Aryam's north-east flank separates it from Al Bahrani Island and also passes southwards, via an area populated by mangrove stands, into Khor Qirqishan. Both these main tidal channels lead seawards (north-westwards) to a broad shoal area of merged tidal deltas where precipitation of $CaCO_3$ from the warm highly saline agitated water leads to the production of ooliths (sand grains with a core surrounded by concentric layers of calcium carbonate). Skeletal carbonate sands and some reefs dominate the offshore region today.

Both Al Aryam Island and the mainland coastal sabkha are believed to be underlain by a Pleistocene unconsolidated brown quartzose sand, although on Al Aryam it is only visible around its southern parts as elsewhere it is covered by marine Pleistocene and Holocene carbonate. This brown sand is wind-blown (aeolian) and is at least six metres thick in the region as was seen in a temporary pit near the junction of the Al Aryam road with the main Abu Dhabi–Jebel Dhanna road (***Fig. 3***).

Outcrops of Pleistocene limestones composed mainly of aeolianites (cemented wind blown carbonate sands locally known as 'miliolite') occur at the northwestern and northeastern extremities of the island *(**Fig. 4***). A wind-deflated platform exposing aeolianite covers part of the southwestern part of the island. As in Al Dabb'iya, these upstanding patches of aeolianite probably represent erosional remnants of long, curved palaeo-*seif* dunes which were at one time continuous with the prominent palaeo-*seif* dunes that extend across the mainland from the coastline to Al Ain and the Hajar Mountains. They formed about 125,000 years ago (125Ka) and became cemented before being partly drowned by the rising sea of a Pleistocene marine transgression that deposited marine sediment on their crests and around their flanks.

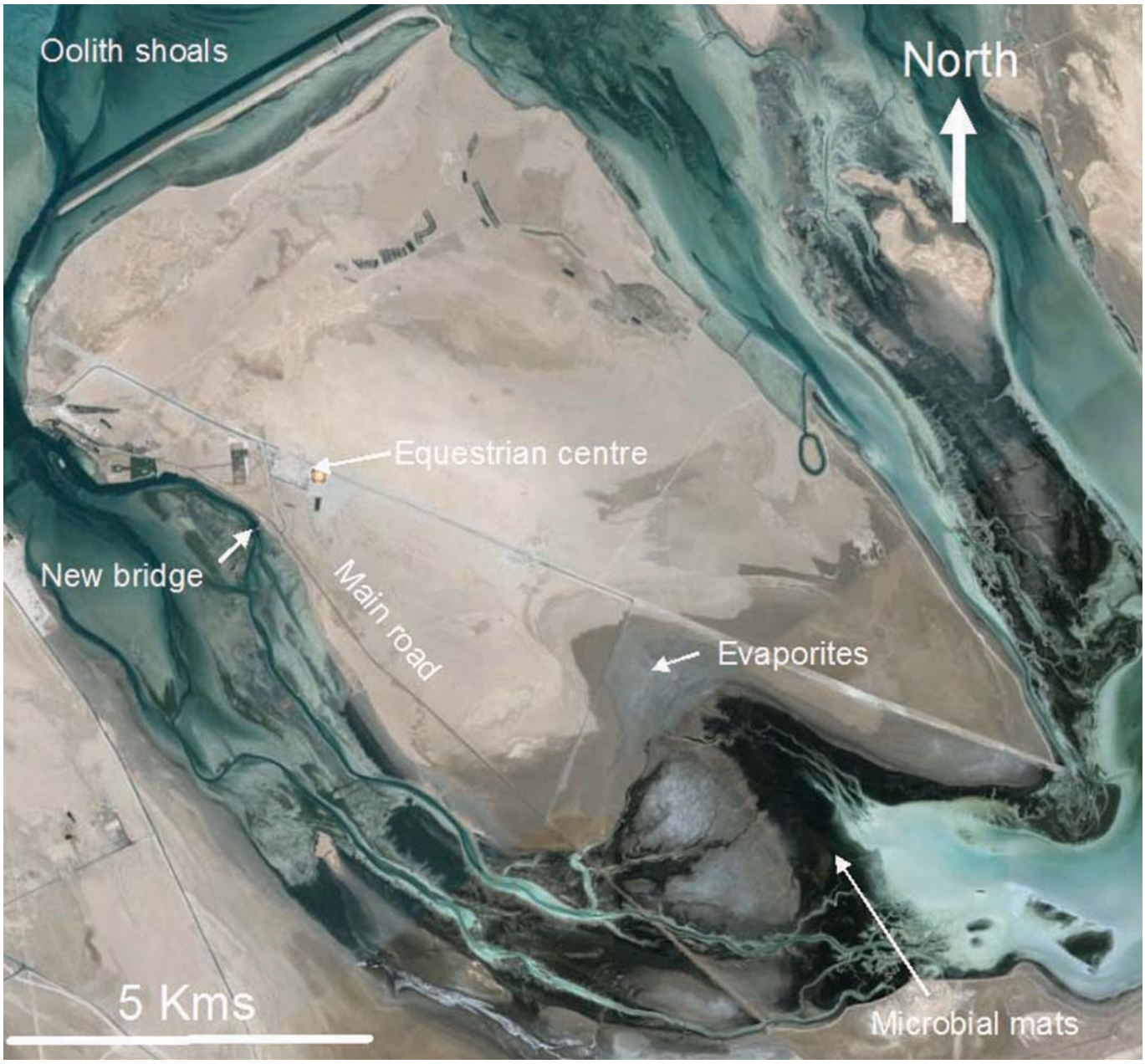


Fig 2. Detailed satellite image of Al Aryam. (Courtesy: Google Earth)

In some locations, as near the equestrian centre on the island, the Pleistocene marine sediments which dip off the flanks of the *seif* dunes are cross-bedded and probably formed under high energy (tidal) current conditions (***Fig. 5***). Lower down the flanks of the palaeo-*seif* dunes the marine sediment is intensively burrowed. Elsewhere, the marine sediments are horizontally bedded and highly bioturbated and commonly contain fossil red algal fragments and barnacles. On the north central area of the island (*e.g.* east of the equestrian centre) are large areas where marine Pleistocene carbonate accumulated in a lower energy tidal embayment. Similar sediments are also observed immediately south of the new bridge near the north-west corner of the island and both sides of the main island road.

In some places, during the marine transgression, the sea eroded the partially cemented sediments of the flanks of the *seif* dunes to create cliffs. Large angular blocks of the aeolianite accumulated as a scree at the bases of the cliffs. These blocks were eventually buried by the later marine sediments (***Fig. 6***).

A later sea level fall exposed the area to deflation (***Fig. 7***). The latest sea level rise (the Flandrian transgression) commenced about 18,000 years ago and drowned most of the deflated remnants of the earlier dunes and marine sediments to deposit the modern (Holocene and Recent) carbonate muds, sands and, in places, coral reefs developed offshore.

Fig 3. A temporary pit near the junction of the Aryam road with the main Abu Dhabi-Jebel Dhanna coast road. At least six metres of brown sand are exposed. It probably extends beneath the whole of Al Aryam. (The apparent cross-beds are actually digger markings).

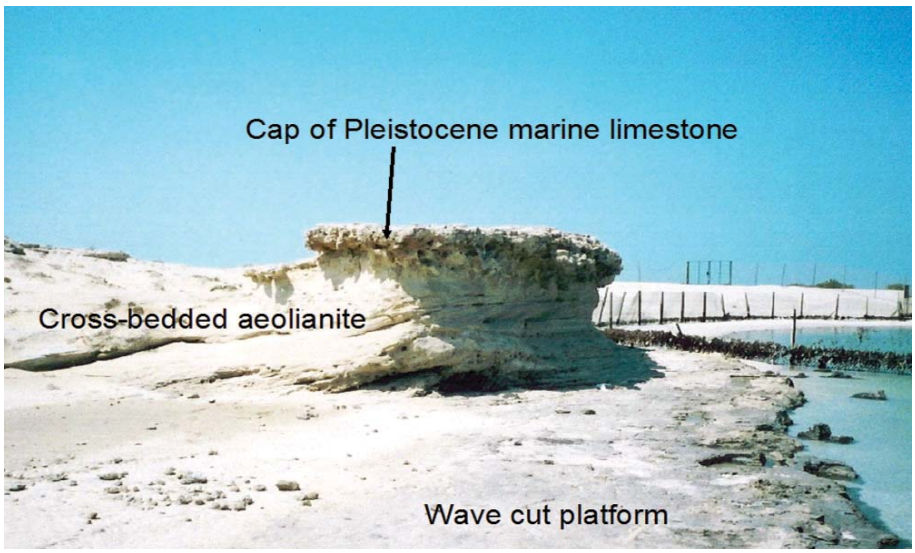
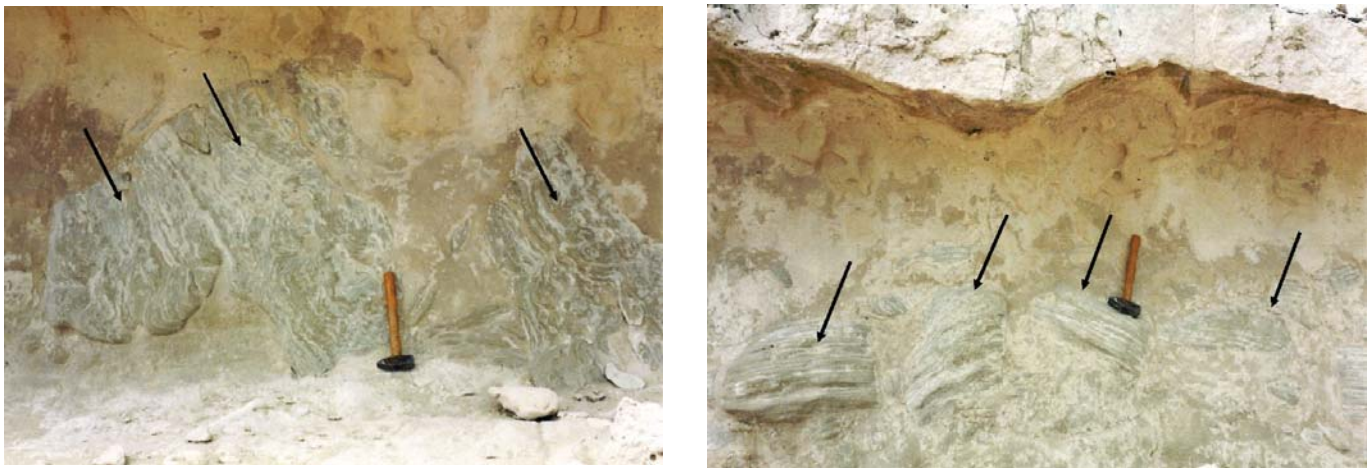


Fig 4. Pleistocene aeolianite with large-scale cross-bedding capped by intensely burrowed Pleistocene marine strata. NE corner of Al Aryam.

Fig 5. Pleistocene cross-bedded marine carbonate overlying aeolianite. Top of hammer coincides with the contact. Top of marine transgressed palaeo-seif dune near the equestrian centre.



a b

Fig 6. Pleistocene cliff scree deposits comprising boulders (arrowed) of carbonate aeolianite surrounded and encased by Pleistocene marine sediments. The upper overhanging hard crust in b) is calcrete (this is a hard crust formed by contemporary conditions on exposed carbonate rocks).

Isolated rock outcrops (zeugen) forming islands composed of aeolianite with marine caprock are very well preserved offshore to the east of Al Aryam, (***Fig. 8***). As on the main island, they are surrounded by wave–cut platforms with their surfaces about a metre above present day mean sea level. These platforms probably formed about 4,000 years ago when mean sea level was about a metre higher than today. Mangrove stands developed on these platforms where their fossilised root systems (rhizoliths) are abundantly exposed. These ancient mangrove stands developed in similar intertidal environments to those of the present day mangrove stands around Al Aryam (***Fig. 9***).

Modern marine sedimentation has extended (prograded) the northern shore of Al Aryam slightly seawards over approximately the last 4,000 years. More importantly, as on the other barrier islands of Abu Dhabi Emirate (*e.g.* Marawah, Al Dabb'iya and Abu Dhabi Island), Al Aryam has clearly also been extended southwards by leeward accretion towards the mainland as Shamal-driven waves have driven sand southeast along the margins of the old seif dune remnants and beyond.

Most of the southern half of Al Aryam comprises what appears at first sight to be a monotonous deflated sabkha plain with halite crust (***Fig. 10***). However, traces of accretionary lobes extending landwards to the south-east are evident along the southern shores of Al Aryam and suggest that the island is a composite of two former islands that probably nucleated on the vestiges of two(?) former *seif* dunes, eventually being linked by marine deposition in the form of beach bar sands. The accretionary 'growth lines' on the south-eastern leeward part of the island are clearly visible on satellite images and probably represent successive spits or strand lines (***Fig. 11***).

Fig 7. Deflation surface of Pleistocene cross-bedded aeolian dune sand. NW Al Aryam.

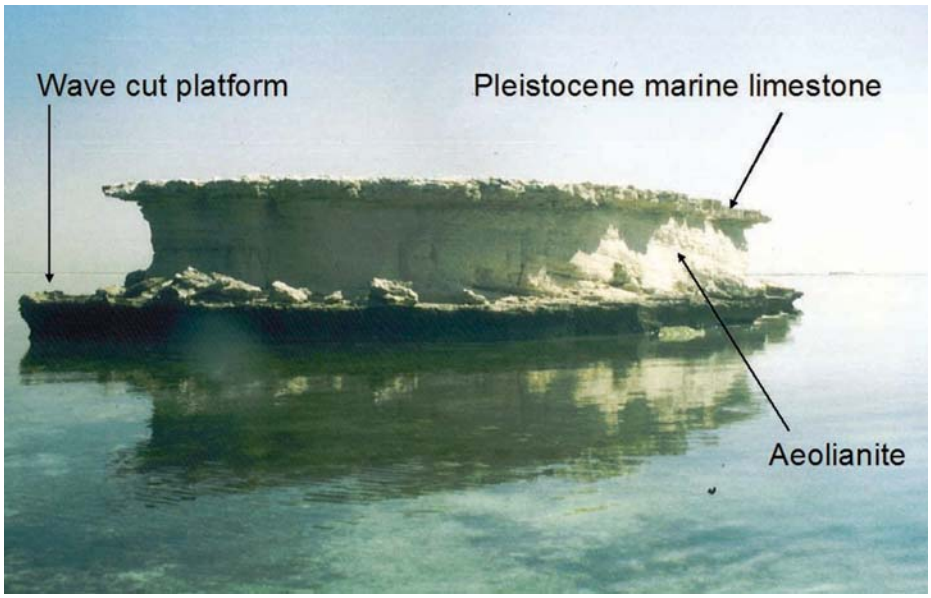


Fig 8. A zeuge off the east coast of Al Aryam. It comprises large scale, Pleistocene carbonate aeolianite capped by Pleistocene marine carbonate. The island is bordered by a wave-cut platform cut about 4,000 years ago when sea level was about a metre higher than today. Numerous lithified mangrove roots (rhizoliths) are exposed on the platform.

Fig 9. A mangrove stand *(Avicennia marina).*

Fig 10. Partly wind-eroded salt (halite) crust on the sabkha of southern Al Aryam. (View is about 1.5 m across).

Fig 11. Satellite image showing Al Aryam (left). Ancient beach ridges extend along the mainland coast and are traversed by old tidal channels. Note the growth lines around the southern coast of Al Aryam and the two lobes of Pleistocene sediments which extend to the southeast from the front of the island.

Fig 12. A major tidal channel with halophytic plants (*Arthrocnemum* sp.) growing along the crest of its levee. Looking north, east Al Aryam tidal channel. Extensive microbial mats (left background) cover the muddy intertidal flats behind the levee.

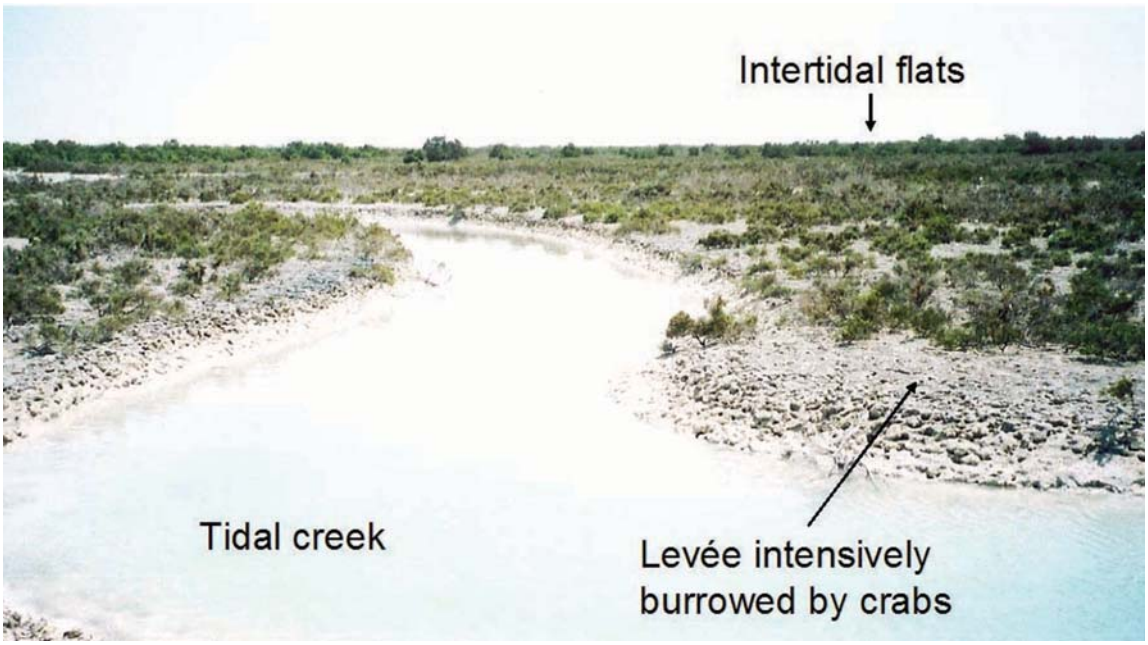


Fig 13. A two-metre wide tidal creek which branches off the main tidal channel, east side of Al Aryam. The sediment of its banks is intensively burrowed by crabs and the adjacent intertidal flats are populated by halophytic shrubs.

Fig 14. A close-up of intertidal crab burrows with excavated pseudo-faecal pellets of mud deposited by the crab in a 20 cm area around the burrow entrances. Many other crab burrows and 'middens' surround the prominent burrows.

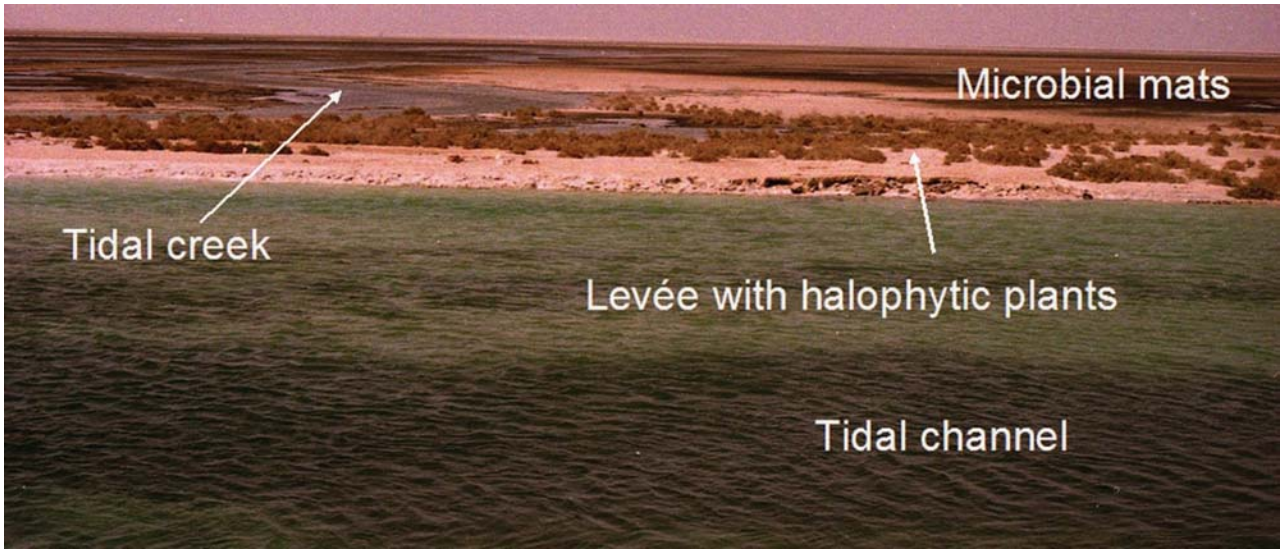


Fig 15. View northwards from the mainland across a major tidal channel to a halophyte colonised levée beyond which are extensive intertidal microbial mats. Southern coast of Al Aryam.

As the leeward accretionary wedge developed, the subsequent surface was only drowned at exceptional high tides and became converted to sabkha as the accretion proceeded. Both the beaches and the sabkhas were subsequently severely deflated as indicated by the exposure of large gypsum crystals which originally grew beneath the surface and are now exposed on the present day sabkha surface. Immediately beneath the evaporitic crust is the brown quartzose aeolian sand. Extensive gypsum 'mush' or minor anhydrite occurs along the southern flank of Al Aryam. This is believed to be the first recording of anhydrite on any of the Abu Dhabi barrier islands.

Along the south-eastern flank of the island, and between the southern flank and the mainland, are wide areas of intertidal flats cut by numerous tidal channels and creeks in which carbonate sands and muds are accumulating. The tidal channels are bordered by slightly raised banks (levées) produced by sediment deposition on the channel flanks during floods. Salt-tolerant halophytic plants populate these near-channel environments whereas mangroves flourish in the lower, more frequently flooded areas (***Fig. 12***). Narrow (1-2 m wide) tidal creeks that pass through the levées act as distributaries and carry sediment onto the adjacent intertidal flats during extreme high water. The sediments of these levées and their adjacent tidal flats are very extensively burrowed by crabs that sometimes deposit their pseudo-faecal pellets as low sub-circular mounds on the surface around the entrances to their burrows (***Figs. 13 & 14***). These channels and their associated intertidal flats are very similar to those of the Bahamas' intertidal zones.

Beyond the levées are wide intertidal flats colonised by microbial mats where carbonate muds accumulate (***Fig. 12 & 15***). Especially on the mainland side of the main channel, above the limits of normal tides, they pass into the flat, salt encrusted surface of the mainland sabkha which fringes much of the Abu Dhabi coastline. Approximately two kilometres into the mainland coastal sabkha, the salt-encrusted surface is replaced by some slightly higher (now deflated) storm ridges composed of shelly sand which marks the position of the mainland shoreline approximately 4,000 years ago (***Fig. 11***). Inland of these, beyond the Abu Dhabi-Jebel Dhanna coast road, the deflated flat sabkha surface extends into the rocky escarpment composed of Miocene rocks.

Al Aryam is well-preserved and relatively unspoiled. There is only limited building, mainly around its north-west corner and there is a limited network of dirt tracks that facilitate easy access to many parts of the island. The only obtrusive, non-natural feature is a long, 50 m wide road that extends for many kilometres on a NW-SE trend across the island and effectively splits it into two parts. Otherwise, Al Aryam is one of the best preserved of the barrier islands of the Abu Dhabi coast in terms of its natural state and it will hopefully continue to be preserved as part of the natural heritage of Abu Dhabi. The island and its immediate surrounding terrain also has the potential to be a very important natural laboratory for scientific teaching, research and conservation. It is valuable because it is one of the very few undisturbed and unspoiled extensive areas of natural beauty in the Abu Dhabi coastal region, an area already renowned globally in the geological community as a model for the deposition of carbonate and evaporitic sediment although unfortunately the entire coastal region is rapidly losing its natural identity because of ever-increasing civil engineering projects.

It is strongly recommended that a more rigorous geological and sedimentological study of Al Aryam and its surrounding marine fringe involving pre-defined transects and with the aid of satellite images should be made. The area is possibly the last chance to truly conserve a relatively unspoiled landscape and provides excellent potential to protect part of Abu Dhabi's natural environment for future generations of both the Emirates and the world at large.

Acknowledgements

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* Further details of the whole coastline of Abu Dhabi can be seen in: The Emirates: A Natural History. *Eds*. P. Hellyer and S. Aspinall, 2005, Trident Press Ltd., London. See especially articles therein by 1) G.Feulner, A Geological Review, p.41-63, 2) G.Evans and A.Kirkham, The Quaternary Deposits, p.65-78. These articles have a reasonably complete general bibliography of the Quaternary and sedimentology of the coast of Abu Dhabi.