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New archaeological investigations at Abu Dhabi Airport, United Arab Emirates

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Introduction

This paper details the recent re-examination of a multi-period archaeological site discovered by the Abu Dhabi Islands Archaeological Survey [ADIAS] at a site located just to the south of Abu Dhabi International Airport in the United Arab Emirates (Fig. 1). The site originally designated as ADA 1, is now known to extend both to the north-west and the north (Sites ADA 2 and ADA 7). A number of Late Islamic pottery scatters have also been observed to the north (Sites ADA 3–5) and east (Site ADA 6) of the main site.

An earlier study of pottery collected from the surface of Site ADA 1 suggested sporadic occupation at the site from the Hafit period, *c.* 3100–2700 BC, with maximum settlement in the second half of the third millennium BC (de Cardi 1997). The pottery could be related to both the Umm an-Nar culture, as well as to the sequence established at Hili 8 in Period II, including wares of probably Mesopotamian and Eastern Arabian origin. The site does not appear to have been utilized during much of the second millennium BC and the Iron Age, although some pottery was recognized dating to between the first century BC and second century AD. Small quantities of Late Islamic pottery were also noted on the surface.

Although lithics identified as being from the fifth and fourth millennium BC were found at the site, no pottery of ʿUbaid-type has been recognized amongst the pottery assemblage, although ʿUbaid material is now known from a number of sites along the Abu Dhabi coastline from al-Aryam, Dalmā, Ghāghah and Marāwiḥ (Beech & Elders 1999; Beech, Elders & Shepherd 2000; Flavin & Shepherd 1994; Popescu & Beech, in prep), as well as further north on the Emirates Gulf coastline.

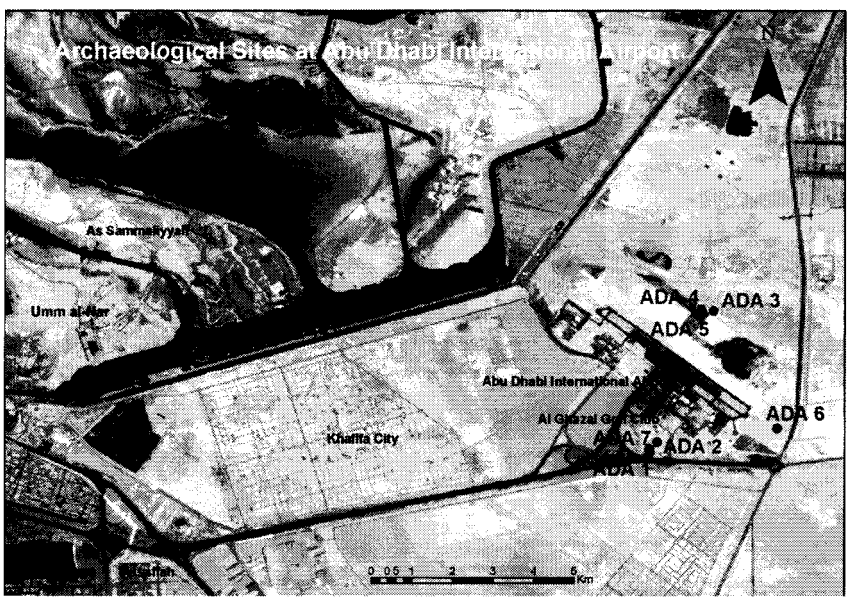

FIGURE 1. *The location of the archaeological sites in the vicinity of Abu Dhabi International Airport.*

Site discovery and previous work

The site was first discovered in February 1995 by Peter Hellyer who observed an extensive scatter of pottery sherds and flints on the surface, as well as two apparent stone structures. The site at that time was open to vehicular traffic and was used for the grazing of camels, both of which had led to significant surface disturbance, although it appeared that it was not subject to any other serious threat. A subsequent visit was made to the site by Peter Hellyer with Dr Geoffrey King, ADIAS director. A further visit was made to the site in mid-June by Jakub Czastka and Alex Wasse and it was discovered that bulldozers were already working on part of the site, as part of ground-levelling and infilling operations for the nearby sabkha, in preparation for construction of the Abu Dhabi Airport Golf Club (now al-Ghazal Golf Club). Bulldozers had already removed a substantial part of the central area of the site. A rescue exercise, involving a detailed pick-up of surface material, took place during a six-week period in June and July 1995 by an ADIAS team under the directorship of Jakub Czastka, assisted by Alex Wasse and a number of volunteers. An interim report on this work was presented to H.E. Sheikh Hamdan bin Mubarak al-Nahyan, Chairman of the Abu Dhabi Department of Civil Aviation, in 1996 (Czastka & Wasse 1996).

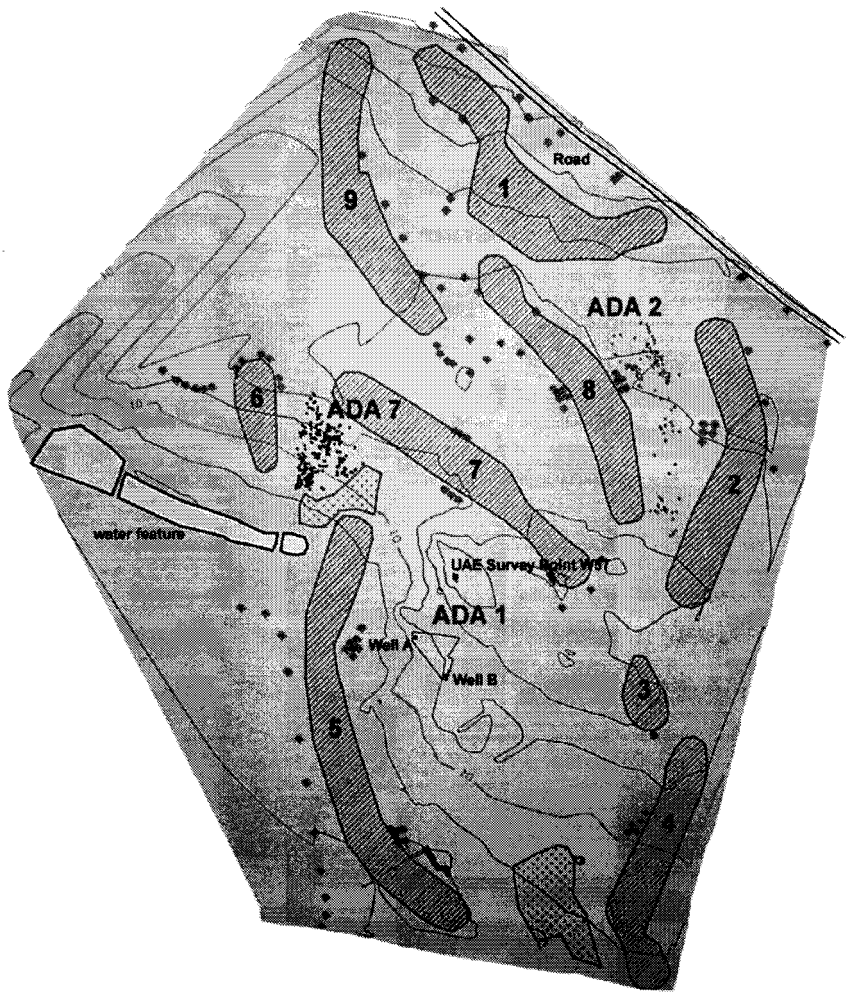

FIGURE 2. *The distribution of archaeological sites at al-Ghazal Golf Club. Hatched areas mark the golf fairways and greens. Dotted areas are plantations.*

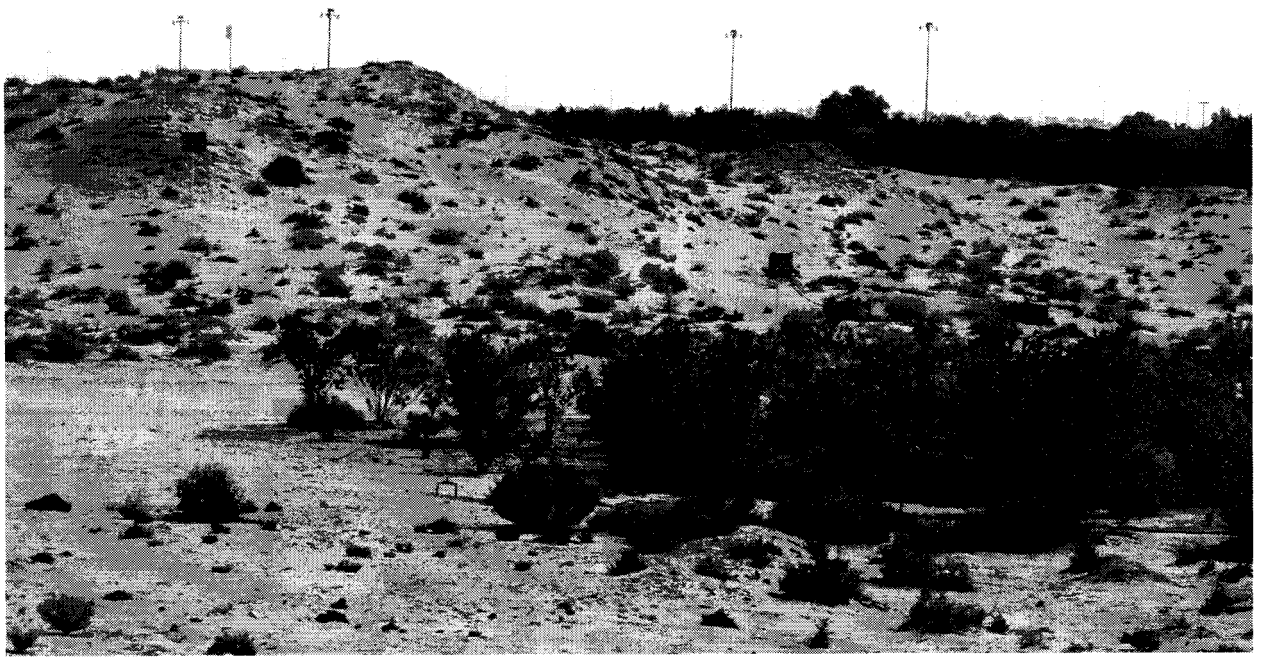

FIGURE 3. *A general view of the highest point on the site looking towards ADA 1 from ADA 7.*

Location

The initial site discovered, designated as ADA 1, lay on and amid a series of consolidated fossil Pleistocene sandstone ridges running roughly north-west to south-east (Fig. 2). A GPS co-ordinate taken with a Garmin 12 channel GPS 12XL at Site ADA 1 is 24.41233 N and 54.64473 E (datum = WGS84). The area of the fossilized sandstone dunes provides the most elevated spot in the immediate vicinity, rising to a height of around 10 m above the adjacent sabkha salt flats to the west, now covered with sand as a result of landfill operations in 1995 (Fig. 3). A landmark on the highest point of these dunes is a trig point from official UAE mapping. A plaque on this is labelled "UAE Survey Point W57". Sedimentological studies on the sabkhas of Abu Dhabi indicate that formation of the sabkha began around 4000 years ago (Evans, Kirkham & Carter 2002), prior to which the edge of the site would have been on the coastline.

A hundred metres to the north of the main site, the geology changes, and the sandstone is superseded by the appearance on the surface of the underlying limestone, the latter being overlain in places by a weathered bed of tabular flint. However, the exact extent of the limestone and tabular flint beds is unclear, because of the degree of modern disturbance, including the deposition of building rubble during and after the construction of the Airport, which opened in 1982.

The sandstone and limestone ridges are part of a raised relief trend running roughly north-west to south-east, which curves in to form an embayment around the

nearby Sweiḥan/Mafraq/Dubai roundabout, carrying on from here on a roughly north-east to south-west trend. The sabkha immediately abuts this ridge. The surface deposits covering the raised area that comprises the main part of the site are an aeolian matrix of fine to medium carbonate sands. The depth of these deposits is dependent on the underlying topography, which is essentially a series of ridges and depressions conforming to the crests and troughs of the ancient dune system where the sandstone is found. The limestone area to the north-west of the main site presents a far more level terrain, although with evidence of erosion, probably primarily by water, along the outer edges.

Where the archaeological artefacts are lying on bedrock, the damage to which they have been exposed, by weathering as well as by human activity, is more extensive, but the artefacts were more easily recoverable. In areas where there is sediment-cover of aeolian sand, the artefacts are more difficult to see, and would have been subject to redistribution within the matrix.

The level of disturbance was most obvious where recent levelling had taken place, or where refuse had been left over recent years, the latter primarily on the limestone ridge. Apart from the removal of part of the central area of the site by bulldozer activity immediately prior to the commencement of archaeological investigations, the cumulative effect of trampling, by human agency or by animals, vehicular damage and the redistribution of the sediment-cover had all left their mark on the site. Many of the artefacts recovered reflected these effects, most showing breakages.

The 1995 fieldwork

The approach taken during the fieldwork carried out in June-July 1995 at Site ADA 1 was twofold. Firstly, a systematic collection of surface material was made, followed by the excavation of visible features.

A 5 m grid system was adopted covering the main area of Site ADA 1. This extended 140 m north–south and 120 m east–west (Fig. 4). Each 5 m square was assigned a letter code along an east-west transect (A–X), and a number code on the north–south line (1–28).

Based upon the density of finds from the surface collection of artefacts, five of these squares (A8, D16, J15, M22 and M23) were chosen for sub-surface excavation, all excavated soil being dry sieved using a 0.5 cm mesh to a depth of approximately 50 cm. This allowed an evaluation of the representative sample from surface pick-up material. Artefacts can of course re-distribute over distances of several metres both horizontally and vertically within loose unconsolidated sandy matrices.

Random surface collections were also made at two other locations. Firstly, between the northern side of the site (squares A1–A28), and a nearby deeply-rutted track being used by construction lorries. Artefacts collected from this area were described as "Peripheral". Secondly, a further pick-up was undertaken on the westward facing slopes of the limestone and tabular flint-capped hill around 100 m to the north-west of the site, concentrating on surface flint and potsherds. This area was described by the name "Limestone Hill".

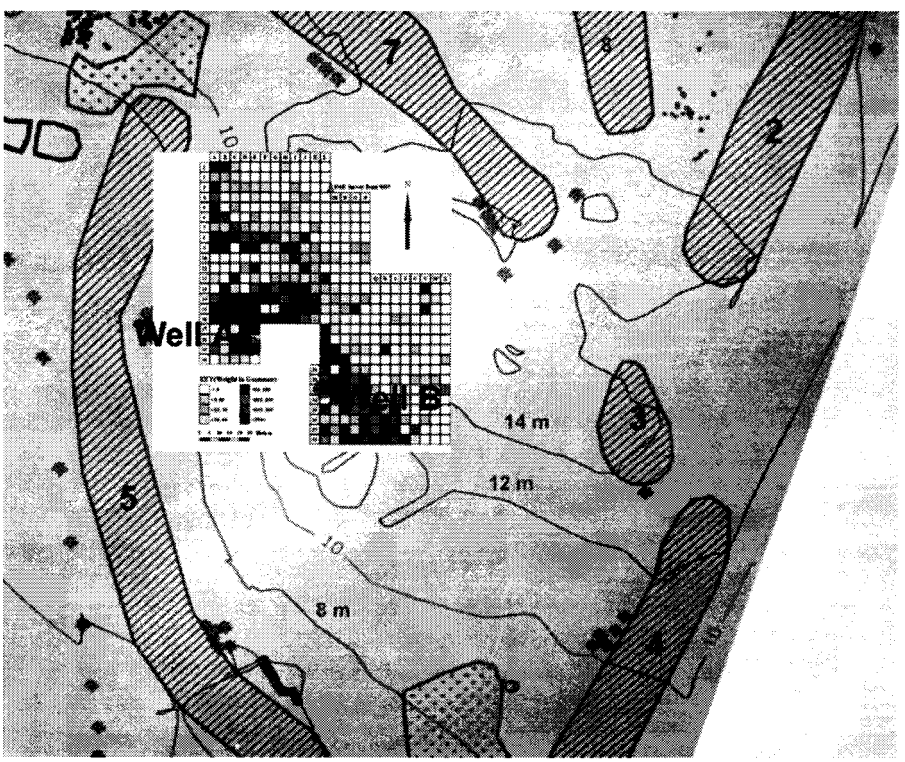

FIGURE 4. *The location of the surface grid pick-up at site ADA 1 (1995 season).*

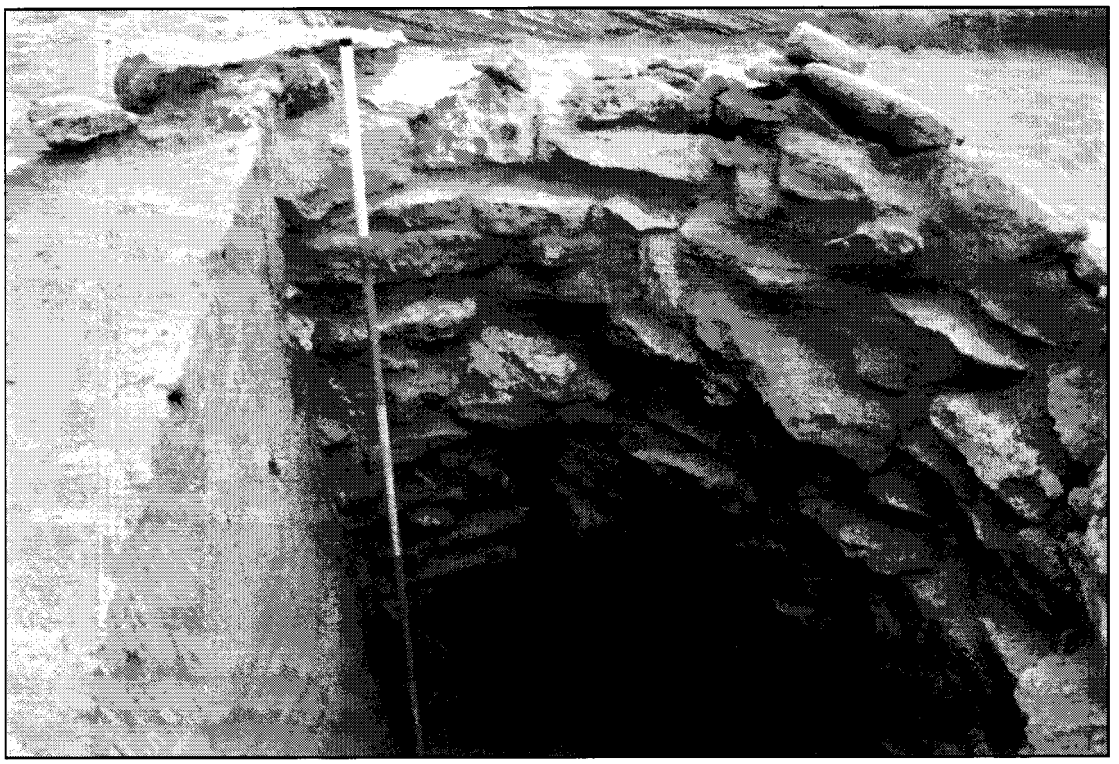

FIGURE 5. *Well A after partial excavation, showing, to the right, the stone lining wall sitting on bedrock below, and layers of aeolian sand to the left.*

The 1995 excavations

At the time of the first recognition of the site in February 1995, two structural features were identified on what was later to prove to be the western perimeter of the grid system. Subsequent surface examination of the site revealed a third structural feature within Square L23, immediately east of the bulldozer cut made in June 1995. These three features were subsequently excavated in July 1995. One of the three features (Cairn 2) proved after partial excavation to be only a surface scatter of rocks, possibly removed from Cairn 1.

Cairn 1 (Well A)

The structure was located within Squares D18–D19 and E18–E19, towards the western end of the site, and close to the edge of a ridge comprised of fossilized aeolian sand. Initial clearance of surface deposits of windblown sand and vegetation revealed a broadly circular structure, which proved to be a well. The overall dimensions of the feature in plan were 3.60 m east-west by 3.20 m north-south. Clearance of the upper layers revealed a small circular depression, around 1 m in diameter, lined with fragments of tabular limestone. This central depression may represent the remains of a cover for the top of the shaft. The feature was then half-sectioned to aid the interpretation of the process of infilling (Fig. 5). A maximum depth of 2.50 m was reached without any sign of the bottom of the well-shaft. Work was ceased at this point due to danger of collapse.

The walls of the feature, above the bedrock, were constructed of either limestone or anhydrite blocks, and the coursing went down to a depth of 2 m on the northern side of the feature. The nearest source of limestone is located 100 m to the north on an adjacent ridge, while a source of anhydrite was identified 2–3 kms to the north. However, the extent of modern levelling and land-fill operations in the general area of Abu Dhabi International Airport over the past fifteen years has obscured much of the original landscape, and a closer outcrop of anhydrite may have been available in the past.

The stone was roughly hewn into broadly square through to rectangular forms. The sizes varied considerably, with maximum dimensions being *c.* 0.80 m in

FIGURE 6. *Well B after partial excavation.*

length and 0.40 m in width. The nature of these building blocks and the roughly circular plan of the feature meant that the inside of the feature was further found to be faced with uneven drystone courses. No bonding material was evident between the blocks except sand.

The section in the west part of the shaft, down to 2.50 m, revealed seven levels of fill. This fill consisted entirely of a wind-blown or slopewash sand matrix. It is, therefore, reasonable to assume that the central area of the feature was filled in naturally over time, presumably after the feature itself had fallen into disuse. This may have been because of the drying up of the water, or the falling of the water table.

Cairn 3 (Well B)

This cairn was identified as a result of detailed surface pick-up in Square L23. From a distance, the feature appeared simply to be several clumps of vegetation which had trapped aeolian deposits, creating a small mound. Initial cleaning of the feature revealed broadly rectangular alignments of limestone and anhydrite blocks, the materials used in the construction of Well A (Cairn 1). Subsequent excavation revealed the feature to be an upwards tapering dry-course and roughly circular wall (Fig. 6). The blocks, of sandstone and anhydrite, varied considerably in size, as in the case of Well A. The overall plan of the feature at the surface prior to excavation was 1.60 m east-west by 1.50 m north-south. The central opening into the shaft was broadly rectangular in plan, its dimensions being 0.60 m by 0.50 m. Immediately below its entrance, the shaft widened, a fact also confirmed by the outward splaying of the coursing of the surrounding wall. All of the building blocks were roughly hewn and randomly coursed to create a sealed surface. No further excavations were carried out here owing to the dangers of collapse, so no estimate can be provided of the depth of the feature. It is assumed, though, that the well here was of a structural type similar to Well A, i.e. with the surrounding dry course wall resting on the sub-surface sandstone bedrock, with a shaft dug into the latter.

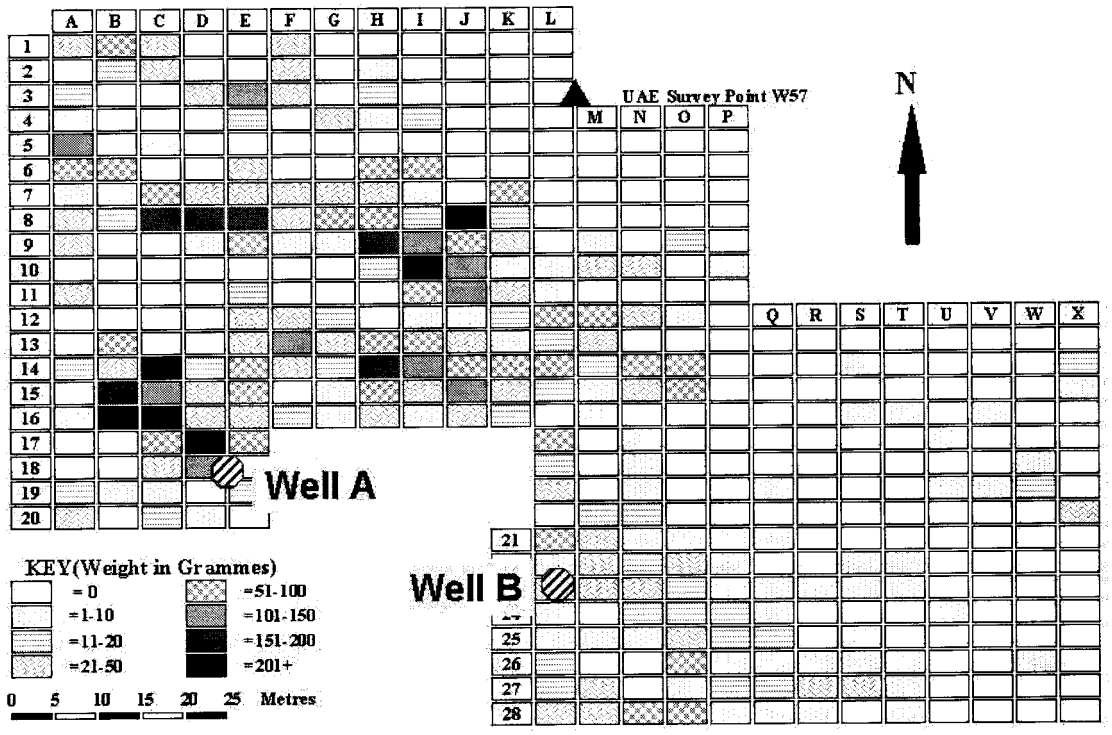

FIGURE 7. *The distribution of the pottery at ADA 1 (1995 season).*

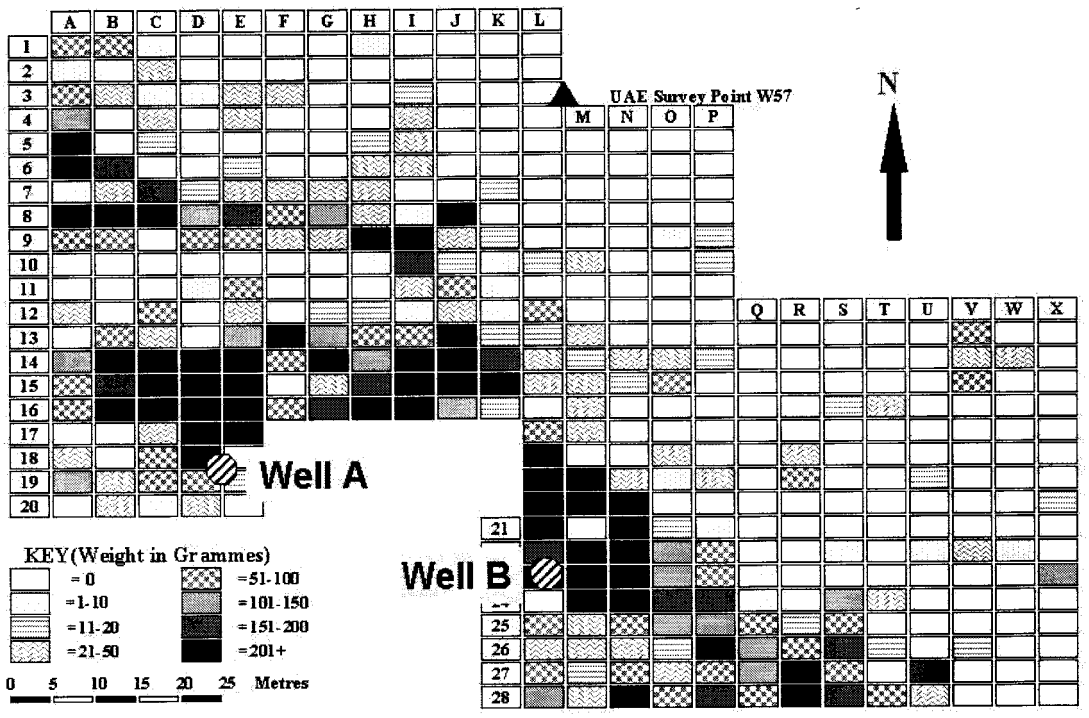

FIGURE 8. *The distribution of the lithics at ADA 1 (1995 season).*

Finds from the 1995 season

All finds from the surface collections, as well as from the five specially selected squares, were counted and weighed. This allowed the mapping of the density of finds across the site. Some notable concentrations of both pottery and lithics occurred around the area of the two wells (Figs 7–8). This may suggest that their use goes back far into antiquity.

In terms of overall weight, pottery represented by far the most numerous component of the finds. Almost without exception, the pottery was in a generally poor condition, weathering processes and sand blasting having taken their toll.

As stated earlier, analysis of this pottery assemblage has suggested sporadic occupation at the site from the Hafit period, *c.* 3100–2700 BC, with the main settlement at the site being in the second half of the third millennium BC (de Cardi 1997). The pottery seems to be largely related to the Umm an-Nar culture, as well as to the sequence established at Hili 8 in Period II. Although no signs of occupation are visible during much of the second millennium BC and the Iron Age, it was possible to identify some pottery as belonging to between the first century BC and the second century AD. Small quantities of Late Islamic pottery were also noted on the surface.

Large quantities of flint were also recovered from the surface of the site. Although the raw material is not available on the site itself, there is a source 100 m to the north, on the adjacent limestone ridge. This is tabular flint, and is found capping the limestone deposits. Generally of poor quality, it is mostly suitable for making only a few basic tool types, as shown by the discovery on site of a number of tabular scraper/knife tools, some very crude in form. At least four other types of flint, however, were recovered from the site, divided on the basis of their colour. This includes blond, black and reddish-brown flint and a grey flint, partly coated with white patination. The fact that such a range of flint, not available locally, was found on the site, naturally has implications relating to the provenancing of the raw material, and therefore to the movements or trading relationships of the early populations of the Abu Dhabi area. Blond flint is known from the al-Ain/Buraimi area, for example at Jabal Ḥuwayyah — popularly known in the Western expatriate community as Fossil Valley — located around 160 km due east of the site. Reddish-brown flint is known from the Ra's al-Khaimah and Kalba regions, in both cases originating from the Hajar Mountains. Grey flint is fairly widely distributed, and is therefore more difficult to tie to a particular source. Black flint is not known within Abu Dhabi Emirate and may well originate from the Hajar Mountains or further afield in Oman. The wider significance of the lithic assemblages from the Abu Dhabi Airport sites is discussed in another paper in this volume (Kallweit 2004).

Only very few mollusc shells were collected from surface pick-ups. The majority of these were cerithids, small species typically found in shoreline sand. Only a few fragments were from larger gastropods which might have been used as food sources. Several shell beads were recovered. A number of small ostrich eggshell fragments were also retrieved. The Arabian Ostrich (*Struthio camelus syriacus*) became extinct in the Arabian Peninsula in the 1930s, but its range until at least the nineteenth century reached into the south-western areas of Abu Dhabi. Local oral tradition suggests that ostrich shells were occasionally used as water containers.

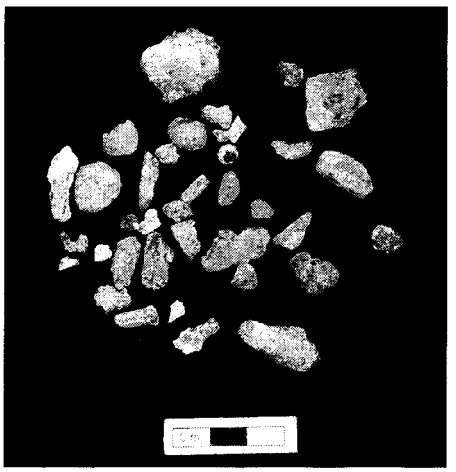

FIGURE 9. *Copper/Bronze fragments collected from the surface of ADA 1 during the 1995 season.*

An interesting discovery during the surface pick-up at the site was some small and badly corroded fragments of copper/bronze (Fig. 9). These are currently being analysed by a PhD student of Prof. Ernie Haerinck's at the University of Ghent in Belgium.

Numerous fragments of igneous and metamorphic rocks were also recovered, of types readily available in and around the Oman (Hajar) Mountains, and thus presumably imported to the site. Selected samples of these rock types have been examined by the Geology Department of the Abu Dhabi Company for Onshore Oil Operations (Fig. 10).

Sedimentary rock	Colour	Characteristics	Age	Source
Sandstone	red	ferruginous friable fine-grained sub-rounded quartz sandstone.	Unknown, most probably Tertiary to Recent	There are similar sandstones in the Miocene clastics of Western Abu Dhabi (outcrops in the Jabal al-Dhannah and Shuweihāt areas) and in nearby outcrops. Thus this sandstone could have been sourced from nearby.
Chert Types 1 and 2	reddish/dark brown	Two types of chert are noted, one contains a flood of ghosts of rounded ?radiolaria	Unknown	These cherts could have come from the allochthonous Hawāsinah Complex or from the par-autochthonous Sumeinī Group (Permian-Cretaceous in age), which are outcropping in the Oman Mountains, mainly in Sumeinī, Ḥattā, Idhn and Dibba [Dibā] Zone areas.
Chert Type 3	greenish	Contains abundant radiolaris and sponge spicules	Unknown	As for chert types 1 and 2
Limestone Type 1	grey	Micropeloidal grainstone with abundant small foraminfera (textularids and miliolids), common echinoids and rare ooids.	Unknown	The source of this undated limestone cannot be extrapolated since no diagnostic feature was found to allow comparison.
Limestone Type 2	grey	Ferruginous fractured (abundant hairline fractures) burrowed mud limestone to wackestone with rare ostracods.	Unknown	The source of this undated limestone cannot be extrapolated since no diagnostic feature was found to allow comparison.
Limestone Type 3	grey	Wackestone with Nummulites, abundant shell debris and rare to common echinoids. Minor amounts of quartz sand grains are also present. There was also a piece of crystalline calcite.	Tertiary	Similar Tertiary limestones with Nummulites are outcropping in the Jabal Ḥafīt – al-Ain area. It should be borne in mind, however, that similar rocks can also occur in the small Tertiary outcrops of the Oman Mountains front, as, for example, in the Jabal Fā'iyah area.
Anhydrite	whitish	An evaporite mineral, whitish anhydrous calcium sulphate, abundant in the recent sabkhas of the UAE.	Unknown, most probably Tertiary to Recent	Nearby sabkha areas, could even be *in situ* adjacent to the site.
Eruptive rock	**Colour**	**Characteristics**	**Age**	**Source**
Microgabbro (Dolerite) with Basalt Andesite or Basalt Syenite		One sample consists of 70 per cent of microgabbro (dolerite) and 30 per cent of basalt. The basalt infills fractures of the microgabbro, suggesting that the basalt was formed after the microgabbro.	The 'Semail Ophiolites' are believed to have formed approximately 90 million years ago at the site of a middle-oceanic ridge where the Indian Ocean lies and to have been transported to their present position, (that is they are an allochthonous association), some 70 million years ago.	Similar eruptive rocks are the component of the "Semail [Samā'il] Ophiolite Complex." The term "Ophiolite" designates a complex of basic and ultra-basic rocks of the oceanic crust which range from mantle peridotites and serpentinites at the base, through gabbros and basalts and volcanic breccias and pillow lavas at the top. The "Semail Ophiolite Complex" is the world's largest massive slice of exposed former oceanic crust, which extends for hundreds of kilometres through Oman and the UAE. They do not occur to the north of Dibba. All the rocks recovered during the Airport excavations could have come from any place within this large ophiolite exposure of the Oman (Hajar) Mountains.

FIGURE 10. *Rock samples from the Abu Dhabi Airport archaeological site. Sedimentary rocks were identified by Jose de Matos (Geology Department, Abu Dhabi Company for Onshore Oil) and eruptive rocks by Dr J. Rushton (Core Laboratories, Aberdeen, Scotland).*

2002 season

The aims of the recent work carried out by the ADIAS team at the archaeological site at Abu Dhabi airport in April and December 2003 were:

1. to re-evaluate the 1995 work carried out at the site and to bring some of the archaeological data previously collected to publication in this present paper;

2. to undertake systematic mapping of the area in order to examine the spatial distribution of archaeological material at the site;

3. to pick up systematically all the archaeological material (lithics and pottery) from two areas under threat from human disturbance (Sites ADA 2 and ADA 7);

4. to excavate a test trench to evaluate the archaeological deposits (Site ADA 2);

5. to prepare advice and recommendations to the al-Ghazal Golf Club concerning the archaeological site, including the preparation of an information leaflet about the site, as well as two exhibition cases to display objects recovered from the site;

6 to increase UAE national awareness about the site by arranging a visit of students from Zayed University, Abu Dhabi.

New fieldwork (April and December 2002)

The initial aim of the fieldwork carried out in April 2002 was to re-visit the site to check its state of preservation, and to check upon new plantation areas being developed by the al-Ghazal Golf Club. New archaeological material was clearly visible eroding out of the surface of the main Site, ADA 1. A visit to the site by Dr Heiko Kallweit and Dr Mark Beech in April 2002 recovered a flint arrowhead from the surface of the site, as well as other interesting lithic material (Kallweit 2004).

Further material was also observed in an area to the east of Site ADA 1, as well as in areas located to the north-east and north-west of the site, Sites ADA 2 and ADA 7 (the area described as "Limestone hill" during the 1995 season). Further work was clearly required to map these areas, as well as to remove any archaeological material located there, since they were located in areas of "rough" in between golf holes, where players regularly trampled in search of their golf balls.

The December 2002 season began with the undertaking of a complete topographic map of the eastern half of the al-Ghazal Golf Club course. This mapped not only the positions of Sites ADA 1, ADA 2 and ADA 7, but also the distribution of individual lithics and pieces of pottery collected from the surface of the site. The survey was carried out with the assistance of Hilalco geodetics department to whom we are most grateful. The final result of this mapping was the production of a detailed contour map covering the areas of archaeological interest on the golf course.

The fieldwork carried out during the December 2002 season was directed by Dr Heiko Kallweit, with the assistance of a number of volunteers from the Abu Dhabi Emirates Natural History Group. These volunteers assisted initially with the marking of the location of all archaeological finds at Sites ADA 2 and ADA 7. Lithic finds were marked by blue flagged nails, while potsherds were marked with red-flagged nails. The 3-dimensional co-ordinates of each of these finds was then recorded in collaboration with the Hilalco surveying team. Each find, or cluster of finds, was then bagged up with a registration number and its 3-D co-ordinates recorded. It is estimated that approximately 200 potsherds and around 350–400 lithics were recorded from both sub-sites. Around 20% of the lithic finds comprised worked or used material.

Site ADA 2 — surface pick-up

Site ADA 2 is located in the "rough" between the second and eighth fairways on the al-Ghazal Golf Club course. It is a flattish area with an altitude of about 14 m above sea level. A total of 43 pottery sherds, or clusters of sherds, and 98 lithic finds or clusters were collected from the site. There was a strong clustering of both lithics and pottery towards the northern end of the area, with notable clusters of pottery and then lithics towards its southern limit (Fig. 11).

Site ADA 2 — trial trench

A 20 m^2 trial trench (Trench A) was excavated towards the northern end of Site ADA 2. This was located at UTM N 2701898.646, E 261378.688 (south-east corner of the trench); N 2701906.939, E 261360.489 (south-west corner); N 2701916.845, E 261386.982 (north-east corner); and N 2701925.139, E 261368.783 (north-west corner). Note that these UTM co-ordinates are given using the Nahrwan UAE datum. A series of height levels were taken across the trench prior to commencing the excavation. The area was deliberately selected

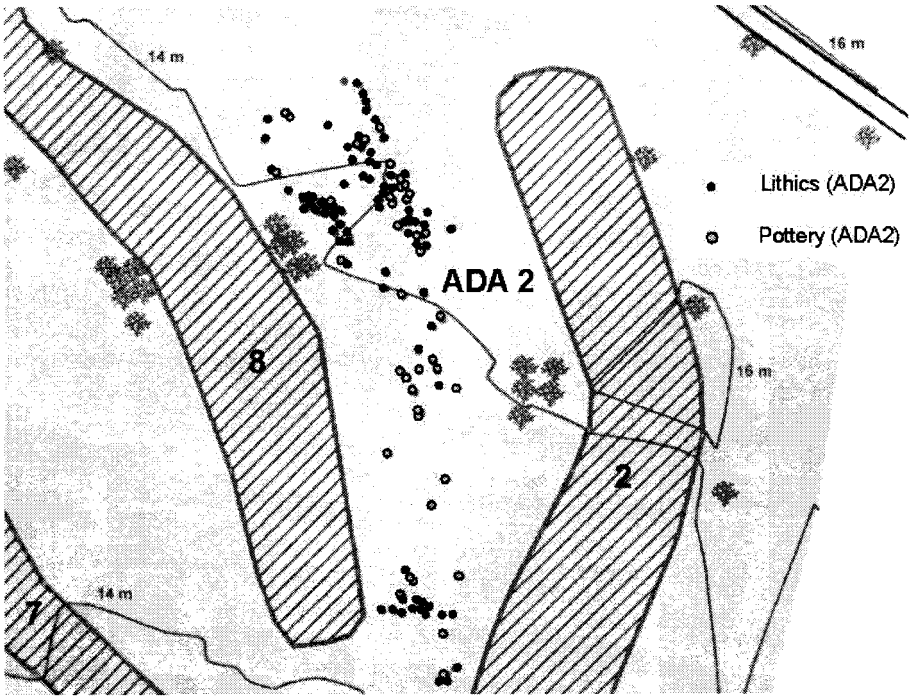

FIGURE 11. *The distribution of pottery and lithics at ADA 2 (2002 season).*

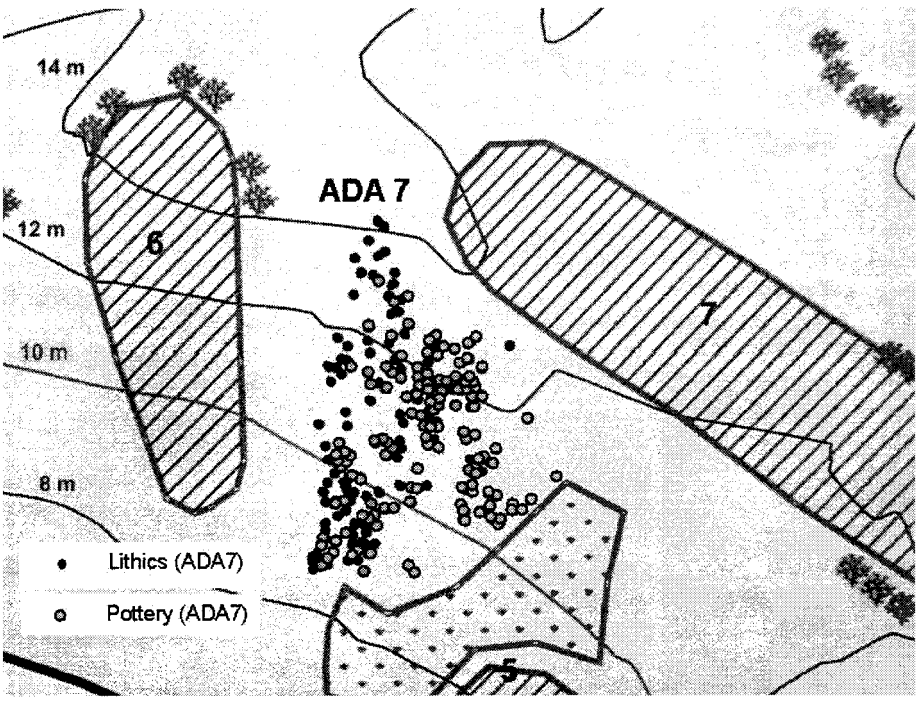

FIGURE 12. *The distribution of pottery and lithics at ADA 7 (2002 season).*

on the basis of the notable density of finds from the surface pick-up.

As excavation commenced, it immediately became evident that archaeological finds were only present within the top 10 cm layer which consisted of a loose sandy matrix. This material was therefore all collected in buckets and dry sieved, using 3 mm mesh sieves to recover any small finds. Just below the surface layer, the sediment became more compacted but this lower layer was absolutely sterile of finds. This hard compacted layer appeared to be the upper part of fossilized quaternary dunes (aeolianite). Such deposits are typical along much of the Gulf coastline of the UAE.

The southern part of the trial trench appeared to be somewhat disturbed on the surface compared to other parts of the trench. The excavation subsequently uncovered a modern metal water pipe cutting across the southern half of the trench heading in an east–west direction. This clearly formed part of the irrigation system for the golf course.

Site ADA 7 — surface pick-up

Site ADA 7 (known as "Limestone Hill" during the 1995 season) is located in a triangular section of "rough" between the sixth and seventh fairways on the al-Ghazal Golf Club course. It is just upslope from the plantation at the northern end of the fifth hole. All the finds were made on a south-facing slope between an altitude of 8–14 m above sea level. A total of 150 pottery sherd clusters and 111 lithic clusters were collected from the surface of the site. There was a good degree of overlap in the distribution of both lithics and pottery, although there was a hint of more pottery present in the eastern and south-eastern part of the area (Fig. 12). This did not seem to be entirely due to heavier potsherds versus lighter lithics slipping down the slope. Modern ground disturbance when the golf course was being built may partly explain these distributions. Much of "Limestone Hill" has been bulldozed since 1995 as part of the landscaping activities for the golf course.

Finds from 2002 season

The newly collected pottery sherds are generally in a very poor condition, identical to the earlier material collected during the 1995 season. Their surfaces have been sand-blasted away, and there are few diagnostic sherds. The hardness and general characteristics of the fabric, as well as its colour, however, make it appear very comparable with the material previously studied and published from the site by de Cardi (1997). The majority of sherds are compatible with wares from Umm an-Nar and other sites in Eastern Arabia of similar date. The authors are grateful to Christian Velde of the National Museum of Ra's al-Khaimah, and to Beatrice de Cardi, for examining the pottery collected during the 2002 season and for sharing their thoughts on this poorly preserved material.

The lithics collected from the surface of the site are discussed in another paper in this volume (Kallweit 2004). Small quantities of marine shells were the only other finds recovered during the 2002 season. These were similar in character to the earlier finds from the 1995 season.

Groundwater investigation

During the 2002 field season, two subterranean caverns were examined. Cavern 1 opened accidentally in May 2002 and was briefly investigated by ADIAS archaeologist Dan Hull. A re-examination in December 2002 revealed ground water at a depth of approximately 5.50 m below the present-day ground surface. Detailed measurement was impossible, due to the tube-like shape of the cavern and danger of collapse. The cavern is accessible by a small hole on the surface, about 1 m in width. The walls of this cavern were of interest as different layers of fossilized dune were clearly visible. The tube-like shape and the smoothed walls suggest a kind of subterranean gully erosion as the agent that formed the cavern. Comparable patterns of erosion can also be observed on outcropping layers at Site ADA 1.

At the time in the mid-Holocene when occupation of the ADA sites commenced, the landscape was probably, therefore, one of fossilised ancient dunes, covered for the most part by loose sand and vegetation. Visible sections of the outcroppings of aeolianite as well as in the landslide holes show layers orientated in different directions and angles. Such a pattern is comparable to dune surfaces, where changing wind directions affect the erosion and accumulation of sand.

After the mid-Holocene "wet phase", erosion and deflation would have removed any soil that had developed as a result of the vegetation cover. The cultural remains of human occupation, i.e. more durable material like lithics and pottery, would then have been left as a surface scatter.

A second hole in the ground opened further to the north-west of Site ADA 7, close to the thirteenth hole, during the night of the 9th–10th December 2002. The whole north-western part of the golf course is a former flat sabkha plain. When the golf course was built, the plain was covered with a layer of about 10 cm of gravel

and sand. This artificial layer can clearly be distinguished in the section of the hole which was approximately 1.50 to 1.60 m in diameter. The water table was present at a depth of just 1.20 m.

We were informed by the staff of the golf club that such holes regularly appear especially during the winter months each year, suggesting that such events indicate large scale subterranean erosion. The ADIAS team subsequently invited Mike Brook, a water resources specialist for the Terrestrial Environment Research Center (TERC) within the Environmental Research and Wildlife Development Agency (ERWDA), Abu Dhabi, to undertake a systematic examination of the ground water at the site. His study revealed that the water in this latter hole, and within other water features at the centre of the golf course, was unsuitable for drinking according to modern standards (Brook 2003). The origin of the water was probably a mixture of modern irrigation water from the Mafraq waste water treatment plant (where Abu Dhabi's irrigation water originates), mixed with traces of surviving ground water. During the winter period when high tides meant that the sabkha became inundated, this led to the annual appearance of sink holes on the golf course.

What was clear, however, from the groundwater investigation was the fact that the location of the site appears to take advantage of the local hydraulic gradient flow system. Both Wells A and B were constructed in a similar manner acting as access points and covers for tapping water through the aeolianite. Immediately to the east of the site, the topography reveals a rainwater catchment that can be identified by the presence within it, even in high summer, of more luxurious and slightly less salt-tolerant vegetation than that present on the site itself. Peter Hellyer was informed by a UAE national who visited the site that the area had once been used as a stopping place in the relatively recent past by Bedouin tribesmen coming across the desert from al-Ain or down the coast from Dubai, because there was sweet water present in the vicinity. This, presumably, explains the presence on the site of Later Islamic period sherds.

The climate of the Abu Dhabi area is believed to have been substantially wetter in the past, particularly during the so-called "Neolithic Moist Phase", which ended around 4000 BC, but also in more recent periods, until the present arid phase set in around AD 1500. If some fresh water was available in very recent times, it is reasonable to assume that greater supplies could well have been available in the past.

The Abu Dhabi Airport site lies on a range of low hills that, until the development of recent times, looked out across an unbroken stretch of sabkha flats towards the offshore islands of Abu Dhabi and Umm an Nar, around 12 km away. Sedimentological studies suggest that the formation of the sabkha commenced around 2000 BC, and that, prior to that, the intervening area was covered by the sea. In consequence, the Abu Dhabi Airport site lies on what would, until around 2000 BC, have been a headland on the coastline. Indeed, the nature of the erosion of some of the sandstone outcrops on the edge of the site, particularly in an area immediately to the west of Well A, as well as beyond the limestone ridge to the north-west of the site, is indicative of marine action.

Once the sabkha had formed, the site was isolated from the sea. However, the nature of the sabkha is such that, after heavy rainfall, or as a result of a combination of exceptionally high tides and strong winds, it would have been so wet as to have been virtually impassable. Indeed, on occasion it was flooded. As recently as the 1950s, for example, according to information provided to Peter Hellyer by one local inhabitant, the whole area could be covered by water, so that vehicles crossing the sabkha from near what is now the Airport to Abu Dhabi could at times be out of sight of land.

Thus even in the period after the formation of the sabkha, it is likely that, on occasion, the Airport site was effectively on a temporary coastline, where, when conditions were unfavourable, travellers to Abu Dhabi island might have been obliged to halt to wait for the sabkha to become passable. Such travellers, of course, would have found a site with supplies of fresh water to be even more attractive.

Conclusions

The archaeological site located within the perimeter of the al-Ghazal Golf Club (now described as ADA 1, ADA 2 and ADA 7) is now known to extend over a much wider area than was previously thought. The location of the site appears to take advantage of the local hydraulic gradient flow system for the exploitation of sweet water. Was this area originally an important supply point on the coast for local settlements, re-supplying passing travellers and traders, etc.? This area represents one of the nearest points on the former mainland coast to the well known third millennium BC settlement and tombs on Umm an-Nar island, located only some 12 km to the west. Although the site has clearly been affected by deflation and some degree of modern disturbance it is nevertheless clear that its location was of strategic importance from as long ago as the Neolithic period through until the more recent pre-oil era.

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