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RICHARD CUTTLER, MARK BEECH, HEIKO KALLWEIT, ANJA ZANDER & WALID YASIN AL-TIKRITI

Summary
Survey work in 2004 identified two extensive lithics scatters in the south-eastern desert of Abu Dhabi at Umm az-Zumālī. Both scatters were within small interdunal areas to the south-east of large barchan dunes. At the first site (Khor al-Manāhīl) a controlled pick-up of lithics recorded almost 3000 fragments of flint and stone artefacts. The typology of the artefacts suggests the scatter belongs to the so-called Arabian Bifacial Tradition (ABT). This dates the scatter to the mid-Holocene, between the seventh and fifth millennia, when the climate was wetter and the conditions more favourable. A series of undated “burnt mounds” at Khor al-Manāhīl was also recorded and excavated. The second scatter (Kharimat Khor al-Manāhīl) was again comprised of flints belonging to the Arabian Bifacial Tradition. OSL dating suggested that these must date later than 9000 years ago. Two shell beads, found in association with the flint scatter resemble types well known from the Neolithic cemetery of Jebel al-Buhais 18, located in Sharjah emirate in the UAE.

Keywords: UAE; Neolithic; lithic assemblage; Arabia; archaeology

Introduction
Between 9000 and 6000 years ago many desert areas experienced a higher rainfall, described within the Arabian Peninsula as the “Climatic Optimum” (Parker, Davies & Wilkinson 2006). This paper examines new evidence about the pastoral nomadic communities during this period, with reference in particular to flint debitage collected from two sites within the north-eastern corner of the “Rub‘ al-Khali” or Empty Quarter in the south-eastern desert of Abu Dhabi in the United Arab Emirates. Survey and excavation undertaken over three seasons also included Optical Stimulated Luminescence dating on deposits above and below these flint horizons. The sites, Kharimat Khor al-Manāhīl and Khor al-Manāhīl, are located within 7 km of each other in the Umm az-Zumālī region, close to the border with Oman and Saudi Arabia (Fig. 1). These were first examined as part of a joint project by the Abu Dhabi Islands Archaeological Survey (ADIAS) and the Department of Antiquities and Tourist in Abu Dhabi’s Eastern Region, now both absorbed by the Abu Dhabi Authority for Culture and Heritage (ADACH).

The Umm az-Zumālī region is characterized by relatively low-lying, rolling barchanoid dunes and interdunal plains. The plains comprise a deflated land surface of sub-horizontal fluvial sediments deposited during the later part of the Pleistocene when the climate fluctuated from hyper-arid to humid. During intermittent pluvial periods waterborne sediments were transported westwards from the Hajar mountains in Oman and deposited as alluvial fans that now form the interdunal plains (Glennie 2001). These plains are overlain by salt-covered sabkhas and much younger sands forming barchan dunes, the eastern limits of which coincide approximately with the Oman border.

Early surveys within the Rub‘ al-Khali discovered several Neolithic flint sites, mostly within the western extent of the desert, covering Saudi Arabia and Yemen (Zarins, Muzad & Al-Yaish 1981; Edens 1982). The presence of a lithic scatter at Kharimat Khor al-Manāhīl was first noted in 2003 by a team from the Terrestrial Environment Research Centre (TERC), part of the Environment Agency — Abu Dhabi, EAD (then known as the Environmental Research and Wildlife Development Agency, ERWDA). In November 2003 the sites were revisited and evaluated by Dr Mark Beech from the Environment Research and Wildlife Development Agency — Abu Dhabi, EAD (then known as the Environmental Research and Wildlife Development Agency, ERWDA). In November 2003 the sites were revisited and evaluated by Dr Mark Beech from...
FIGURE 2. The Khor al-Manihil (KAM) survey area showing the location of the "burnt mounds" and interdunal areas with flint debitage.
ADIAS, together with a team from TERC. It was real-
ized that further fieldwork would be needed in order to map the extent of the lithic scatter, and the first season of work took place between 24th January and 6th Feb-
ruary 2004. A total of eighty fragments were mapped at Khor al-Manāhil (KAM) where there were significant clusters of worked flint and other stone material.

In the Khairmat Khor al-Manāhil (KHM) region lithics were spread almost continuously along the north-
erth edge of the plain for more than 3 km (Kallweit, Beech & Al-Tikriti 2005). Three possible building structures (KHM0045–KHM0047) at Khairmat Khor al-
Manāhil were investigated but found to be the result of recent seismic studies.

Two further seasons have since been undertaken at KAM and KHM during January 2005 and January 2006. This involved a topographic survey of both sites and their landscape features. While survey work at Khor al-
Manāhil concentrated on the systematic collection and mapping of lithic finds, a concentration of lithics was noted in an interdunal depression known as ‘Area 9’. Given the density of flints a regime of recording and number-
ing each lithic find was clearly inappropriate, particu-
larly for small pressure flakes, so this area was left for the third season (2006).

In April 2005, a team comprised of Dr Anja Zander (then based in the Geography department at Marburg University in Germany), Dr Heiko Kallweit, and Dr Mark Beech, visited the Umm az-Zumāl region to ob-
tain suitable samples for OSL dating. Aims and methodology

The fieldwork priorities for 2005 and 2006 were to map the locations of flint finds and the extent of the scatters at Khairmat Khor al-Manāhil (KHM) and Khor al-
Manāhil (KAM). It was also hoped that topographic mapping and OSL dating would contribute to our under-
standing of the chronology of the lithic debitage and the depositional processes of the sites and their environs.

The area of the lithics scatter was walked in ap-
proximately 2 m transects. All finds, with the exception of those from Area 9, were collected from the deflated land surface using Nikon C100 Total Station and data logger. Flints were logged as X, Y, Z data points in local grid co-ordinates and stations were fixed to national co-ordinates using a hand-held GPS. Each point was recorded with a relative positional accuracy of ± 0.01 m. Finds numbers were incremented by the logger, and the points processed using Geosite and AutoCAD software. The more general topographic survey mapped interdunal areas, terraces, archaeological features, and modern dunes, which accounts for an ab-
sence of debitage within parts of the site. A database of the lithic types was then combined with the topographic survey using ArcGIS. This enabled individual tool types to be plotted within the topography of the site.

Specific aims for the two seasons included:

Khor al-Manāhil (KAM)

--- Dry-sieving of the lithics-bearing layer within Area 9 by 1 cm-grid squares using 1 mm-mesh hand sieves.
--- An investigation of discrete areas of stone within the western part of the site, to determine their natural or anthropogenic origin.
--- Further investigation of the area south-east of the main lithics spread, including excavation and mapping of newly discovered “burnt mounds” and additional surface finds.

Kharimat Khor al-Manāhil (KHM)

--- An investigation of a series of three possible limes-
stone structures (KHM0045–47).

Results

Khor al-Manāhil (KAM)

Work at KAM concentrated on completing the mapping of lithics and a topographic survey of the immediate vicin-
ity of the scatter (Fig. 2). The lithics collection and topographic survey was also augmented by the excava-
tion of stone scatters within the north-eastern extent of the survey area, and “burnt mounds” recorded beyond the southern extent of the area.

A total of 2681 lithics find spots were recorded over three seasons from Khor al-Manāhil, with the vast ma-
jority (approximately 2000) being recorded during the second season (2005). New material was exposed each season, and as part of the 2006 season a further 600 flints were collected to the north and west of Area 9 (Figs 2 and 3), where flints had been collected the pre-
vious year. Clearly smaller quantities of material were constantly being exposed and buried.

The greatest part of the work in 2006 involved the controlled sieving of debitage concentrations within Area 9 where no flints had been collected the previous season. This comprised an interdunal depression about 20 m in width and 30 m in length (Fig. 3). A larger modern dune was aligned along the southern edge, and the northern edge of the depression was marked by a flat and rounded modern dune corpus. Flint debitage was

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also recovered from the surface of a palaeodune within the south-western extent of Area 9. A 1 m² planning frame was used to mark 20 cm grid squares along a north to south baseline with the sediments from a total sieved area of 90 m², using 1 mm-mesh hand sieves. All flints were recovered exclusively from the uppermost 2 cm of sand. Below this was a fine loose sand (approximately 0.15 m in depth), which in turn overlay a hardened, deflated surface. This was also the case at Kharmat Khor al-Manāhil (KHM 0035) where the debitage was concentrated in the uppermost few centimetres below the modern ground surface (Kallweit, Beech & Al-Tikriti 2005).

**Analysis of the Khor al-Manāhil lithic assemblage**

To date, 458 pieces of tools and debitage have been recorded and analysed by Dr Heiko Kallweit. The largest number and most important group were the weaponry, which includes thirty-seven arrowheads (two of them semi-products), five large projectile points (two of them semi-products), and fourteen bifacials (including eight semi-products). All the arrowheads are stemmed with the exception of a few very thin, elongated, willow-leaf shaped forms. The arrowheads are carefully manufactured and, usually bifacially pressure retouched. Most of the stemmed specimens are triangular-shaped. A few pieces are barbed and some have denticulated edges. The raw material is almost exclusively flint with a few exceptions of coarse grained material, most likely of volcanic origin.

From a typological perspective, all the arrowheads are typical of seventh–fifth-millennium Neolithic assemblages commonly reported from many sites in the UAE and the Arabian Peninsula. Larger projectile points are elongated, significantly larger, and heavier than arrowheads as they weigh in excess of 7 gm. Khor al-Manāhil also produced a number of interesting semi-products of large projectile points and bifacials, which serve to explain the necessary technical steps and stages
of manufacture. Larger projectile points are made of either large blades or fragments of tile flint (the latter technically being core-tools). This also applies for almost all bifacials found in the stage of a semi-product. They are made from elongated, flat pebbles of locally available flint. Flint pebbles similar in colour, texture, and size have been found on the surface of different sites at Irq az-Zahar, just a few kilometres to the north of the KAM sites.

The assemblage, with its emphasis on weaponry, does not look domestic but appears to reflect the remains of temporary camps. The scraper, cutting tool, and piercing tool frequency is very low compared to the level of weaponry, particularly when compared to broadly contemporary assemblages. At the coastal Ubaid settlement of Dalma, for example, very few arrowheads were noted, but significantly more knives, drills, piercing tools, and wedges were recorded (Kallweit, in preparation). This would tend to suggest that the assemblage at Khor al-Manāhil is perhaps the result of seasonal husbandry missions into the desert with weapons to hunt, slaughter, and eat, as well as comprising tools for the repair of toolkits and for the manufacture of weapons.

Concave side scrapers

Of particular interest was a tool type new to the Khor al-Manāhil assemblage, which was classified as a concave side scraper (Kallweit 2006). In contrast to common end-scrapers or side-scrapers, the working edge is formed by steep retouch in a notch of winged flakes as shown on KAM282 (Fig. 4). On all examples so far (seven in total), the flake is torn to the right. The dorsal face of the flake displays scars of previous removals, and in some cases cortex remains are visible at the terminal edge. It is likely that curved flakes were produced intentionally to create this tool. Of course an accidental creation of such flakes cannot be excluded, but seems less likely. The scrapers are about 5 cm long, 1.5 cm in width, and less than 1 cm thick. Typically 2–3 cm of the right side of the concave edge is subject to a steep parallel retouch from the ventral to the dorsal face. Opposite to this, the left edge is also typically retouched, comparable to the modifications on a backed knife. This retouch could well form a finger rest because it has been designed to break sharp edges rather than providing a second working edge, although the backing modification was not observed on all examples. While the purpose of this tool remains uncertain, the single hand-held character of the tool suggests it may have functioned as a smoother, perhaps for wooden shafts or handles. Further investigation of the assemblage could include use-wear analysis, which may provide a better insight into the function of the tool, which so far does not have any parallels from similar sites in the UAE.

The excavation of features at Khor al-Manāhil (KAM)

The stone spreads

Towards the north-eastern edge of the lithics scatter was several spreads of loose stone (Fig. 2). Given that much of the deflated land surface comprised calcified

of manufacture. Larger projectile points are made of either large blades or fragments of tile flint (the latter technically being core-tools). This also applies for almost all bifacials found in the stage of a semi-product. They are made from elongated, flat pebbles of locally available flint. Flint pebbles similar in colour, texture, and size have been found on the surface of different sites at Irq az-Zahar, just a few kilometres to the north of the KAM sites.

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FIGURE 5. A plan and a photograph of "burnt mound" No 1, with a 70 m-high barchan dune to the south.
gypsum (resulting from precipitation) it was considered that the rubble might be the remains of up to five building structures (KAM0003–KAM0007; cf. Kallweit, Beech & Al-Tikriti 2005). The recovery of a limestone mortar (KAM0008) from the immediate vicinity suggested domestic activities took place in the vicinity. However, a single 1 x 5 m trench, excavated across one of the spreads to a depth of 0.3 m, demonstrated that the rubble was of natural origin.

The "burnt mounds" (Figs 2 and 5)

Three "burnt mounds" were located to the south-east of the site, and comprised circular concentrations of burnt limestone. The largest mound (No 1) measured 4.5 m in diameter and about 15 cm in height. Its surface was littered with grey limestone fragments, each no larger than 20 cm, which give the impression of having been burnt. Close observation of the surface of these limestone fragments revealed a consistent pattern of weathering from the prevailing north wind, which may imply some antiquity.

About 7 m to the south a second, less-well preserved "burnt mound" (No 2) was clearly more deflated, the stones being dispersed over a flat area about 3 m in diameter. A third and much smaller concentration of burnt stones (No 3) was recorded 70 m to the south, and was only 1.5 m in diameter. The original sediments associated with both "burnt mounds" (Nos 2 and 3) were completely eroded. The best-preserved mound (No 1)
washed and further treated with sodium hypochlorite solution to remove manganese and other contaminants. The samples were then dried at 60°C and ground to a fine powder. The powder was sieved, and the size fraction between 53 and 63 μm was used for further analysis. The mineralogical composition of the samples was determined using X-ray diffraction (XRD) analysis. The results showed that the samples were dominated by quartz, feldspar, and clay minerals. The carbonate content was determined using a Leco analyzer. The samples were loaded into the analyzer, and the carbonate content was measured by the loss on ignition method. The results showed that the carbonate content ranged from 1 to 5%. The elemental composition of the samples was determined using a scanning electron microscope coupled with an energy-dispersive X-ray spectrometer (SEM-EDS). The results showed that the samples were rich in calcium, silicon, and oxygen, with trace amounts of other elements such as iron and magnesium. The calcium content was measured using an inductively coupled plasma optical emission spectrometer (ICP-OES). The results showed that the calcium content ranged from 2 to 5%.

**Pastoral nomadic communities of the Holocene climatic optimum**

Kharimat Khor al-Manhāl (KHM)

Work at KHM concentrated on three low mounds, each with a central shallow sub-circular depression and what appeared to be vertically set limestone. An initial test trench (Trench 1, Fig. 6) excavated through KHM0046 suggested that these might be the remains of some form of house-type structures (Kallweit, Beech & Al-Tikriti 2005) or even tombs (Beech et al. 2006). Further excavation of KHM0045 and KHM0046 during the January 2007 season revealed the presence of a borehole, 4 m deep and approximately 0.15 m wide, in the middle of each of the depressions. Limestone fragments in both depressions were found to be angled downwards towards the apex at the centre of the depression where the borehole was located. The features are without doubt the result of seismic studies undertaken for the purpose of oil exploration in the early to mid-1960s. Fragments of limestone were forced into a vertical position when the charge at the base of the borehole was detonated. Small metal and wire fragments adhering to limestone fragments were discovered in the centre of each depression. Each of the boreholes contained water, and a sample was taken for further analysis. Dr Mike Brook, a hydrologist at the Abu Dhabi Environment Agency reported that the water was slightly salty and that it was within the typical regional range, having a salinity measurement of 17,200 mg/litre and a pH of 7.6. This would not be considered suitable for human consumption, watering animals, and/or for agriculture at the present time.

**Lithics collection at KHM sites**

A concentration of lithics was recorded to the north-west of the three depressions (KHM0045–KHM0047, cf. Fig. 6), and a second some 60 m to the south-east. A total of 388 lithics find spots were collected and mapped during the 2005–2006 season, including debitage as well as completed and semi-completed artefacts and projectile points. Other tool types included retouched flakes and blades, retouched pieces of debris, chisels, scrapers, awls, a knife, and one axe.

**Shell beads**

Surface finds also included two shell beads approximately 5 and 10 m west of KHM0046 (Fig. 6; cf. Beech et al. 2006: 24, fig. 9). The first example was a typical flat, round disc-bead, about 7 mm in diameter, with a hole about 2 mm in diameter drilled through it. It had been manufactured from a marine bivalve shell, possibly from a species like Cardiidae. The second example was an almost complete small marine gastropod, Olividae, Ancilla farsiana, whose apex had been cut off to facilitate it being threaded as a bead. This species is present in both the Arabian Gulf and the Gulf of Oman in intertidal habitats as well as sandy offshore habitats (Dance 1995: 246, no.1090).

**Dating the dunes**

The problem of absolute dating of Neolithic sites within inland desert environments is the absence of associated suitable organic matter for radiocarbon dating. This is also the case for the lithic scatters at KAM and KHM. For this reason dating was carried out using Optically Stimulated Luminescence (OSL) on quartz grains within layers above and below the flint horizon. Luminescence dating methods determine the time elapsed since a radiation-produced charge in natural minerals was last reset by sunlight (for comprehensive overviews of luminescence dating techniques see Wintle 1997; Ai'tken 1998; Stokes 1999; Murray & Wintle 2000).
FIGURE 7. Location of OSL dating trenches at Khor al-Manihl.
## Method and protocol

OSL measurements on coarse grain quartz (150–200 μm) were taken with an automated Risø TL–DA 15 reader using blue (470 ± 30 nm) stimulation and a 7.5 mm Hoya U340 detection filter (280–380 nm). Equivalent dose (ED) measurements were performed using the single-aliquot regenerative-dose (SAR) protocol on twenty-four aliquots per sample. OSL was measured for 40 s at 125°C with a 10 s preheat at 240°C and a cut heat of 200°C. The integrated signal of the first 0.5 s shine down were used to calculate the ED. Radionuclide analysis for dose rate determination was performed by high-resolution gamma spectrometry using a 20% p-type HPGe detector (Preusser & Kasper 2001). The age of each sample was then calculated from the average and given in years (Figs 8 and 12).

### Luminescence dating results

#### Khor al-Manahil

A test trench (WPT144, Fig. 7) was excavated at the southern extent of the debitage spread in Area 9, and a sample of the laminated palaeodune, taken at a depth of 0.5 m (KAM–19), was dated to 7975 ± 611 years ago. This was sealed by gypsum and then a laminated, partly cemented, sediment (KAM–18) lying immediately below the lithics horizon, which provided a date of 7887 ± 602 years ago (Figs 8 and 9). Two further trenches (WPT142 and WPT143, Fig. 7) were excavated into the dunes overlaying the flint debitage. Three samples (KAM–15 to KAM–17) from these dunes showed that the dunes were deposited within the past fifty years (Fig. 8).

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#### Luminescence dating results

**Khor al-Manahil**

A test trench (WPT144, Fig. 7) was excavated at the southern extent of the debitage spread in Area 9, and a sample of the laminated palaeodune, taken at a depth of 0.5 m (KAM–19), was dated to 7975 ± 611 years ago. This was sealed by gypsum and then a laminated, partly cemented, sediment (KAM–18) lying immediately below the lithics horizon, which provided a date of 7887 ± 602 years ago (Figs 8 and 9). Two further trenches (WPT142 and WPT143, Fig. 7) were excavated into the dunes overlaying the flint debitage. Three samples (KAM–15 to KAM–17) from these dunes showed that the dunes were deposited within the past fifty years (Fig. 8).
FIGURE 10. Location of OSL trenches at Kharimat Khor al-Manāhil KHM0646.
A trench excavated into the terrace to the north-west of KHM0047 (WPT 138, Fig. 10) provided a sample at a depth of 0.82 m, which dated the sediments to 9609 ± 693 years ago (KAM–9). Sediments at a depth of 0.25 m below the flint scatter provided a date of 9439 ± 706 years ago (KHM–10, Figs 12 and 13). A sample from the dune to the west, which overlay the terrace and flint debitage, suggested that the dune had accumulated within the past ten years (WPT140, KHM–11).

The site of KHM0001 is an interdunal depression approximately 1 km to the west of KHM00046 (Figs 1 and 11). A trench (WPT 141) was excavated below the palaeodune and samples taken from the sediments beneath the flint scatter. The earlier palaeodune material (KHM–12) was dated to 12,280 ± 952 years ago and the sediments immediately below the flint scatter (KHM–13) to 9097 ± 655 years ago (Figs 12 and 13).
The discovery of flint sites in the Rub al-Khali over the past fifty years has altered our perception of a seemingly barren and inhospitable landscape. The flint scatter at Khor al-Manīl, Kharmat Khor al-Manīl, and associated structures, can provide techno-typological comparisons with other Neolithic assemblages within the Rub al-Khali, particularly in an environment where lithics provide the main and often only source of evidence for Neolithic habitation.

The surface assemblages can be dated to around 7500–6000 BP, as the tools all belong typologically to the so-called "Arabian Bifacial Tradition" (ABT) or more closely to the "Rub al-Khali Neolithite", as first defined by Christopher Edens (1982). Unusual tool types within the assemblage, for example the concave side scrapers, can provide techno-typological comparisons with other Neolithic assemblages within the Rub al-Khali.

<table>
<thead>
<tr>
<th>Site code</th>
<th>OSL sample site</th>
<th>Sample No</th>
<th>Lab. No</th>
<th>Assumed water cont. (G/EW, %)</th>
<th>Uranium (ppm)</th>
<th>Thorium (ppm)</th>
<th>Potassium (ppm)</th>
<th>Cosmic dose (Gy/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KHM0001</td>
<td>WPT 141</td>
<td>12</td>
<td>MR0469</td>
<td>8 ± 5</td>
<td>1.08 ± 0.05</td>
<td>1.99 ± 0.1</td>
<td>1.05 ± 0.05</td>
<td>165.0 ± 8.2</td>
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<tr>
<td>KHM0001</td>
<td>WPT 141</td>
<td>13</td>
<td>MR0470</td>
<td>8 ± 5</td>
<td>0.74 ± 0.04</td>
<td>1.47 ± 0.07</td>
<td>1.09 ± 0.05</td>
<td>168.5 ± 8.4</td>
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<tr>
<td>KHM00045-7</td>
<td>WPT 138</td>
<td>9</td>
<td>MR0466</td>
<td>8 ± 5</td>
<td>0.71 ± 0.04</td>
<td>1.29 ± 0.06</td>
<td>1.04 ± 0.05</td>
<td>167.6 ± 8.4</td>
</tr>
<tr>
<td>KHM00045-7</td>
<td>WPT 138</td>
<td>10</td>
<td>MR0467</td>
<td>8 ± 5</td>
<td>0.55 ± 0.03</td>
<td>1.06 ± 0.05</td>
<td>0.93 ± 0.05</td>
<td>172.7 ± 8.6</td>
</tr>
<tr>
<td>KHM00045-7</td>
<td>WPT 140</td>
<td>11</td>
<td>MR0468</td>
<td>5 ± 3</td>
<td>0.52 ± 0.03</td>
<td>1.11 ± 0.06</td>
<td>1.11 ± 0.06</td>
<td>172.0 ± 8.6</td>
</tr>
</tbody>
</table>

Discussion

The discovery of flint sites in the Rub al-Khali over the past fifty years has altered our perception of a seemingly barren and inhospitable landscape. The flint scatter at Khor al-Manīl and Kharimat Khor al-Manīl, combine with other sites within the Rub al-Khali, including Yaw Sahhab in the Liwa Oasis (Harris 1998; Kallweit 2001) and Bida al-Mutawar in western Abu Dhabi (Crombe 2000), to add significantly to our assessment of the exploitation of resources in the Rub al-Khali, particularly in an environment where lithics provide the main and often only source of evidence for Neolithic habitation.

The surface assemblages can be dated to around 7500–6000 BP, as the tools all belong typologically to the so-called "Arabian Bifacial Tradition" (ABT) or more closely to the "Rub al-Khali Neolithite", as first defined by Christopher Edens (1982). Unusual tool types within the assemblage, for example the concave side scrapers, can provide techno-typological comparisons with other Neolithic assemblages within the Rub al-Khali.
al-Khâli. Both assemblages, with their emphasis on weaponry (arrowheads and large projectile points) rather than domestic tools, suggest the scatter results from temporary or seasonal camps. Future work will focus on the spatial distribution ofdebitage and tools, as well as provide comparative analysis with other sites from the Rub al-Khâli.

The two shell beds found on the surface of KHM may have originally been produced by a community exploiting coastal resources, and brought into the desert interior via a trade network as part of seasonal migration. Marine shells have been recorded at a number of Neolithic sites in the Rub al-Khâli and various parts of inland Arabia. Whether the beads were produced at coastal workshops or were simply carried as whole shells into the interior and then worked, is not clear. Archaeological evidence demonstrates that a good number of the beads could have been produced in coastal workshops.

Identical examples of both types of bead are known from the Neolithic cemetery of Jebel Al-BuHâs 18, located in Sharjah emirate in the UAE (Kiesewetter, Uerpmann & Jasim 2000: 140, fig. 3; 144, fig. 10 and table 1). Grave EE contained a 30-35-year-old woman with a loincloth around her waist decorated with many Ancilla cf. Jarsiana shells (2000: 142). Gravels FG, GG, AL, AK and GI, contained five adults buried close together, partly in each other's arms. Pierced Ancilla shells were used as decoration on the headband of a man (grave FO). The man also had on his right wrist a bracelet with disc-beads, alternating black and white tubular beads, and pierced Ancilla shells, similar to the ones found on the other two women and men. Grave GI was also adorned with Ancilla shells, which probably are the remains of cloth decoration (2000: 142). More than 24,000 objects of presumed ornamental purpose were recorded during the Buhais excavations, the largest assemblage of Neolithic jewellery known from the region (Beauclair, Jasim & Uerpmann 2006).

The material and environmental context to these sites? Recent work on deflated megalicinal sand dunes at Awatif in Ras Al-Khaimah, showed that around 10,000 years ago these dunes were accumulated very rapidly, caused by winds blowing from south-west to north-east (Goudie et al. 2000: 1011). Cores from the Arabian Sea suggest changes in the Indian Ocean Monsoon resulted in higher precipitation over the Arabian Peninsula between 10,000 and 6000 years ago (Preussler, Radies & Matter 2002). A shift in the Inner Tropical Convergence Zone (ITCZ) may have resulted in the development of lacustrine, arid, and steppe conditions, with vegetation more akin to savannah (Van Campo, Duplessy & Ros-sigol-Strick 1982) across parts of the Rub al-Khâli. Former lacustrine deposits in the Ayn al-Faydah region (Gebel et al. 1989) seem to confirm this, with sediments from a dry interdunal lake basin at Awatif also indicating grassland with a strong woody element between 8300 and 6600 cal. yr BP (Parker et al. 2004: 673). Radio-carbon dating of fossil lake beds in the Rub al-Khâli confirms lakes lasting from a few years to several hundred years between 10,000 and 6000 cal. yr BP (McClure 1988). Terracing within some of the interior plains may reflect the former shorelines of these ancient lakes (United Arab Emirates University 1993; Gienicke 2005: 142, 144, fig. 9/27), which may have also held water, at least seasonally, during humid periods.

The time period of 9500 cal. yr. BP for dune development at Kharimat Khor Al-Manâhil fits well with the expected age range, as does the lowestry grysbank sand, which provided dates of around 12,000 years (possibly corresponding to the Younger Dryas in Europe). However, the second period of around 8800 years ago for the dune mobilization at Khor Al-Manâhil is well into the climatic optimum, when precipitation should be sufficient to prevent aeolian dune reactivation.

This period corresponds with a rapid cooling and drying of parts of the earth's climate system at around 8200 BP, as recorded in temperature records derived from central Greenland ice cores (Rohling & Pälike 2005). High-resolution speleotherm records from Qumf Cave in Dhofar suggests this dune remobilization may coincide with a temporary weakening of the monsoon during around 8400-8200 cal. yr BP (Flettmann et al. 2003). The flint assemblages post-date this event, once vegetation cover and palaeosoils had become established on the cemented aeolian carbonate dune sands. At Awatif in Ras Al-Khaimah the dune megadicars are overlain by patterns caused by north-west "Shamal" winds (Parker et al. 2000: 1001), with a shift towards the development of the Indian Ocean Monsoon resulted in higher precipitation over the Arabian Peninsula between 10,000 and 6000 years ago (Preussler, Radies & Matter 2002). A shift in the Inner Tropical Convergence Zone (ITCZ) may have resulted in the development of lacustrine, arid, and steppe conditions, with vegetation more akin to savannah (Van Campo, Duplessy & Ros-sigol-Strick 1982) across parts of the Rub al-Khâli. Former lacustrine deposits in the Ayn al-Faydah region (Gebel et al. 1989) seem to confirm this, with sediments from a dry interdunal lake basin at Awatif also indicating grassland with a strong woody element between 8300 and 6600 cal. yr BP (Parker et al. 2004: 673). Radio-carbon dating of fossil lake beds in the Rub al-Khâli confirms lakes lasting from a few years to several hundred years between 10,000 and 6000 cal. yr BP (McClure 1988). Terracing within some of the interior plains may reflect the former shorelines of these ancient lakes (United Arab Emirates University 1993; Gienicke 2005: 142, 144, fig. 9/27), which may have also held water, at least seasonally, during humid periods.
ners provide us with a terminus post quem for the debi-
tage at the two sites (less than 9500 years at Khairat
Khor al-Manahil and 8000 years at Khor al-Manahil).
As the overlying dunes provide a modern date, no ter-
minus ante quem for the assemblages can be deter-
mined. The dunes above the flint horizons at both sites
ranged from 0 ± 6 years ago to 35 ± 7 years ago and the
OSL dates clearly demonstrate the mobility of some of
the smaller-sized dunes in both areas, which seem less
stable than their larger counterparts.

An appreciation of the earth’s climate system during
the Holocene is key to understanding how nomadic
Neolithic communities exploited the Rub’ al-Khāli, and
how these groups responded to both minor fluctuations
and long-term environmental change; and how they devel-
oped under favourable lacustrine, savannah conditions,
and their response to gradual desertification. In such a
marginal environment minor fluctuations in the climate
must have had a major impact on resources, and it is no
surprise that flint assemblages are associated with lacus-
trine deposits. Furthermore, fluctuations in the climate
may have caused enforced migration of communities
living in the Rub’ al-Khāli, not only within the early
Holocene, but possibly during other periods. Clearly
climate was a crucial mechanism in determining the
level of resources available to Neolithic groups in the
Rub’ al-Khāli. Further work still has to resolve funda-
mental questions regarding migration patterns, and how
these communities adapted to the onset of a hyper-arid
environment. Future seasons of the project will be con-
ducted under the auspices of the new Abu Dhabi Au-
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University of Birmingham (UK) as a collaborating part-
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2004 and 2006 as a joint project between the Abu Dhabi
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Department of Antiquities and Tourism. The following
staff from the Department of Antiquities and Tourism
assisted during the fieldwork: Ahmed Abdullah Elhaj,
Jaber Al-Mirri, and Díaz’edidn Tawalbeh. The depart-
ment also provided Sami, our camp cook. The following
additional staff from ADIAS assisted with the work:
Phil Glover volunteered for the entire 2006 season, and
Suzan al-Mutawaa and Roxana Linklater-McLennan
joined the team for the final week of the 2006 season.
Hamed Al-Mutairi from the Department of Museums &
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beginning of the 2006 season. Particular thanks go to
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