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Middle to Late Pleistocene human habitation in the western Nefud Desert, Saudi Arabia

Eleanor M.L. Scerri [a, *], Paul S. Breeze [b], Ash Parton [c], Huw S. Groucutt [c], Tom S. White [c], Christopher Stimpson [c], Laine Clark-Balzan [c], Richard Jennings [c], Abdullah Alsharekh [d], Michael D. Petraglia [c]

[a] PACEA, University of Bordeaux, UMR 5199 Bâtiment B8, Allee Geoffrey St Hilaire, CS 50023, 33615 Pessac Cedex, France
[b] Department of Geography, King's College London, K4U.06 Strand Campus, London WC2R 2LS, United Kingdom
[c] School of Archaeology, Research Laboratory for Archaeology and the History of Art, University of Oxford, 28 New Barnett House, Little Clarendon Street, Oxford OX1 2HU, United Kingdom
[d] Department of Archaeology, King Saud University, P.O. Box 2627, Riyadh 12372, Saudi Arabia

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ABSTRACT

The Nefud Desert is crucial for resolving debates concerning hominin demography and behaviour in the Saharo-Arabian belt. Situated at the interface between the Mediterranean Westerlies and African Monsoonal climate systems, the Nefud lies at the centre of the arid zone crossed by *Homo sapiens* dispersing into Eurasia and the edges of the southernmost known extent of the Neanderthal range. In 2013, the Palaeodeserts Project conducted an intensive survey of the western Nefud, to: (1) evaluate Pleistocene population dynamics in this important region of the Saharo-Arabian belt and (2) contribute towards understanding early modern human range expansions and interactions between different hominin species. Thirteen Lower and Middle Palaeolithic sites were discovered in association with palaeolake basins. One of the sites, T'is al Ghadah, may feature the earliest Middle Palaeolithic assemblage of Arabia. Preliminary analyses show that the Lower and Middle Palaeolithic sites discovered display diverse technological characteristics, indicating that the Nefud was important for population turnovers and exchanges throughout the Pleistocene. Periodic environmental amelioration appears to have attracted hominin incursions into the region, and subsequent ephemeral occupations structured around lakes and, to a lesser extent, raw material sources. However, differences between the Lower and Middle Palaeolithic sites are indicative of greater mobility during the later Pleistocene. A rarity of formal tools, but strong similarities in lithic production techniques, are also suggestive of demographic affinities across the Nefud during the Pleistocene, and perhaps beyond. These preliminary results support the view that the Arabian Peninsula was a critically important region of southwest Asia during the Late Pleistocene, in which demographic responses to climatic amelioration may have structured connectivity across the Saharo-Arabian belt, the Levant and as far as India.

1. Introduction

Southwest Asia is a critical locus for understanding dispersals out of Africa during the Pleistocene, as well as the interactions between different hominin populations precipitated by these processes (e.g., Shea, 2003, 2013; Rose and Petraglia, 2009; Green et al., 2010). The Levant in particular has yielded a rich array of Palaeolithic sites and fossil remains (see e.g., Shea, 2003, 2013; Hovers, 2009 for recent summaries) which have played a central role in constraining the chronology of hominin dispersals and the southern spatial extent of the Neanderthal range. However, because these data still represent information from an extremely small area of Southwest Asia, the extent of population continuity, exchange and replacement in this region during the Middle and Late Pleistocene is difficult to ascertain.

* Corresponding author.
E-mail addresses: eleanor.scerri@u-bordeaux.fr (E.M.L. Scerri), paul.breeze@kcl.ac.uk (P.S. Breeze), ash.parton@rlaha.ox.ac.uk (A. Parton), huw.groucutt@rlaha.ox.ac.uk (H.S. Groucutt), tom.white@rlaha.ox.ac.uk (T.S. White), christopher.stimpson@rlaha.ox.ac.uk (C. Stimpson), laine.clark-balzan@rlaha.ox.ac.uk (L. Clark-Balzan), richard.jennings@rlaha.ox.ac.uk (R. Jennings), alsharekh@hotmail.com (A. Alsharekh), michael.petraglia@rlaha.ox.ac.uk (M.D. Petraglia).

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Recent research conducted in the Arabian Peninsula has significant potential to investigate the degree of demographic complexity in the Palaeolithic of Southwest Asia (Rose and Petraglia, 2009; Groucutt and Petraglia, 2012, 2014; Groucutt et al., this issue). Stratified sites found in northern Arabia may represent a southerly incursion of Neanderthals from the Levant and/or further evidence for dispersing modern humans during periods such as Marine Isotope Stage 5 (MIS 5, ~130–75 thousand years ago or ka) (Petraglia et al., 2011, 2012; Scerri et al., in press). In southern Arabia, the site of Jebel Faya has been argued to reflect a 'southern route' dispersal out of East Africa (Armitage et al., 2011), while a series of 'Nubian Complex' sites across the Peninsula may represent a dispersal of northeast Africans into the Peninsula, also during MIS 5 (e.g. Crassard and Hilbert, 2013).

While these discoveries have catalysed interest in the Arabian Palaeolithic, its characterization is in its early stages. Many new sites discovered have yielded new technological characteristics, which may represent dispersals from elsewhere and a subsequent variety of autochthonous developments (see Groucutt and Petraglia, 2012; Scerri et al., in press for reviews). Verifying and linking such demographic processes are hampered by low chronological control due to current low numbers of stratified, dateable primary contexts. The current lack of pre-Holocene hominin fossils from the region also makes it impossible to make any definitive statements as to the taxonomic nature of the hominins responsible for the archaeological sites discovered, particularly during the Late Pleistocene. Pleistocene sites in the Arabian Peninsula are widely dispersed across a land mass stretching over three million square kilometres, which has significantly problematized the provision of a framework for understanding technological variation across the Arabian Palaeolithic and its relationship with Africa and the rest of Southwest Asia.

In order to make sense of the technological variability apparent in the Arabian Palaeolithic and address its place in the Palaeolithic of Southwest Asia, the Palaeodeserts Project developed a programme of interdisciplinary research in the southwestern Nefud Desert. The programme of research had two key aims: to (1) understand the technological characteristics of the Lower and Middle Palaeolithic and their relation to the landscape in a geomorphologically and ecologically bounded region, and (2) strategically extend fieldwork southwards from the borders of the relatively well investigated Levant. Due to its geographic situation, the Nefud Desert shares a number of ecological features with the southern Levant, such as flora, fauna and other biogeographic features (Harrison and Bates, 1991; Stimpson et al., this issue). Research indicates that this may also have been the case in the Pleistocene, with significant water bodies such as the Mudawwara palaeolake (Petit-Maire et al., 2010) spanning what is presently southern Jordan and northern Saudi Arabia. Critically, the Nefud Desert also provides important information regarding the nature and extent of climatic variability within the Arabian interior, where stratified, dated Middle Palaeolithic sites have been found (Petraglia et al., 2012).

Here, we present the discoveries and preliminary analyses of our southwestern Nefud Desert survey. The survey was conducted in 2013 and led to the identification of new lithic assemblages at two sites which have chronometric age estimates (Rosenberg et al., 2013) and the discovery of several new Lower and Middle Palaeolithic sites. We report descriptions of the techno-typological assignations for two dated Middle Palaeolithic sites, including one very early Middle Palaeolithic site, together with descriptions of the further 11 sites located, which are considered in the light of their similarities to the dated sites. A discussion of the associated multiproxy studies of both local and regional geomorphology and sedimentary records is subsequently presented, contributing towards some preliminary interpretations of landscape use in the Middle and Late Pleistocene of the Nefud Desert.

2. The Nefud Desert

The Nefud Desert is located north of the Arabian shield at ~27°–30°N, ~38°–44°E and is the northernmost sand sea, or erg in Arabia. The Nefud covers an area of ~72,000 km^2 (Goudie, 2002) and is mainly comprised of high (~120 m) east–west longitudinal dunes and barchanoid dunes overlain by smaller traverse and branching dunes. Despite the current, hyperarid conditions, relict lacustrine sediments are exposed in numerous interdunal areas, in particular those nearer the western and southern peripheries of the sand sea. Such deposits are indicative of wetter periods in Arabia's history, when rainfall incursions transformed the arid desert interior into savannah grasslands featuring many large freshwater lakes. Understanding the timing and character of these climatic amelioration events is critical for determining the context of Palaeolithic archaeology in the Arabian Peninsula.

Numerous palaeoenvironmental studies have demonstrated several periods of past environmental amelioration in the Nefud during the Pleistocene. These periods of environmental amelioration are typically associated with interglacial periods. Early palaeoclimatic studies (i.e. Whitney and Gettings, 1982; Whitney, 1983; Whitney et al., 1983) suggested that lake formation within the Nefud occurred during the latter part of Marine Isotope Stage 3 (MIS 3, ca. 40–25 ka, although as discussed below, this is based on problematic radiocarbon dates) and during the early Holocene wet phase (ca. 10–6 ka). More recent studies now suggest that lake formation occurred during interglacial periods associated with MIS 11 (ca. 410 ka), MIS 9 (ca. 320 ka), MIS 7 (ca. 200 ka) and MIS 5e (ca. 125 ka) (Petraglia et al., 2011; Rosenberg et al., 2013). Utilising a detailed suite of optically stimulated luminescence (OSL) dates from a number of lacustrine archives in the eastern and western Nefud, Rosenberg et al. (2013) suggested that a single perennial lake covered the entire southwestern Nefud during MIS 9 (~320 ka) and that during MIS 7 and MIS 5, lake formation was restricted to smaller interdunal water bodies. The discrepancy between ages of lake formation in recent and earlier studies (the latter being based on radiocarbon chronologies) is explained as the result of contamination with younger ^{14}C from the precipitation of CO_2 dissolved in meteoric waters, which has produced younger age ranges (Rosenberg et al., 2013). Palaeohydrological analyses from multispectral satellite data also indicate the presence of hundreds of palaeolakes across the southwestern Nefud, in both interdune depressions and structurally defined closed basins (Breeze et al., this issue).

Taken at face value, these findings indicate a predominantly arid climate, punctuated by brief but dramatic landscape changes every ~100 ka. However, recent studies have demonstrated that the climate of Arabia is more complex than what simplistic wet/dry indicators suggest (Parton et al., this issue). Findings from central and southern Arabia (Mclaren et al., 2009; Parton et al., 2013) have shown that humid periods in Arabia may also occur during mid-high latitude glacial periods, while the overall timing of pluvials exhibits a periodicity in line with insolation maxima every ~23 ka (Parton et al., this issue). This is demonstrated by recent findings from southern Arabia, which provide evidence of Middle Palaeolithic assemblages dated to ca. 55 ka (Delagnes et al., 2012), and indicates that dispersals and refugial population continuity/expansions may not be limited to interglacials. Indeed, prior to the onset of intensified agriculture, large oasis basins in the southern

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Nefud such as Tayma and Jubbah had surface and near-surface groundwater until recent times (Garrard et al., 1981). The dated archaeological sites discussed in the text are summarised in Table 1.

Table 1
Dated sites mentioned in the text.

Site name	Date	References
Khall Amayshan 1 (Saudi Arabia)	117 ± 8 and 99 ± 7 ka	Rosenberg et al. (2013)
Jebel Qattar 1 (Jubbah)	75 ± 5 ka	Petraglia et al. (2011)
Shi'bat Dihya 1 (Yemen)	~55 ka	Delagnes et al. (2012)
T'is al Ghadah (Saudi Arabia)	318 ± 24 ka and 328 ± 26 ka	Rosenberg et al. (2013)

Notwithstanding this emerging climatic complexity, the predominant source of precipitation, during either glacial or interglacial periods in Arabia, remains unresolved. The Nefud in particular, may have been a cross-over between different atmospheric systems, with rainfall sourced from Mediterranean (westerly), African/Indian Monsoon and Red Sea regions. Previously, precipitation incursions into the Arabian interior have been viewed within the context of monsoon and mid latitude westerly systems. During glacials, Mediterranean-sourced rainfall is enhanced, with cyclonic depressions tracking down through the Levant to produce increased humidity and a north–south precipitation gradient (Rosenberg et al., 2013) extending to the northern Negev (e.g., Vaks et al., 2010). Conversely, northward shifts in the Intertropical Convergence Zone (ITCZ) during interglacial periods deliver monsoon-sourced rainfall across the Arabian Peninsula, with a south-north precipitation gradient terminating at the southern Negev. Until recently, the source of monsoon rainfall was considered to be the Indian Ocean. However, recent studies have suggested that the East African monsoon is the key driver of moisture throughout central and more northerly parts of the peninsula (Herold and Lohmann, 2009; Jennings et al., this issue), with the advancement of Red Sea troughs into central regions of Arabia also playing a potentially important role.

Understanding of the effects of such temporal-spatial climatic variability on mammalian dispersals throughout the Middle and Late Pleistocene is still at a preliminary stage (see e.g., Drake et al., 2013). Overlap between increased humidity in the Levant during periods such as MIS 7 and MIS 6, resulted in lake formation in southern Jordan at Mudawwara (Petit-Maire et al., 2010). During interglacial periods, such as MIS 7 and MIS 5, lake formation in the Nefud was broadly synchronous with each other (Petraglia et al., 2011; Rosenberg et al., 2013). During these periods, speleothem growth is documented in the central/northern Levant, together with the formation of sapropels in the eastern Mediterranean and the Mudawwara palaeolake. The synchronicity of these features indicates that at times, northwestern regions of the Arabian Peninsula may have been in receipt of both African Monsoon and Mediterranean rainfall. A good example of this is MIS 5, in which all of the aforementioned records display concordant humidity increases. As such, peak interglacials represent the most likely periods in which faunal expansions along a northern route would have occurred.

The impoverished Quaternary vertebrate record from Saudi Arabia provides further evidence for the periodic development of productive grassland environments and the presence of water bodies and increased productivity during the Pleistocene in areas that are now hyper-arid. Thomas et al. (1998) described fossil assemblages of purportedly Early Pleistocene age from the southern Nefud desert, although a late Middle Pleistocene age estimate has now been obtained (Rosenberg et al., 2013, see Table 1). Further south, investigation of palaeolake deposits in the Rub' al Khali yielded assemblages of Pleistocene and Holocene material, although these are not dated (McClure, 1984). Most of the species represented in both regions are indicative of productive grassland habitats, and the occurrence of hippopotamus indicates the presence of substantial bodies of standing water (see also discussion Stimpson et al., this issue).

Despite the limited faunal and palaeoenvironmental records, the prevalence of arid-hyperarid conditions throughout the Nefud suggests that at least the major demographic shifts would have been largely restricted to interglacial periods. This hypothesis is supported by the close association of dated Middle Palaeolithic sites in the Nefud with well-established humid phases during MIS 7 and MIS 5 (Petraglia et al., 2011, 2012). However, it should be noted that palaeoclimatic records for these regions only cover the last ~400 ka and therefore do not provide an environmental framework for most of the Lower Palaeolithic.

3. The sites

Survey during the November 2013 field season commenced with a series of reconnaissance investigations of three areas of the Nefud desert (Fig. 1) with prior reported fossil and lacustrine sites (Thomas et al., 1998; Rosenberg et al., 2013). These investigations led to the discovery of five archaeological sites in the vicinity of the village of Khall Amayshan (KAM 1–4 and 6), two archaeological sites in the vicinity of Al Raba (RAB 3–4), three archaeological sites at Khab Mussayib (KM 1–2), as well as the individual archaeological sites within the T'is al Ghadah basin (TAG 1), a wildlife Reserve near Tayma and HIS 1, an archaeological site situated along a line of jibal (i.e., rocky hills) in the Munasafiyah basin (Fig. 1). These are detailed in turn, beginning with TAG 1 and KAM 1, which are the only currently chronometrically dated sites (Table 1).

3.1. T'is al Ghadah

T'is al Ghadah (TAG 1) is a palaeolake basin featuring numerous lithic and well preserved fossil fauna surface scatters. Previous studies at T'is al Ghadah have suggested that the lake at this site was of considerable size, and likely perennial (Thomas et al., 1998; Rosenberg et al., 2013). The palaeolake basin consists of a series of relict surfaces and features indicative of changing climatic conditions and are described in detail elsewhere (see Stimpson et al., this issue). Lithic scatters were found in low-density, but discrete concentrations on the surface of the basin, but there is currently no evidence conclusively supporting an association between the fossils preserved and found stratified at this site and the archaeology. Although an Early Pleistocene age was suggested by Thomas et al. (1998) based on the vertebrate fossils collected from the site, Rosenberg et al. (2013) have dated the palaeolake formation and fossil deposition at this site to MIS 9 (Table 1). A sample from the white sand underlying the green silty sand and marls returned similar ages via both TT-OSL and OSL techniques (318 ± 24 ka and 328 ± 26 ka, respectively). The site, however, is more complex than the simple stratigraphy indicated by the Rosenberg et al., and it is possible that more than one phase of *in situ* fossil deposition has occurred (see Stimpson et al., this issue). If the archaeological material found at TAG 1 also dates to this period, it represents the earliest Middle Palaeolithic so far identified in the region.

3.2. Khall Amayshan 1–4 and 6

The Khall Amayshan (KAM) sites are a series of lacustrine deposits situated within interdunal depressions in the north of the survey area (Fig. 1).

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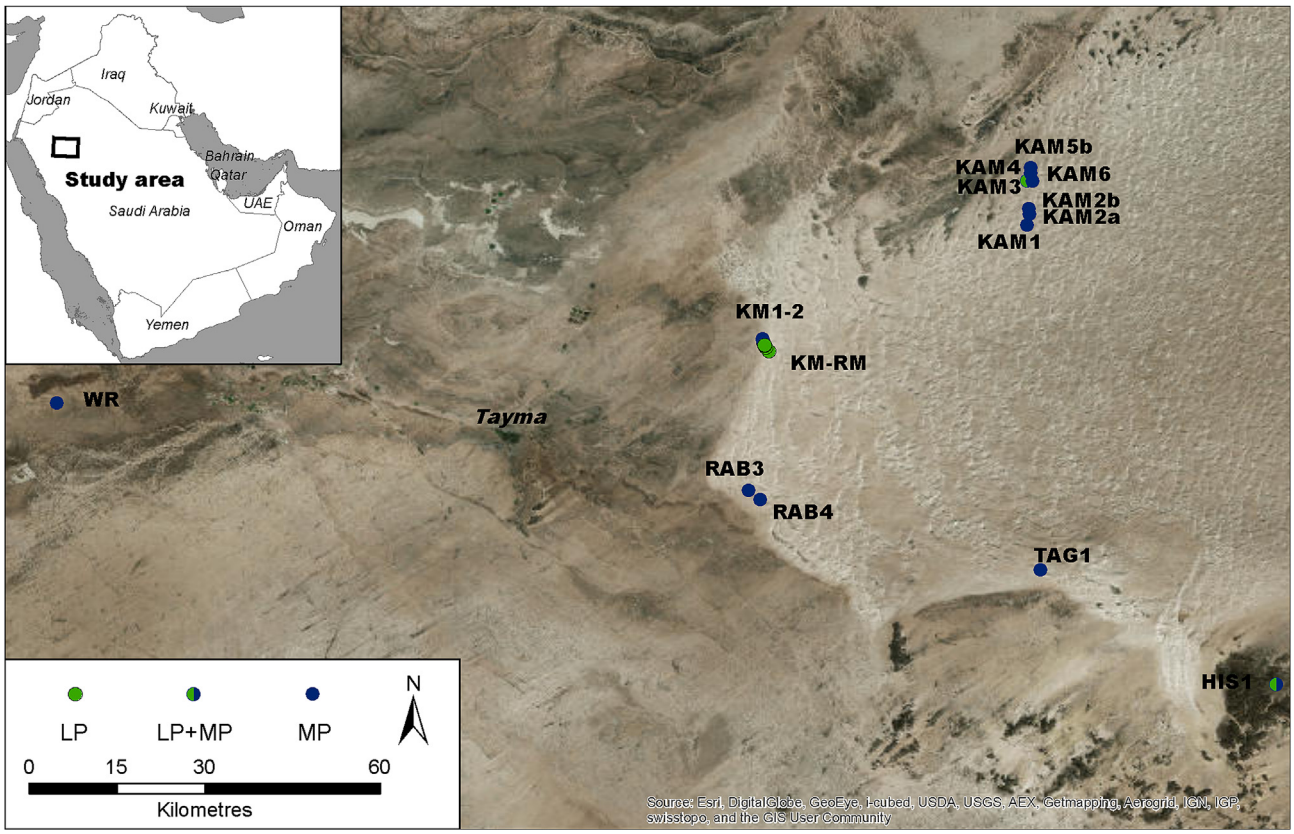

Fig. 1. Map of the Middle and Upper Palaeolithic sites found during the Palaeodeserts 2014 survey of the southwestern Nefud. KAM 1–5 refer to Khall Amayshan sites; KM 1–2 and KM-RM refer to the sites at Khabb Musayyib; TAG 1 refers to Ta'is al Ghadah; HIS 1 refers to a site along a line of jibal; RAB 3 and 4 refer to the Al Raba sites; WR refers to the Wildlife Reserve site.

3.2.1. Khall Amayshan 1

Khall Amayshan 1 (KAM 1) was discovered by Thomas et al. (1998) and chronometrically dated by Rosenberg et al. (2013). The site constitutes a circular relict lake feature with a basinal topography, which is elevated up to 2.5 m above the surrounding basin floor (Fig. 2). The preserved lake sediments are situated ~10 m from the west-facing lee side of a large barchan dune, whilst smaller branching linear dunes bound the northern and southern extents, and interfinger with eroded lake sediments to the east. The depth of the feature is laterally variable and the whole sequence is inclined steeply at its northwestern periphery. The distinct morphology of the relict lakebed is likely representative of an interdunal lake. The surface of the feature is covered in highly weathered and indurated dark grey marl fragments, whilst small mounds of calcareous silts underlain by reddish medium sands are preserved across the surface of the feature. The surface of the feature was also covered in medium–low density lithic scatters and faunal fossils. In comparison to TAG, the fossils found at KAM 1 were very poorly preserved.

The sedimentary sequence at KAM 1 demonstrates a number of climatically driven lake water changes during MIS 5. Previous research at the site (Rosenberg et al., 2013) has yielded ages of 117 ± 8 and 99 ± 7 ka for the lake formation: as these dates are inverted, the most parsimonious estimate lies somewhere between them. The authors attribute lake formation to MIS 5e, based on the suggestion that the Last Interglacial was the 'wettest' period and therefore most likely to be linked to extensive lake formations.

A new sedimentary sequence was logged at the deepest exposure of the lake beds, which comprised 3.24 m of interstratified lake marls, silts and sands, indicative of lake level changes. Diatomite analyses (Rosenberg et al., 2013) indicate a dominance of freshwater species *Fragilaria brevistriata*, *Fragilaria construens*, *Fragilaria construens* v. venter, *Aulacoseira granulata* and, in the upper part, *Cyclotella ocellata*, with the sequence showing a gradual change from periphytic taxa (i.e., tiny organisms living on the surfaces of rooted, aquatic plants) in the lowermost units, to planktonic (i.e., living in the water column) and facultatively planktonic taxa (i.e., capable of living in benthic, or bottom dwelling, habitats as well) in upper units. Such changes indicate a shift to deeper water conditions. Further analysis of gastropod samples extracted from the sequence during the current fieldwork, will provide additional palaeoenvironmental data for the site. Additionally, OSL samples extracted from cemented silts situated on the surface of the relict basin may provide evidence for a further phase of lacustrine sedimentation within the basin.

A combined systematic collection of all surface archaeological and fossil materials was performed across the site using a Differential Global Positioning System (DGPS). Survey transects of 2 m spacing were walked by a team of surveyors, with all lithic materials observed collected and their positions recorded with the DGPS.

3.2.2. Khall Amayshan 2

Khall Amayshan 2 (KAM 2) consisted of a small area of diatomite situated on the lee of a barchan dune. Two handaxes in a very poor condition were found at this site, and not collected.

3.2.3. Khall Amayshan 3

Khall Amayshan 3 (KAM 3) consisted of a small area of diatomite situated on the lee of a barchan dune. Unlike KAM 1, the deposits at

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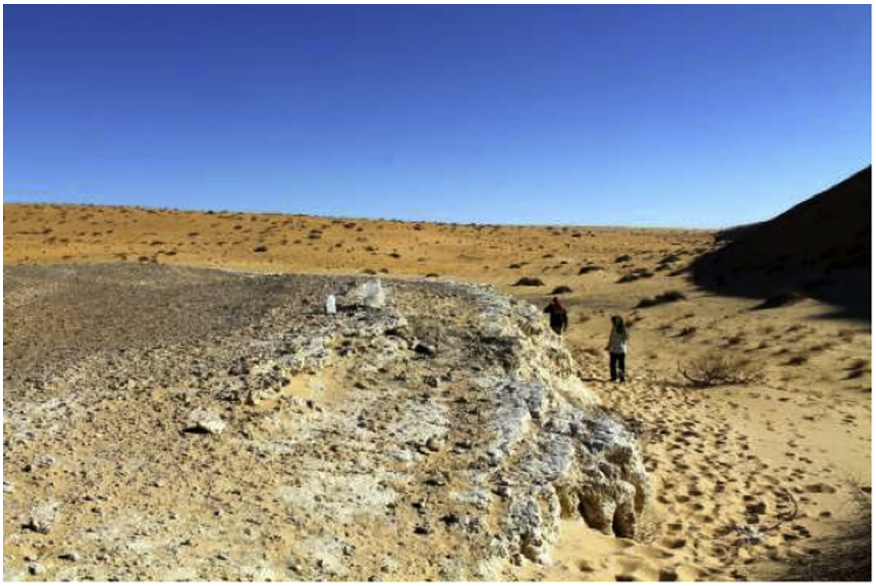

Fig. 2. Photo showing exposed lakebed and location of the sampled section at KAM 1. Photograph by P. Breeze.

KAM 3 were largely eroded, except for a small raised feature at the northern end which was sampled for micromorphology. A small number of Lower Palaeolithic artefacts were found at this site, which were left in the field.

3.2.4. Khall Amayshan 4

Khall Amayshan 4 (KAM 4) comprises four relict lake deposits associated with Lower and Middle Palaeolithic archaeology. The relict lake beds are situated within the basinal lee of a large barchan dune and elevated up to 10 m above the basin floor. Smaller branching dunes extend eastwards at the northern and southern end of the basin, whilst relict lake deposits interfinger with aeolian sands at the eastern periphery of the interdune. Each lake sedimentary sequence was excavated and logged in the field, with sedimentary and OSL samples retrieved for further laboratory analysis. Survey at Khall Amayshan 4 consisted of systematic lithic collection across the interdune depression using the DGPS system. In excess of 1500 lithic finds were recovered during this process. KAM 4 is currently under detailed analysis. However, initial results of the artefact and environmental analyses suggest that each lake is associated with a different chronological period.

3.2.5. Khall Amayshan 6

The site at KAM 6 is situated in the lee of a large barchan dune immediately adjacent to the large bounding barchan at KAM 4 (Fig. 1). The site comprises an exposed ~50 m N–S trending bed of finely laminated diatomite capped by gypsiferous marls with numerous crayfish burrow holes, indicative of shallow-water/shoreline conditions.

3.3. Khabb Musayyib 1 and 2

The Khabb Musayyib (KM) sites (Fig. 3) consist of a pair of relict indurated, grey, eroded and likely gypsiferous marl palaeolake deposits and a raw material site, located at the base of KM 2. The sites appear to have formed in a small interdunal depression, as they retain a barchan-like basin shape, and are preserved in inverted relief as elevated mounds ~10 m high above the basin floor. Immediately to the south is KM2 (Fig. 3), an extensive large relict lakeshore mound where a medium–low density scatter of Lower Palaeolithic artefacts was found. The artefacts mainly featured small and finely made handaxes, similar to those found at KAM 4. A potential chopper core was also located at this site, alongside Levallois cores and flakes. A raw material source comprising sandstone with quartz cobbles was found downslope nearby, where further artefacts were located.

3.4. Raba 3 and 4

Raba (RAB) 3 is a lake sediment site in the south-western area of the Nefud. The site consists of two adjacent interdunes, created by the large stable transverse barchanoid dunes to the south. These interdunes host an extensive area (~1.16 km^2) of indurated grey sediments, likely gypcrete, most strikingly defined by a ~150 m long ridge of these materials, trending northeast–southwest in the easternmost interdune and standing proud of the depression base by ~5 m. In the western interdune, a series of undulating shallow gypcrete mounds are positioned, overlooking a small playa of reworked gypcrete and silts in the depression core. Middle Palaeolithic lithic artefacts were recovered from this site. However it is not clear whether the lithics are also reworked or *in situ*.

RAB 4 is also defined by large areas of lake sediment, lying approximately 1.5 km to the southeast of RAB 3, in the same connected series of interdunes. In this basin, palaeolake sediments capped exposed white palaeodune sands, mirroring the situation seen elsewhere in the southern Nefud, such as TAG 1. The palaeodunes were evident as a ~3 m high cliff of poorly consolidated white sands on the western side of the lake sediment exposure, overlooking a series of eroded shallow mounds of white palaeodune material. The palaeodune material had not been armoured by the lake deposits further to the west. Indurated grey lake sediment, apparently gypcrete, covered an area of ~0.2 km^2 and was preserved as a rough pair of elevated, eroded mounds, with a gully eroded between these. At the base of this gully, a small Middle Palaeolithic assemblage was recovered.

3.5. Tayma Wildlife Reserve

The site is located along the southwest-facing flanks of a W–E trending escarpment to the north of Tayma. Bedrock material from

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Fig. 3. KM1b (mid ground) and KM2 (background, viewed from the top of KM1a, looking south-east. Photograph by P. Breeze.

the slopes of the escarpment has been heavily eroded by small incisional channels and transported southwards downslope towards a large, desiccated mud flat. Most of the lithics were found on the surfaces of point bar features and eroded bedrock ridges, created by downslope channel flow. The large mud flat to the south of the site is indicative of the seasonal activation of ephemeral channels in the region.

3.6. Hisan 'Irnan

Hisan 'Irnan (HIS) 1 formed a discrete scatter of Palaeolithic artefacts along the lower slopes of a line of jibal. Many examples of rock art were found amongst the jibal, however, the relatively low-density scatter of Lower and Middle Palaeolithic artefacts were only found in a small area at the base of the jibal.

4. Technological descriptions

Seven Lower Palaeolithic sites and six Middle Palaeolithic sites were discovered in the course of the survey, described above. Lower Palaeolithic artefacts were identified on the basis of lithic techno-typology and consisted primarily of Acheulean-type handaxes of various sizes. The smaller and finer examples of these handaxes were sometimes found in association with discoidal and Levallois core technology. Middle Palaeolithic artefacts consisted of core and flake technologies, featuring no handaxes. The Middle Palaeolithic flake technologies were predominantly Levallois in character. In addition to these techno-typological characteristics, differences were also noted in the degree of patination and weathering between the Lower and Middle Palaeolithic artefacts. Notwithstanding these variations, all the artefacts were rounded and weathered, and the handaxes were heavily so. The proximity of artefacts to raw material sites or the presence of refits indicates that these artefacts were overwhelmingly weathered *in situ*, following deflation. Each assemblage, together with its technological characteristics is described below.

4.1. Lower Palaeolithic sites

4.1.1. KAM 3

Six handaxes and four bifacial thinning flakes were located at KAM 3 and left on site. Four of the handaxes are shown in Fig. 4. The site appears to have been a small pond and may have attracted Acheulean hominins to the location.

4.1.2. KAM 4

KAM 4 featured several different phases of lake formation, as described above. An intensive programme of dating and geomorphological analysis is underway to date the lakes. Each lake was associated with different assemblages, ranging from Acheulean to Middle Palaeolithic type assemblages (Fig. 5). The total number of lithics collected from all the lakes was 1561. A detailed analysis of these lithics is also currently being conducted.

Preliminary analysis indicates that the Acheulean artefacts are associated with what appear to be the oldest lakes. The handaxes are often small and finely made ovates and triangular forms similar to those from the KM sites described below (Fig. 5, nos. 5–6). They are made on a variety of largely local raw material including various quartzites. The points are finely defined, as at the KM sites. Some of the handaxes and thinning flakes are made from a distinctive banded 'wood grain' rock that appears to weather easily. This raw material is currently of unknown provenance, but also found at the KM sites and at KAM 1 in a Middle Palaeolithic context.

Fig. 4. Acheulean Handaxes from KAM 3. The handaxes were heavily weathered and abraded, suggesting a long surface exposure. Photograph by E. Scerri.

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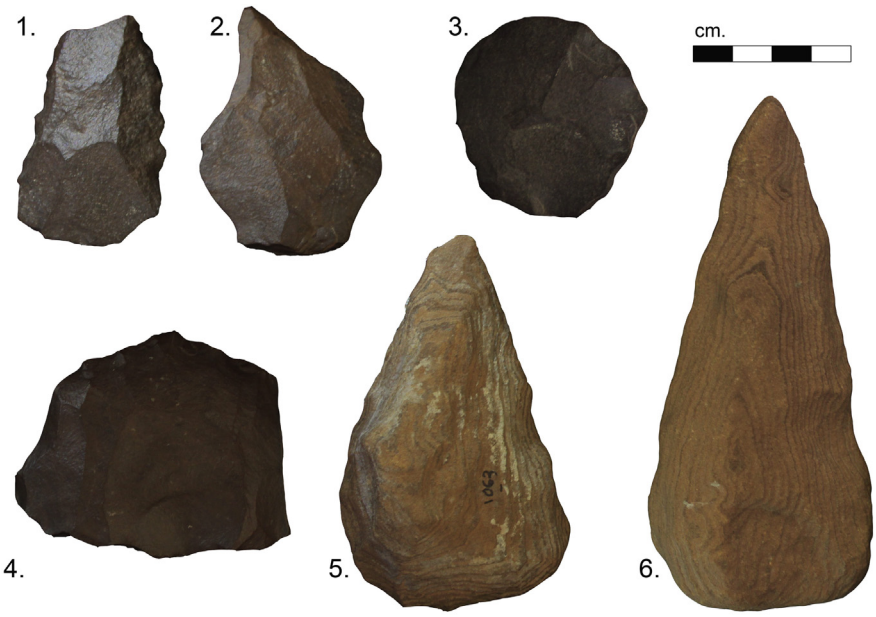

Fig. 5. Artefacts from KAM 4. 1: Side denticulated flake; 2: Point produced using the unidirectional convergent Levallois method; 3: Recurrent centripetal Levallois core; 4: Centripetally prepared preferential Levallois core; 5–6: Handaxes. Photograph by E. Scerri.

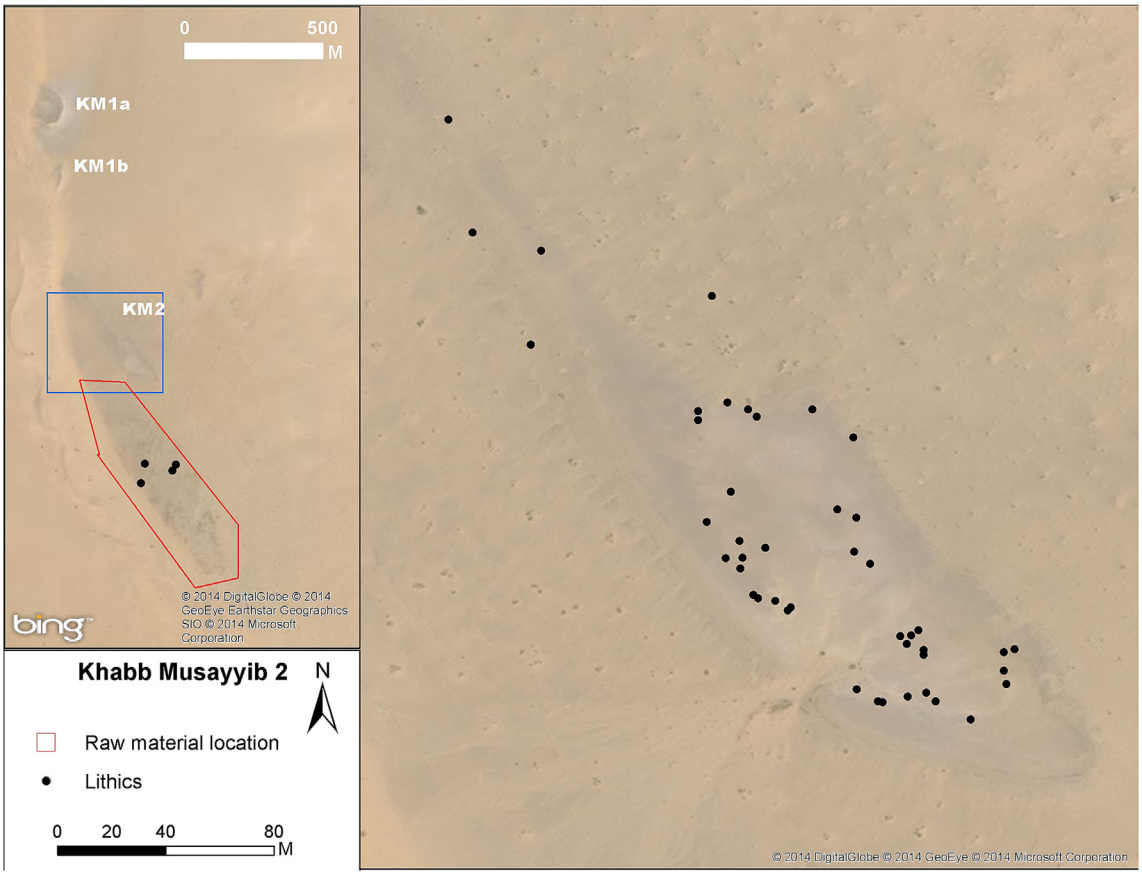

Fig. 6. Georeferenced artefacts collected from KM 2, together with the locations of the other sites in the KM cluster. Blue inset box on the overview map marks the area shown in detail on the right (KM 2). Each dot represents a single lithic. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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4.1.3. KAM 6

Several Levallois cores and debitage flakes were located at KAM 6. The raw material originated from a small raw material outcrop at the edge of the site. The low density scatter was left in the field.

4.1.4. KM 2 and raw material site

A total of 68 artefacts were collected from the KM sites. The artefacts are mostly made from local quartzite of varying grades of granularity, but one high grade chert handaxe was also found (Figs. 6–8, no. 3). The finer, quartzitic material originates from pebbles, while the coarser quartzitic sandstone originates from bedrock exposures. The raw materials appear to originate a few metres downslope, from and around a possible relict river bed, which features quartzite outcrops as well as transported, rounded quartzite cobbles. A total of 57 artefacts were collected from the relict lakeshore mound (Figs. 7 and 11 further artefacts were collected downslope at the raw material source location. We treat these two collections as separate since the collection from the mound appears to represent a homogenous group, while those from the raw material site appears to represent different time periods.

The artefacts collected from the mound overwhelmingly consist of bifaces (Fig. 7). The 40 bifaces are typically small and finely made, with an average length of 91 mm and a standard deviation of 23 mm. However, two size classes can be differentiated amongst the bifaces. A small group of 8 bifaces with a mean length of 76 mm (σ 14), mean width of 43 mm (σ 8 mm) and mean point angle of 47° (σ 7) and a larger group of 20 small bifaces with a mean length of 93 mm (σ 23 mm), mean width of 56 mm (σ 13.3) and a mean point angle of 51° (σ 10). The bifaces vary between ovate and triangular in form and are finely made, exhibiting a high degree of symmetry in their finished form. However, most of the bifaces appear to be unfinished, often featuring large masses, or build-ups, at the centre of the artefact which the knappers may have been unable to remove during the thinning process, and a lack of symmetry. These differences are illustrated in Fig. 7 (1–5) and suggest that many of the artefacts may have been abandoned. The bifaces appear to have been consistently refined from the tip margins first. These finely made, diminutive

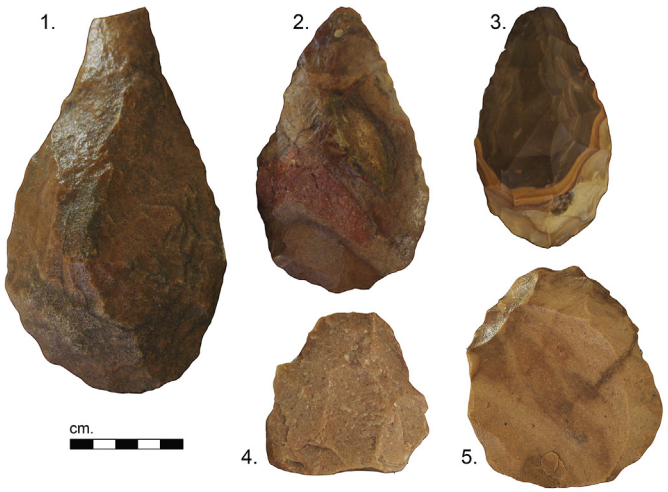

Fig. 8. Artefacts from the second site, KM-2. 1: Micoquian Handaxe with missing tip; 2–3: bifaces; 4–5: Levallois cores. Photograph by E. Scerri.

Fig. 9. Single platform blade cores from TAG showing unidirectional flaking direction, discovered at the base of the dated section. Photograph by E. Scerri.

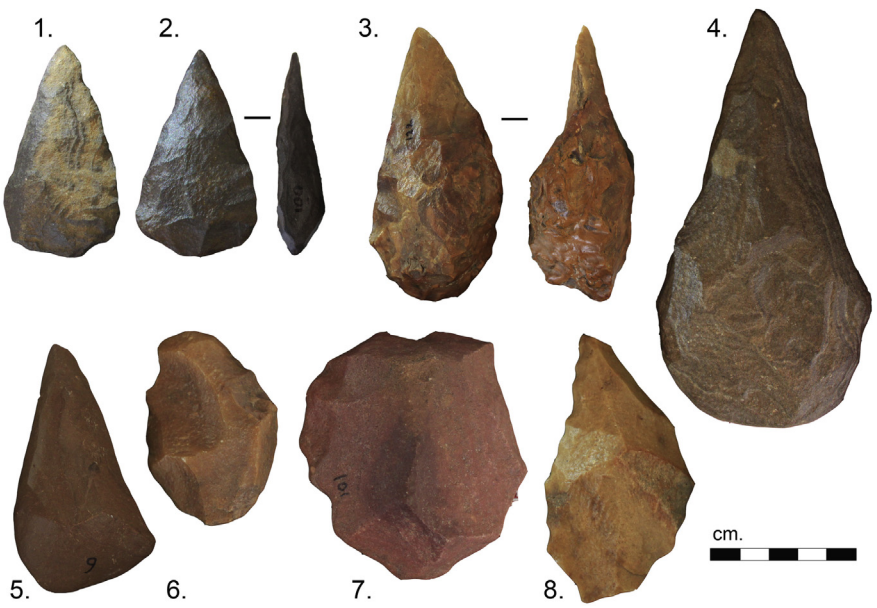

Fig. 7. 1–2: Small finished bifaces; 3: unfinished biface; 4: large finished biface; 5–6: unfished bifaces; 7: discoidal core; 8: denticulated flake. Photograph by E. Scerri.

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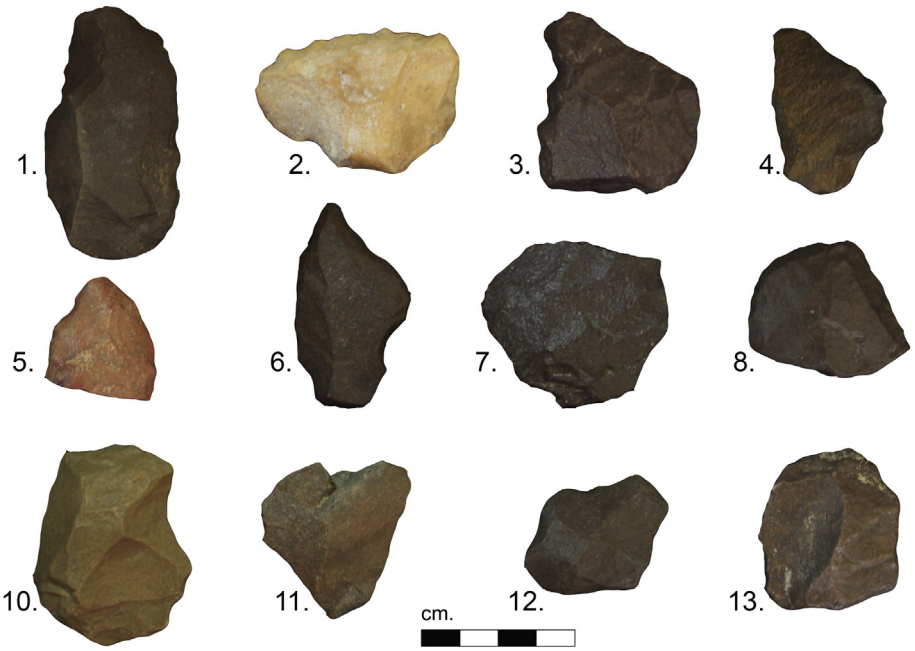

Fig. 10. Flakes from TAG. 1–5: Retouched flakes; 6: pointed flake; 7: Levallois flake; 8: Retouched flake; 10–13: Discoidal flakes. Photograph by E. Scerri.

bifaces may represent a new facies of the Lower Palaeolithic or a transitional phase between the Lower and Middle Palaeolithic. Similar artefacts were also found at KAM 4, but have not yet been reported at other sites in Arabia.

Six cores were also collected from the mound. These cores consist of a single discoidal core (Fig. 7, no. 6), two multiple platform cores and three single platform cores. The discoidal and multiple platform cores are all of a similar dimension (x weight

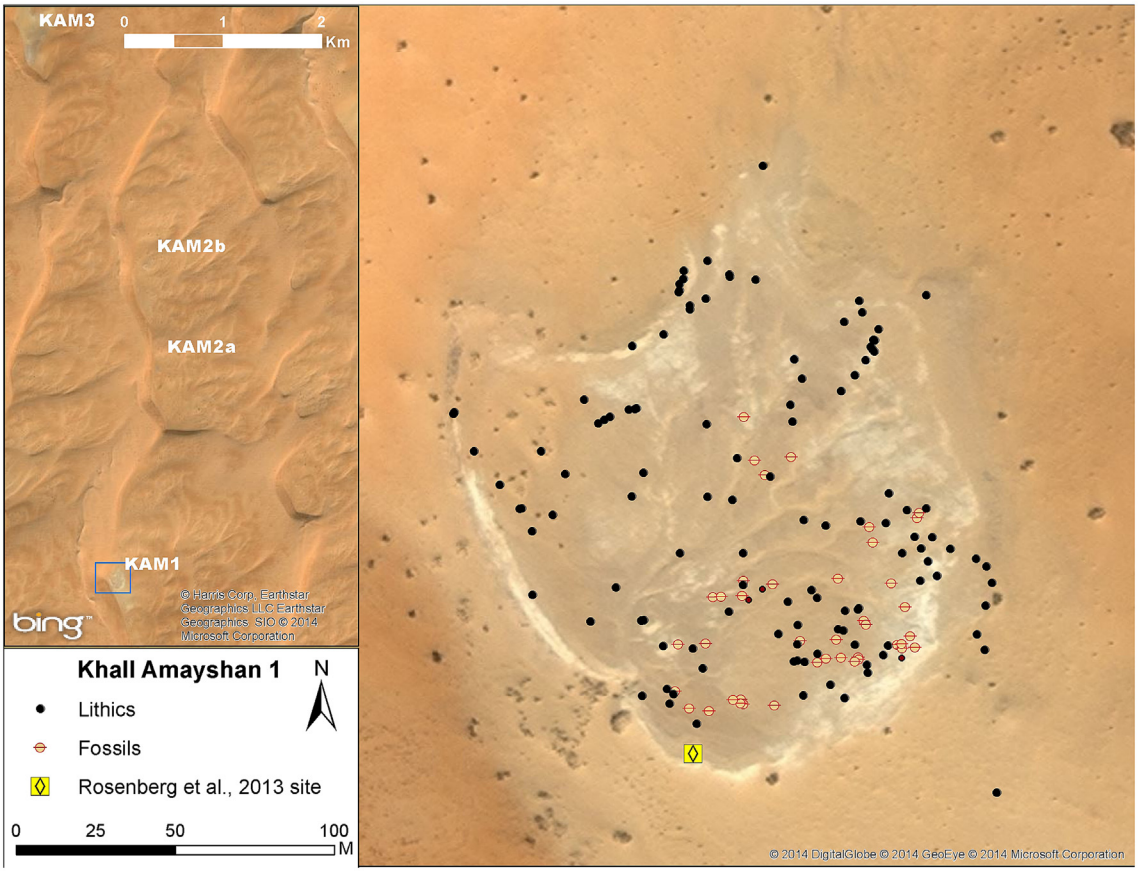

Fig. 11. Spatial organisation of the lithics discovered at KAM 1, also shown in relation to KAM 2. Each mark represents a single lithic or fossil fauna.

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303 g, σ 34 g), but the single platform cores are smaller (x weight 96 g, σ 36 g), perhaps reflecting the final stages of reduction before core exhaustion. Eight flakes were also collected, four of which were retouched. Two of the unretouched flakes are almost certainly bifacial thinning flakes, exhibiting a curved profile and a marginal, angled platform. Three of the retouched flakes feature denticulated retouch (Fig. 7, no. 7), while the fourth has been finely and regularly retouched along the margins. This final flake is of particular interest because it has been retouched along the left margin on the dorsal side, but retouched distally on the ventral side of the flake Fig. 7, no. 8).

The eleven artefacts recovered at the raw material site appear to be less homogenous and reflect a number of different time periods (Fig. 8). Six of the artefacts are finely made bifaces, similar to those found on the mound, apart from an exceptionally finely made chert biface (Fig. 8, no. 3), and a large micoquian handaxe (Fig. 8, no. 1). With the exception of one Levallois retouched flake, the remaining artefacts consist of two centripetally prepared preferential Levallois cores (Fig. 8, nos. 4–5), one recurrent centripetal Levallois core and a single platform core. One Neolithic arrowhead was also found at this site.

4.1.5. RAB sites

RAB 3 and RAB 4 consisted of large relict lake deposits, associated with scattered Lower and Middle Palaeolithic artefacts. All artefacts were left on site. The handaxes were large and did not resemble the finely made, small varieties found at KAM 4 and the KM sites.

4.1.6. HIS 1

HIS 1 was located in a discrete location along a line of jibal, which also featured numerous examples of rock art. The site consisted of mixed Lower and Middle Palaeolithic assemblages, featuring numerous handaxes, bifacial thinning flakes, Levallois cores and flakes and a large amount of flaking waste, including large débordant flakes, core tablets and other core management pieces. The artefacts were all made from a locally sourced dark ferruginous quartzite, similar to that found at most Middle Palaeolithic sites at Jubbah (Petraglia et al., 2011, 2012; Scerri et al., in press). Hominins were accessing scree like deposits of this raw material below and around the jibal. In places subsequent stream incision had produced partially armoured (i.e., pebbles, rocks or boulders) surfaces on which the Palaeolithic material is preserved.

4.2. Middle Palaeolithic sites

4.2.1. TAG 1

A total of 76 artefacts were collected from T'is al Ghadah (TAG 1), mainly from two different areas of the lake basin. The lithics are likely to be early Middle Palaeolithic in type, which formed two distinct scatters. The edge of the second scatter of lithics reached the base of a raised feature, where numerous fossils were found and where Rosenberg et al. (2013) obtained a Middle Pleistocene age estimate. The lithics in this location consisted of simple flakes, amorphous cores and two blade cores, which resemble early Middle Palaeolithic types (Fig. 9). The raw material from this scatter was also different from the dark quartzite found in the other two TAG 1 scatters, and is described as a light, amber coloured quartzite. The exact raw material source has not yet been located but is likely to be local, as it resembles the raw materials from many other sites in the Nefud, such as Jubbah (Petraglia et al., 2012). If these artefacts are associated with the dates provided by Rosenberg et al. (2013) (see Table 1), they would represent the earliest Middle Palaeolithic assemblage in Arabia.

The cores and core fragments found elsewhere at TAG 1 were of a small size. The eight complete cores weighed an average of 87 g (σ 54). Technologically, these cores were either single platform quartz cores or bifacial discoidal cores. One chert single platform core and a chert chunk were also found.

There were also a small number of retouched artefacts. These flakes were typically thick denticulated tools with steep retouch (Fig. 10, no. 1–3). One of the retouched tools was an extremely short and thick flake with distal denticulated retouch, perhaps in the final phase of edge rejuvenation (Fig. 10, no. 2). Another was a thin flake with bifacial marginal retouch (Fig. 10, no. 4). Finally, a single broken bifacial foliate was found (Fig. 10, no. 5).

Three Levallois flakes were also found. Two of these flakes had centripetal scar patterns, while the third was a unidirectional convergent point (Fig. 10, no. 6–7). A further three flake fragments may have also been produced using the Levallois method. Six of the flakes in the assemblage were laminar in their overall form and appear to be the result of simple blade cores and feature a steep central ridge. The remainder of the flakes, however, suggest discoidal flaking characteristics (Fig. 10, nos. 10–13).

The general character of the assemblage broadly indicates an early Middle Palaeolithic affiliation consisting of discoidal, single platform and blade cores producing fairly crude flakes. This notwithstanding, the assemblage is also very broadly reminiscent of the late Lower Palaeolithic Yabrudian of the Levant, with its lack of handaxes, extremely low frequency of Levallois and steeply retouched tools (Shea, 2013). However, given the broadly early Middle Palaeolithic character of the assemblage, a more realistic possibility is that the technological characteristics observed at TAG 1 emerged from a Yabrudian-like late Lower Palaeolithic industry in Arabia. The small size of the assemblage means that it is difficult to make any further definitive attributions at this stage, except that the general characteristics of the TAG 1 assemblage are compatible with the dates provided by Rosenberg et al. (2013).

4.2.2. KAM 1

A total of 106 lithic pieces was collected from KAM 1. The artefacts were collected from the small circular relict lake feature, and appeared to be bounded by this context (Fig. 11). The artefacts were mostly made from different types of quartzite, ranging between a dark quartzite and a light quartzite, and were all of good quality. While the differences between some of the quartzites may also be attributable to weathering differences, the technological analysis of the lithics indicates that the raw material differences may also reflect discrete flaking episodes. A few lithics and two small cores were also made from a distinctive chert and are likely to represent pieces flaked from the same nodule of raw material. One of the chert flakes refitted to a chert single platform core. One further flake was made from quartz. The provenance of these raw materials is not known. While the quartzites are likely to be largely local, the chert is not.

Amongst the lithics collected were 11 cores, including 2 conjoining ends of a core, and three core fragments. Of the 95 flakes collected, were thirteen complete Levallois flakes, including two conjoining pieces and one side-retouched flake. The assemblage also included three Levallois point tips, four distally broken Levallois flakes, two distally broken Levallois points and a laterally broken Levallois flake. A single conjoined débordant blade was also recovered, which may be Levallois in character (Fig. 12, no. 11). A further two flake fragments may also have pertained to Levallois flakes. In addition to the retouched Levallois flake, three non-Levallois flakes were retouched (Fig. 12, nos. 7–8). These non-Levallois flakes consisted of three complete flakes and one flake fragment. The remainder of the assemblage included numerous decortification, platform and convexity management pieces,

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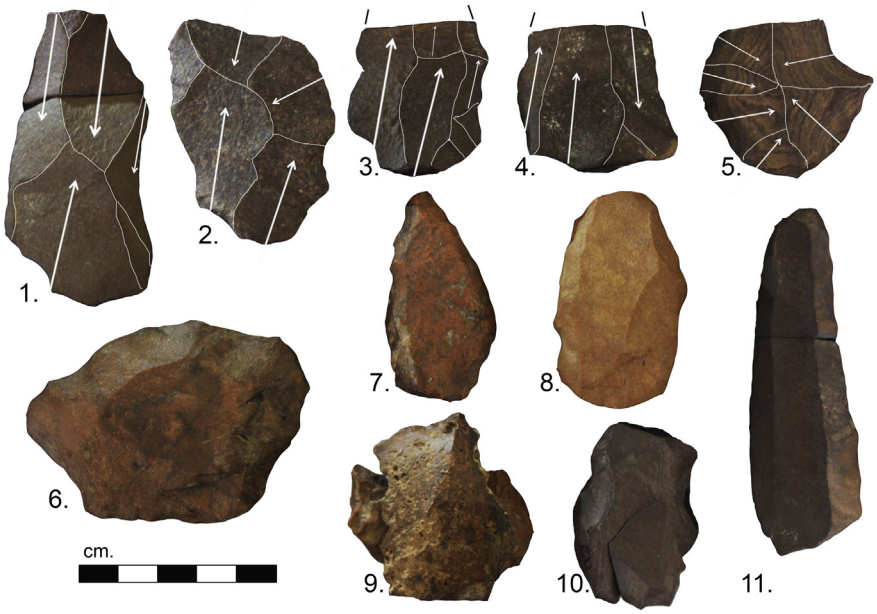

Fig. 12. Selected artefacts from KAM1. 1: Conjoined Levallois flake with bidirectional flaking pattern; 2: Levallois flake with centripetal flaking pattern; 3: broken Levallois flake, possibly a point, with unidirectional flaking pattern; 4: broken Levallois flake, possibly a point, with bidirectional flaking pattern; 5: Levallois flake with centripetal flaking pattern; 6: centripetally prepared preferential Levallois core; 7: double side retouched point; 8: side retouched flake; 9: refitted single platform core and flake; 10: refitted core management flakes; 11: conjoined blade. Photograph by E. Scerri.

broken flakes and chips and chunks. The high amount of flaking waste suggests that knapping occurred by the edge of the lake. The presence of several refitting core management flakes (e.g. Fig. 12, no. 9) indicates that the many of the knapping episodes involving similar raw materials were discrete flaking events.

The unbroken cores are small in size and appear to be heavily reduced. Four cores are amorphous, multiple platform cores which seem to represent a final stage of flaking. One core is a chert single platform core of the same distinctive material that a single Levallois flake is also made from. The single platform core also refits to a flake (Fig. 12, no. 9) and another core chunk, again suggesting that these small, amorphous and single platform cores represent the final stage of reduction of what may have been Levallois cores. Of the remaining whole cores, six are Levallois cores. One of the Levallois cores is a small recurrent centripetal Levallois core. The core appears to have been abandoned thanks to a build-up of mass in the centre of the core as it approached exhaustion. The remaining Levallois cores are centripetally prepared preferential cores (Fig. 12, no. 6). The mean weight of the Levallois cores is 52 g ($\sigma = 15$) and a maximum linear dimension of 56 mm ($\sigma = 14$).

The Levallois flakes all have centripetal scar patterns with the exception of a Levallois flake and a broken Levallois point, which both feature bidirectional scar patterns and a broken Levallois point featuring a unidirectional scar pattern (Fig. 12, nos. 1, 3–4). The platforms are finely faceted, ranging from 3 to 5 main facets with a mean of 3 main facets (σ 0.6). The dominant platform type is the chapeau de gendarme subtype of faceted platforms. The unbroken Levallois flakes have a mean weight of 26 g (σ 10) with a mean logged elongation index of 0.1 (σ 0.3) and mean logged flattening index of 1.5 (σ 0.2). The external platform angle of the Levallois flakes and points had a mean of 73° (σ 6.1).

The assemblage is likely to represent several discrete Middle Palaeolithic flaking episodes connected to the MIS 5 lake. It is probable that people sporadically visited the lake during this time and knapped by the lake edge. The number of Levallois flakes/points to cores and debris suggests that not all the primary flaking products were being removed. Future use-wear analysis may provide some indications as to whether the flakes were being used on site or not. However, the presence of only two broken points may suggest that points were being transported away.

4.2.3. KAM 2

This was located close to KAM 1 and associated with extremely deflated marl deposits and three, widely dispersed handaxes, which were left in the field.

4.2.4. KAM 4

The Middle Palaeolithic archaeology at KAM 4 is associated with several later lakes to those described in Section 4.1.3. Geomorphological and sedimentological affinities between the latest (overlying) phase of lake formation at KAM 4, with lake beds at KAM 1, suggest an MIS 5 age. These later lakes run transverse to the Lower Palaeolithic lakes (see Section 4.1.2) and unlike the older lake beds, appear bounded by the existing dune morphology. Preliminary observations indicate that the Middle Palaeolithic assemblages consist of centripetally prepared preferential Levallois cores, unidirectional convergent Levallois cores and recurrent centripetal Levallois cores (Fig. 5, nos. 3–4). Numerous Levallois points and flakes were also found and some of the lithic core and flake scatters have been refitted, indicating limited spatial movement. The artefacts are primarily made from quartzite, but also feature limited use of non-local rhyolite, chert and the distinctive 'wood grain' material used to make the Acheulean handaxes at KAM 4 and some of the Levallois flakes at the KAM 1. Retouched flakes include denticulated pieces and side retouched flakes. A great number of the flakes also include core management pieces, which together with the refits and chips, indicate that knapping took place on site. Most of the cores tend to be small and highly reduced, suggesting that curation may have been significant.

4.2.5. Tayma Wildlife Reserve

94 flakes, two bifaces and 35 cores were collected from an isolated eminence within a Wildlife Reserve, northwest of Tayma. Raw materials are mostly local quartzites, with quartz, limestone and

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non-local chert and rhyolite present in smaller quantities. The assemblage probably represents multiple phases of occupation, but is of a broadly Middle Palaeolithic character. Primary reduction was conducted at the site, with hominins accessing raw material from the gravel. Some Levallois reduction is present, but the assemblage is on the whole somewhat amorphous. Nevertheless, the site provides an insight into Middle Palaeolithic behaviour in a poorly understood area and is outside the Nefud Desert. The site characteristics are unlike the other identified sites, as it is on a high point in an otherwise flat plain, giving good views of the land up the an escarpment to the east, and providing an excellent source of raw material.

The flakes ranged from large and often cortical pieces to smaller core management pieces, including débordant flakes and other convexity management flakes (Fig. 13). The debitage also included a large amount of chunks and other flaking waste. Comparatively few well made, including Levallois, flakes were found, perhaps suggesting that the products of knapping were removed from the site. Non-Levallois flakes appear to be the products of discoidal and single platform core flaking. The nine Levallois flakes found typically exhibited centripetal scar patterns and featured prepared platforms with 3–4 facets. Only one of these nine flakes was a unidirectional convergent point. This example had been finely retouched on the ventral surface, removing the point tip. A slight difference in patination of the retouch suggests that this artefact may have been recycled (Fig. 13, no. 9). Three other non-Levallois retouched flakes were also recovered. Two of these featured steep denticulated retouch along both margins and the third is an invasively bifacially retouched flake, which may pertain to a period later than the Middle Palaeolithic.

Cores are largely simple and crude. Of the 35 cores, 16 were amorphous multi-platform cores, 7 were single platform cores, 9 were Levallois cores and 2 were discoidal (Fig. 14). One other artefact can best be described as tested (i.e., some extremely limited modification of raw material prior to abandonment). The Levallois cores include centripetally prepared preferential and recurrent cores, and one example of a bidirectional point core made from limestone. The cores all appear to be made from cobbles of different raw materials in a range of different sizes. The mean weight is 156 g, but the standard deviation is high (σ 109). Two small bifaces were also found at this site. These were small and appeared to be Middle Palaeolithic in character (Fig. 14, nos. 10–11).

4.2.6. HIS 1

The Middle Palaeolithic material from HIS 1 included large Levallois flakes, débordant pieces and centripetally prepared Preferential Levallois cores all made from local quartzite. Other large cortical flakes were found. The Middle Palaeolithic material at this site appeared to be strongly Levallois and no discoidal cores were identified. The material was not collected.

5. Discussion

The numerous Lower and Middle Palaeolithic sites identified in the Nefud Desert demonstrate that this region has a rich Pleistocene environmental and archaeological record. Conversely, Holocene sites appear to be extremely limited (but see Engel et al., 2012; Crassard et al., 2013; Hilbert et al., 2014). Geomorphological and sedimentological field observations, in conjunction with ages obtained from previous research (i.e., Rosenberg et al., 2013), have facilitated the identification of two distinct phases of lake formation in the southern Nefud associated with Lower and Middle Palaeolithic archaeology. Older lakes, currently dated to MIS 9 and 11 (Table 1), are characterised by a greater spatial extent, darker and more heavily indurated surficial marls, and an overall north–south orientation of exposed beds. Conversely, on the basis of current evidence, MIS 5-age lake beds appear to be more diatomaceous, paler in colour and generally smaller in size, indicative of smaller ephemeral interdunal lake formation (Rosenberg et al., 2013). Further research will confirm these observations.

The differences in the sediments and geomorphology associated with Lower and Middle Palaeolithic archaeology allows some insights to be made on the character of the different occupations (see also Shipton et al. in press). Larger and perhaps more stable lakes during the Middle Pleistocene suggest that a Lower Palaeolithic occupation in the Nefud may have been extended, perhaps enough

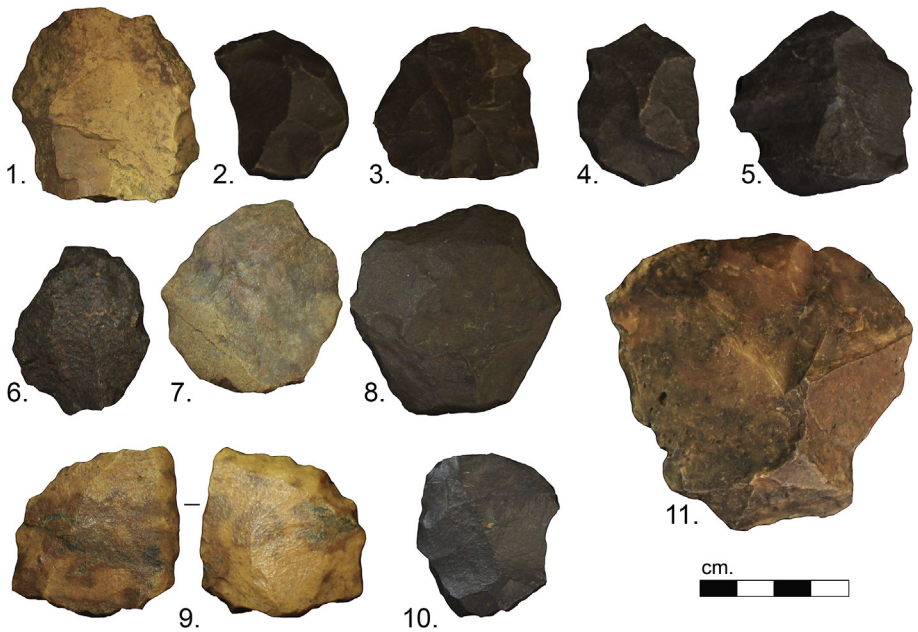

Fig. 13. Flakes from the Wildlife Reserve site. 1–5: single platform and discoidal flakes; 6–8 Levallois flakes; 9: Retouched Levallois point, probably recycled; 10: Levallois flake; 11: large, cortical flakes. Photograph by E. Scerri.

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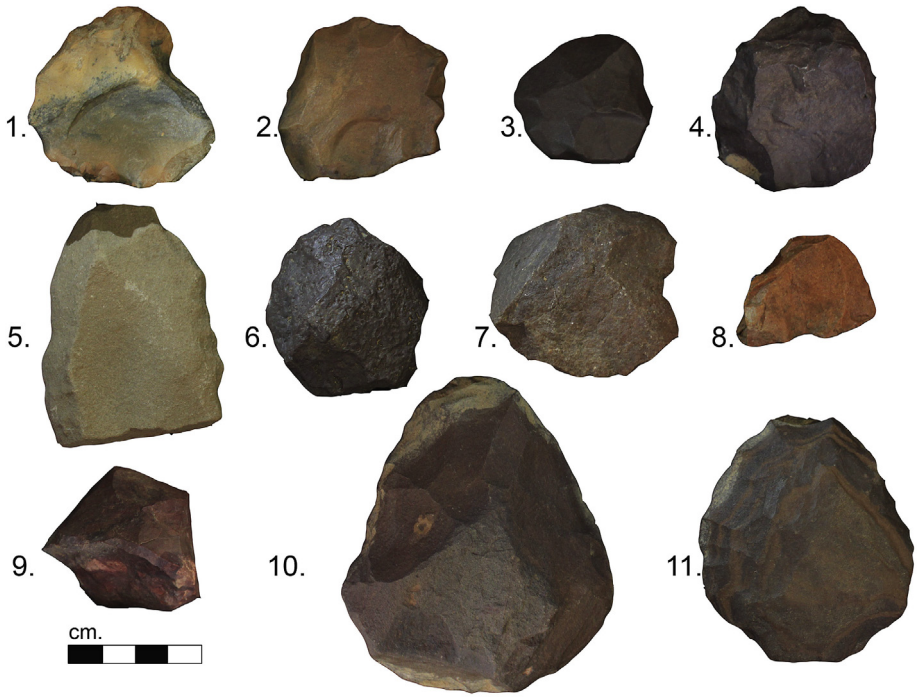

Fig. 14. Cores from GM. 1–2: Centripetally prepared preferential Levallois cores; 3: recurrent centripetal Levallois core; 4: Single platform core; 5: bidirectional Levallois point core; 6–7: discoidal cores; 8: single platform core; 9: multiple platform core; 10–11: bifaces. Photograph by E. Scerri.

to accommodate the development of distinctive autochthonous technological traditions, based on the production of small bifaces with a limited use of core and flake technology. This development appears to have followed a previous stage characterised by large handaxes.

Conversely, the number and nature of Middle Palaeolithic sites do not suggest great density during the Pleistocene. According to Rosenberg et al. (2013), the overall pattern of lakes in the Nefud during MIS 5 was one of small and considerably fluctuating interdunal water bodies. The Middle Palaeolithic archaeology is consistent with this view. Sites are small, often reflecting a few knapping episodes (e.g. KAM 1) of similar technological character and suggestive of repeated, small incursions into the southwestern Nefud. The Middle Palaeolithic sites examined in the survey are all focused on these small and potentially ephemeral lakes and, to a lesser extent, raw material locations. More perennial water bodies may have existed (see Rosenberg et al., 2013) during this time, however the broad patterns indicate the presence of small, scattered lakes throughout the interdune depressions of the Nefud. These features are consistent with a model of periodic incursion during 'boom years' of environmental amelioration. The ultimate origins of these populations may consist of several different source areas. Given the Nefud's proximity to southern Jordan and the Sinai, these areas of ultimate population origin are likely to include both the Levant and northeast Africa (see Scerri et al., in press for discussion). If this was the case, the lakes of the Nefud may have been a nexus of population exchanges.

Parallels to this model are drawn by Smith (2013) in his study of the colonisation of Australian deserts. Building on biological dispersal models, Smith (2013) argues that once a population is established on the periphery of an arid zone, colonisation of that arid zone can be rapid, particularly if interannual climatic variability created a flush of resources in the desert. In this model, during 'boom years', there are strong incentives for opportunistic movement, allowing people to move deep into the arid zones, almost as soon as peripheral areas became occupied. The problem, Smith (2013) argues, was not dispersal across the desert, 'so much as maintaining a presence in the face of continuing climatic variability' (2013, 75).

In attempting to understand the relationship between this continuing environmental variability and Palaeolithic archaeology in the Nefud, preliminary results suggest that hominin occupations had a superficially similar character in the Lower and Middle Palaeolithic of the Nefud, in that they are associated with lakes and raw material acquisition. However, a number of different behaviours can be observed between the Lower and Middle Palaeolithic sites. Lower Palaeolithic sites feature local quartzites and are often found next to or on the raw material outcrops or gravels themselves. Only one chert handaxe was discovered. Conversely, Middle Palaeolithic sites often feature (low levels of) non-local, diverse and exotic raw materials (e.g. rhyolite and chert), suggesting greater mobility and/or transport of raw material. The diversity of the raw materials and flaking episodes identified at the Middle Palaeolithic sites also suggests that incursions into the Nefud may have included a number of different populations, and possibly a high population turnover. The analytical scale is currently coarse due to the low number of sites, artefact density and chronological resolution.

A model of small, mobile populations with a high population turnover is also reinforced by the diversity of Middle Palaeolithic technology in the Nefud. For example, TAG 1 may represent the earliest Middle Palaeolithic in the Arabian Peninsula (i.e., MIS 9), and does not resemble the other Middle Palaeolithic sites discovered, in terms of its technology. The other Middle Palaeolithic sites are more similar and likely to date to MIS 5, the wettest period in the Arabian Peninsula (Jennings et al., in press; Parton et al., this issue), suggesting either population continuity or contemporaneous occupations at least during the Last Interglacial. Apart from TAG 1, the Middle Palaeolithic sites discovered all feature both recurrent centripetal and centripetal preferential methods, and are

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broadly similar to other Middle Palaeolithic assemblages in the Nefud, such as JQ-1 and JSM-1 (Petraglia et al., 2011, 2012), perhaps suggesting affinities between the hominins responsible for these assemblages. Following studies demonstrating that the frequency of hunter–gatherer movements is correlated with toolkit diversity (e.g. Shott, 1986), the near complete absence of formal tools at the Middle Palaeolithic sites discovered may support the view that these populations were also highly mobile, applying their lithics to a broad range of tasks. However, raw material and other pragmatic factors may also structure the low number of formal tools. Further research will determine whether a model of population contemporaneity during climatic 'windows' or a model of short to medium term population continuity is more accurate for this region.

In terms of wider technological affinities, the Middle Palaeolithic assemblages from the Nefud may also resemble other Middle Palaeolithic sites in the Levant during MIS 5. However, the interchangeable use of recurrent centripetal and centripetal preferential Levallois is also a feature of East Africa during MIS 5 (see Groucutt et al., this issue) as part of a constellation of technological features that appears to extend across the arid belt and into India (Clarkson et al., 2012). These characteristics may tentatively suggest that the hominins responsible for most of the assemblages attributable to MIS 5 were modern humans, as *Homo sapiens* are known to have produced these technological features in Africa and in the Levant during MIS 5, but they are not linked to Neanderthals in the Levant. Further research will determine whether the early Middle Palaeolithic in the Nefud Desert represents the presence of archaic populations from the edges of the Levant. Notwithstanding the absence of such further data, the available evidence is consistent with the view that the Arabian Peninsula, and the Nefud Desert, was a critical zone for population expansion, interaction, refuge and turnovers during the Middle and Late Pleistocene.

6. Conclusions

The data from the Nefud Desert survey supports a model in which populations entered the Nefud during humid phases during times of climatic amelioration and lake formation. Future research in the Nefud, including the completion of analyses from the 2013 Palaeodeserts survey, will further elucidate the relationship between demography and environmental change throughout the Nefud, but at a minimum, the results so far support models which suggest that demographic complexity in the Arabian Peninsula throughout the Pleistocene is intimately tied to increased freshwater availability and environmental amelioration.

Finally, the results of the Nefud Desert survey places the Arabian Peninsula at the centre of a biogeographic arc, which featured dramatic environmental oscillations and periods of amelioration throughout the Pleistocene, and thus periods of demographic increase and connectivity. As an interface between weather systems, the Nefud Desert in particular may have been critically important for population exchanges. Depending on the variability of the different climate systems meeting at the Nefud (i.e., Mediterranean Westerlies, African Monsoon), different population incursions from diverse geographic zones (e.g. The Levant, East Africa) may have been able to colonise the Nefud for relatively brief periods, and disperse elsewhere.

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