Large Flake Acheulean in the Nefud Desert of Northern Arabia

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ABSTRACT

Between the Levant and the Indian sub-continent only a few Acheulean sites have been documented, hampering models of hominin dispersals. Here we describe the first Acheulean sites to be discovered in the Nefud Desert of northern Arabia. The four sites occur in a variety of settings including adjacent to an alluvial fan drainage system, at a knappable stone source, and on the margins of endorheic basins. We discuss the implications of the sites for hominin landscape use, in particular the preferential transport and curation of bifaces to fresh water sources. The bifaces correspond to the Large Flake middle Acheulean in the Levantine sequence. The sites occupy a gap in the distribution of the Acheulean across the Saharo-Arabian arid belt, and as such have implications for dispersal routes between Africa and Asia.

INTRODUCTION

The Saharo-Arabian arid belt at times would have presented a significant obstacle to hominin dispersal between Africa and Eurasia, particularly during the Acheulean when ranging patterns were apparently more constrained by fresh water access in comparison to later hominins (e.g., Hardaker 2011). By determining the distribution of Acheulean sites in the Saharo-Arabian belt, po-

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tential dispersal routes across the arid zone between Africa and Asia may be identified. Due to their age, the recovery of Acheulean artefacts is generally dependent upon finding areas in the landscape that have not been subject to substantial sediment reworking or aggradation, or identifying areas where Pleistocene sediments are exposed. Identification of Acheulean sites in a variety of settings allows for reconstructions of hominin landscape use. Here we present the first discovery of four Acheulean sites in the Nefud Desert of northern Arabia, thereby filling a significant geographic gap in our knowledge about the distribution of sites across the Saharo-Arabian arid belt.

The Arabian Peninsula is situated within the Saharo-Arabian desert belt, which stretches from the Atlantic coast of northwest Africa to the Thar Desert in northwest India. The climate of Arabia today, with the exception of the Yemeni Highlands and Dhofar, is classified as arid to hyper-arid. However, periodic incursions of moisture have transformed the inhospitable desert interior into a landscape littered with active drainage systems and large freshwater lakes at various times in the past. Arabia is subject to three major climatic systems—mid-high latitude westerly depressions that originate in the eastern Mediterranean and deliver winter rainfall; the Indian Ocean Monsoon (IOM), which at present brings summer rainfall to the southernmost regions of the peninsula; and, the East African Monsoon which at times has been strong enough to reach across into the Arabian interior. These are, in turn, driven by insolation changes and the timing of northern hemispheric glacial cycles. Generally, the most humid conditions in Arabia coincide with peak interglacial conditions (Fleitmann and Matter 2009), during which times extensive, perennial water bodies are known to have formed within the interior (i.e., Petit-Maire et al. 2010; Petraglia et al. 2012; Rosenberg et al. 2011; 2012; 2013).

There are few analysed paleoclimatic records in Arabia that reach beyond the Middle Pleistocene. While geological investigations have identified a variety of fluvial, fluvio-lacustrine, and alluvial fan deposits associated with substantially wetter climates during the Miocene-Pliocene (e.g., Farrant et al. 2012; Styles et al. 2006), there is a paucity of chronologically-constrained Pleistocene paleoclimatic data beyond ~400 ka. Despite this, a broad body of research attests to the stepwise variability of the monsoon system over the past few million years. In particular, an intensification of summer monsoonal conditions is suggested to have occurred around the Pliocene-Quaternary (ca. 2 Ma) (Qiang et al. 2001; Zheng et al. 2000), and has been associated with widespread fluvial activity in the principal drainage systems of the Peninsula (Anton 1984). Deposition of substantial basal river gravels and extensive alluvial fan deposits has been linked to Pliocene-Pleistocene aggradation in the major wadis (valleys) of Sahba, Batin, and Dawasir (Al-Sulaimi and Pitty 1995; Anton 1984; Edgell 2006), and probable early to middle Pleistocene drainage linked to Acheulean occupations is recorded in Wadi Hadramawt (Edgell 2006) and the Wadi Sirhan basin at Azraq (Copeland and Hours 1989) (Figure 1). SIR (Shuttle Imaging Radar) data (Dabbagh et al. 1997) and geological interpretations (Anton 1984) also have suggested the former presence of large drainage systems crossing the Rub al' Khali, now lying beneath extensive dunes resulting from later Quaternary deflation of the floodplains of these Pliocene-Pleistocene drainage systems (McClure 1978). Comparable systems can be observed exiting the Nefud Desert in remotely sensed data. The Late Pliocene - Early Pleistocene pluvial associated with these major hydrological features has been suggested to have been longer and more intense than any subsequent humid phase (Hötzl and Zötl 1984), with a broad drying trend (though still interspersed with periods of substantially increased humidity relative to the present) therefore implied for the later Quaternary in the Arabian Peninsula.

Further abrupt monsoon intensity shifts occurred between ca. 1.2 and 0.7 Ma (e.g., Donghuai 2004). In particular, the occurrence of the 'mid-Pleistocene' transition (MPT) between ca. 1.0 and 0.7 Ma, saw the important shift from obliquity-timed (ca. 41 kyr) to eccentricity-timed (ca. 100 kyr) global glacial cyclicity (Heslop et al. 2002) and a consequent change in the timing and duration of monsoon intensity increases. While the extent and effects of such changes remain unresolved, it is likely that during periods of monsoon intensification, the incursion of rainfall into the Arabian interior would have facilitated the expansion of floral and faunal populations throughout the Afro-Asiatic belt. Indeed, it is such periods of abrupt and extreme climatic variability within low latitudes that may have acted as an important catalyst for evolutionary change and critical dispersal events among mammals and hominins (Trauth et al. 2007).

Acheulean sites are very often associated with fresh water sources (Copeland and Hours 1989; Korisettar and Petraglia 1993; Potts et al. 1999; Shipton 2011), a pattern which although taphonomic in some cases, at many high integrity sites is clearly the product of hominin preferences (Holmes et al. 2010; Potts et al. 1999). The association of Acheulean hominin sites with fresh water sources suggests that hyper-arid desert regions may have been marginal or uninhabitable areas. Despite this, Acheulean sites are reported in a number of modern desert regions including the Namib Desert (Hardaker 2011), the Kalahari (Ebert et al. 1976), the Sahara (Clark 1965), and the Thar (Misra et al. 1982). Considering the extent of climatic variations over the last 1.75 million years, it is likely that Acheulean sites were occupied when these deserts were considerably wetter than at present. The site of Kiseiba in the Darb el Arba'in Desert, today one of the driest parts of the eastern Sahara, is estimated to have been at least two orders of magnitude wetter when it was occupied by Acheulean hominins (Haynes et al. 1997). Across the Darb el Arba'in Desert, Acheulean artifacts unaffected by fluvial transport occur alongside buried river channels representing a range of different pluvial phases (McHugh et al. 1988). At the site of Nahal Zihor in the Negev Desert, Acheulean localities are associated with different phases of the formation of a palaolake, spanning hundreds of thousands of years (Ginat

Figure 1. Paleodrainage systems reported in the literature (see body text) to have Early to Middle Pleistocene fluvial activity and Large Flake Acheulean localities, including the Jubbah sites reported here.

et al. 2003). In the Azraq Basin in the Syrian Desert, small Acheulean sites occur alongside wadis and large ones at permanent springs (Copeland and Hours 1989). At Singi Talav in the Thar Desert, Acheulean bifaces were discarded by the shore of a now dried-up lake (Raghavan et al. 1991). Acheulean sites in arid regions may thus be associated with fresh water sources activated during humid phases.

The Levant presents the most well researched sequence of Acheulean sites in the Saharo-Arabian arid belt. The density of sites in the Levant probably reflects the fact its core area was never a desert. The earliest well-dated Acheulean site in the Levant is 'Ubeidiya at 1.6–1.5 million years ago, where hominins manufactured large, thick bifaces on cobbles (Bar-Yosef et al. 1993; Martínez-Navarro et al. 2012; Tchernov 1988). Cleavers are rare at the early Levantine sites with none reported from Nahal Zihor (Ginat et al. 2003), while at 'Ubeidiya and Latamne they constitute less than 2% of the biface assemblages (Gilead 1973). A second wave of Acheulean dispersal from Africa is argued to have occurred in the Middle Pleistocene, represented by the site of Gesher Benot Ya'aqov in the Levant (see Figure 1) (Goren-Inbar et al. 2000; Goren-Inbar and Saragusti 1996), which

dates from about 800 to 700 kya (Feibel 2004). Here there was a preference for large flake blanks, the use of relatively coarse-grained volcanic stones, and relatively high proportions of cleavers (Sharon 2010), which ally the Gesher Benot Ya'aqov Acheulean to pene-contemporaneous sites in East Africa (e.g., Gallotti et al. 2014; Shipton 2011). Levantine Acheulean sites younger than 400 kya are of a different character again, containing small, finely made handaxes on flint cobbles without cleavers (Gisis and Ronen 2006).

Across the Arabian Peninsula, Acheulean sites are found in association with rock outcrops, wadis, and springs (Groucutt and Petraglia 2012; Petraglia 2005). Sites are concentrated in the southern and western portions of the peninsula where the exposed bedrock of the Hijaz and Hadramawt Mountains makes them easy to identify (Petraglia 2003). There may also be many Acheulean sites in the sand sheet deserts, but these would mostly be deeply buried.

Two particularly dense Acheulean landscapes occur around the Wadi Fatima near the Red Sea Coast and Dawadmi in central Arabia (see Figure 1). On the north side of the Wadi Fatima, 32 Acheulean sites were discovered near volcanic outcrops and minor tributaries overlooking the main wadi (Whalen et al. 1988). Here handaxes and cleavers were produced on large flakes of andesite. Dawadmi occurs at the headwaters of two very large paleoriver systems, Wadi al Batin and Wadi as Sahba in the center of the Arabian Peninsula. Here numerous sites were found along an andesite dike, often associated with dried-up springs and wadis (Petraglia et al. 2010). The artifacts were similar in character to those at the Wadi Fatima, with handaxes and cleavers produced on large flakes of andesite (Whalen et al. 1984).

Middle Paleolithic and later occurrences in the Nefud Desert of northern Arabia have been known about for some time (Garrard and Harvey 1981), but Acheulean sites were only discovered in 2013 through survey by the University of Oxford Palaeodeserts Project. In this article, we report on the geomorphological setting of the four new Acheulean sites, and describe the raw material, and technology of the lithic assemblages. We discuss the implications of our findings in relation to hominin landscape use and dispersals.

PALEOENVIRONMENT OF THE NEFUD

Presently, sandy deserts cover approximately one third of Arabia. The Nefud Desert is the northernmost sand sea in Arabia, covering an area of ca. 72,000km^2 and exhibiting a variety of dune forms indicative of a complex wind regime history (Goudie et al. 2000). In recent years, paleoenvironmental studies have revealed that during interglacial conditions, prolonged humid periods in the Nefud led to the development of vast freshwater lakes home to a variety of fauna. Findings from the Mudawwara paleolake in southern Jordan, indicate that during interglacials associated with MIS 7a to MIS 5a, the northwestern Nefud contained a perennial lake up to 2000km^2 (Petit-Maire et al. 2010). Additionally, Rosenberg and colleagues (2013) identify numerous lacustrine deposits throughout the Nefud, and indicate that lake formation occurred at ~410 ka, ~320 ka, ~200 ka, ~125 ka, and ~100 ka, with lake formation at ~320 ka (MIS 9) comprising a single, perennial lake that covered the entire southwestern Nefud. The substantial spatial distribution of interglacial-age lake sediments across the Nefud, suggests that lake formation was likely ubiquitous throughout the region during interglacials of the Late Quaternary. The confirmed presence of lakes within the Nefud dated to at least ~410 ka, extends lake formation well back into the Middle Pleistocene, thus providing the widely available freshwater required for Acheulean occupation.

THE ACHEULEAN SITES OF THE NEFUD

Using satellite imagery and digital elevation models and applying the methods outlined in Crassard et al. (Crassard et al. 2013), particular areas with high potential for archaeological discoveries around the modern oasis town of Jubbah in the southern Nefud were targeted for ground survey. These included areas with rocky outcrops where hominins may have exploited the geology and where artifacts would still be exposed on the surface; and areas with a high potential for lake formation (i.e., large endorheic depressions). Following this approach, a workshop site, three small occupation sites, and two off-sites (isolated individual artifacts) were discovered, along with numerous Middle Paleolithic sites. Small representative samples of bifaces and other artifacts from each site were collected for description and illustration. At some of the Acheulean sites, Middle Paleolithic artifacts also are represented although in different sub-localities within the site.

QANA OASIS (QAN-1)

The site of QAN-1 is situated ~5km from the south-eastern edge of the Nefud Erg, on the contact between sand dunes of the Nefud and the distal edge of an alluvial fan lobe which extends ~12km north of Jebel Aja to occupy a large depression to the southwest of Qana Oasis (Figures 2 and 3). Small sandstone jebels of the Tabuk Formation are exposed to the north of the oasis, together with rhyolite dykes shallowly exposed at the apices of some of these hills. The latter represent the main raw material source. The floor of the depression hosting the QAN-1 site is composed of fan sediments, comprising a thin skirt of poorly sorted, moderately well-rounded fine gravels and coarse sands typical of sheetflood deposits. These extend beneath the surrounding dune fields, indicating that they were deposited prior to dune emplacement. Previous studies in the region surrounding QAN-1 have dated interdunal lake deposits to pre-MIS6 (Rosenberg et al. 2013), suggesting that the surrounding dune fields pre-date this period. Weakly incipient paleosols of coarse greyish brown silty-sand, with a thin, moderate to well-sorted gravel lag deposit, also were observed, together with calcretes at the eastern end of the basin. These sediments correspond to lacustrine deposits recorded on the geological map (Bartlett et al. 1986). There is no evidence for channel incision in the vicinity of the site and fluvial processes appear to be limited to low energy sheet flooding. This, together with the very fresh condition of the Acheulean material, suggests that the artifact assem-

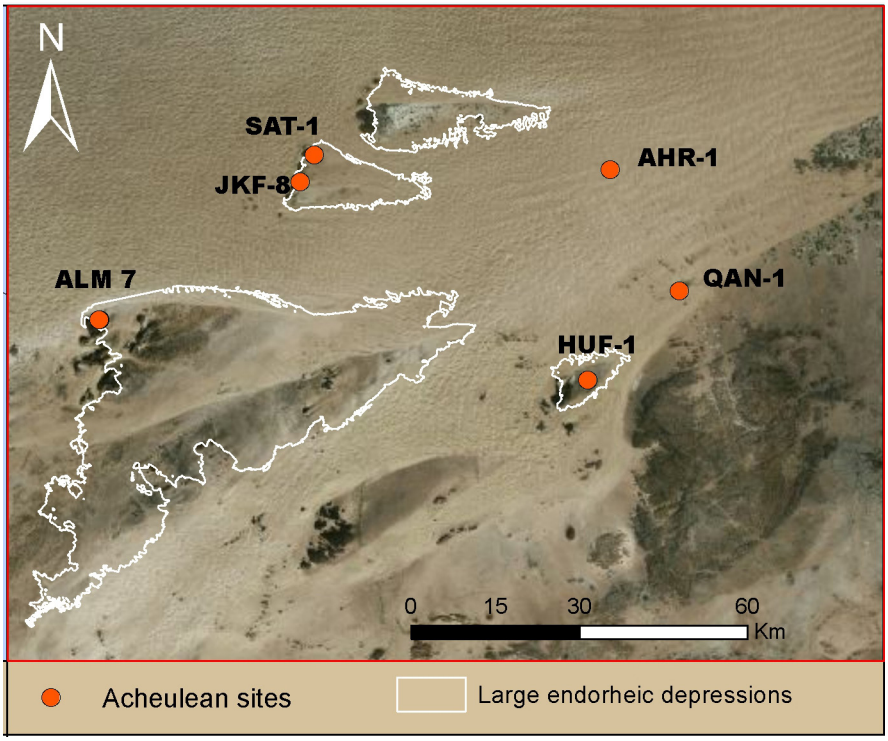

Figure 2. Large endorheic depressions in proximity to the sites discussed in the text which contain evidence for the presence of paleolakes during later Pleistocene humid phases (see Petraglia et al. 2012).

blage at QAN-1 has been unaffected by significant fluvial processes and represents deposition on a relict fan surface. Artifacts were recovered from the western part of the site, with Middle Paleolithic artifacts located higher up on the slope. These are more weathered than the Acheulean artifacts and are likely associated with the inter-dunal depression created by the alluvial fan, rather than the fan itself.

The Acheulean artifacts at QAN-1 comprised a scatter of bifaces together with a few flakes. A representative sample of around one third of the bifaces at the site was collected, comprising 13 handaxes, 3 cleavers, and 3 miscellaneous bifaces. Nearly all of these bifaces are in very fresh condition so fluvial transport can be ruled out. The bifaces are made on rhyolite, except for one which is on limestone (Figure 4). The nearest known limestone outcrop is over 90km away suggesting the possibility of hominin movements through the landscape of considerable distance (Bartlett et al. 1986). In the cases where the blank type was clearly identifiable, the bifaces were made on either slabs or flakes. The bifaces are of variable quality with the finest specimen being an elongate symmetrical piece with a globular butt (Figure 5). True flake cleavers with unretouched bits are a clear component of the assemblage (Figure 6).

AL MARRAT 7 (ALM-7)

The ALM-7 site is located along the western edge of the Al Marrat basin, which is situated ca. 45km southwest of Jubbah (see Figure 2). The basin measures approximately 7.5km x 2.5km and is bordered to the north, east, and south by dunes, and by Jebel Al Marrat to the west (see Figures 2 and 3). As with other sites discussed here, the presence of the jebel has served to protect the area on the eastern leeward side from significant aeolian sediment accumulation resulting in lake formation in the leeward basin during humid phases. This is evidenced by the presence of relict arcuate-circular mounds of highly weathered and indurated gypcrete, overlying interstratified calcrete/lacustrine sediments. Three levels of gypcrete mesa were evident. The lowest level was closest to the deepest part of the basin, and consisted of pale, perhaps younger deposits, displaying mud curl features. An intermediate, darker more indurated level was further towards the basin margin and contained stratified Middle Paleolithic artifacts, while the highest, most peripheral and darkest indurated level was where the Acheulean artifacts are located as well as at the interface between these relict landforms and a series of small, ephemeral drainage channels situated along the eastern slopes of the jebel. This distribution of Acheulean artifacts suggests that they are being eroded from within these sediments. This inverted relief may indicate progressively smaller lacustrine/palustrine humid phases separated by drier periods when deflation and mesa formation occurred.

A sample of around a quarter of the bifaces from the scatter at ALM-7 were collected, comprising one handaxe, four cleavers, a miscellaneous biface, and a discoidal core. The bifaces are fresh and were made on ferruginous quartzite and large flakes of rhyolite some of which were endstruck (Figures 7 and 8). In general the bifaces exhibit alternate flaking with some cleavers finished with finer

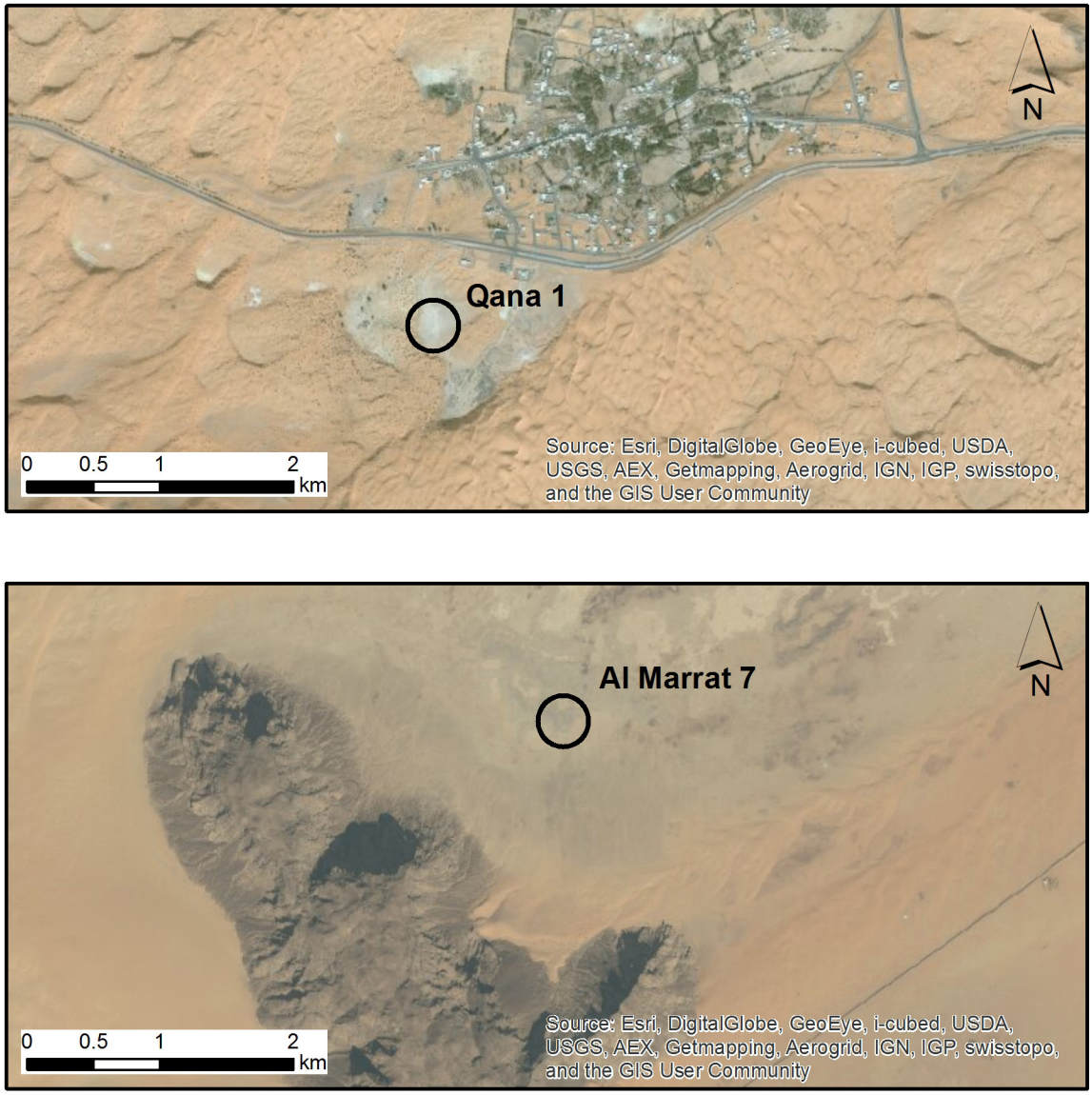

Figure 3. Above: QAN-1. The grey color is the remnant alluvial fan, overlying which are the Nefud dunes. Below: ALM-7. The site is on the eastern leeward side of the jebel and thus in a depression and not covered by sand.

marginal trimming (see Figure 7). In one case, the right dorsal and the left ventral margins were worked last, indicating the deliberate imposition of the final symmetrical cleaver shape. Cleaver bits were formed in a variety of ways including the intersection of one or more dorsal scars and the intersection of both lateral and distal flake margins. In one instance, the bit was formed by a large negative scar and the original slab surface of the ferruginous quartzite clast.

JEBEL SATAIHAH 1 (SAT-1)

Jebel Sataihah is situated approximately 8km southwest of the Jubbah paleolake (Petraglia et al. 2012), and is the first in a line of jebels that extend for approximately 12km in a south/southwesterly direction (see Figure 2; Figure 9). Sataihah has the highest base level of the line of jebels, and thus forms the head of a valley running down the eastern side of the jebels. Jebel Sataihah is bounded to the south, west, and north by climbing barchanoid dunes, and to the east by a ca. 5km^2 basin, which has formed on the leeward side of the jebel. The basin forms part of a large endorheic depression, comparable in size to that of paleolake Jubbah, and may have provided the necessary setting for the formation of a substantial water body during humid periods (see Figure 2). The eastern flanks of Jebel Sataihah have remained protected from the westerly flow of sand around the jebel. This area comprises an elevated highly weathered pavement of sandstone and tabular, purple ferruginous quartzite (Figure 10), which is partly incised by small ephemeral channels that flow eastwards from the jebel. There is no evidence for substantial sediment aggradation or channel incision on this pavement and as such, the surface material remains in the approximate location in which it was left by hominins. This has allowed the ac-

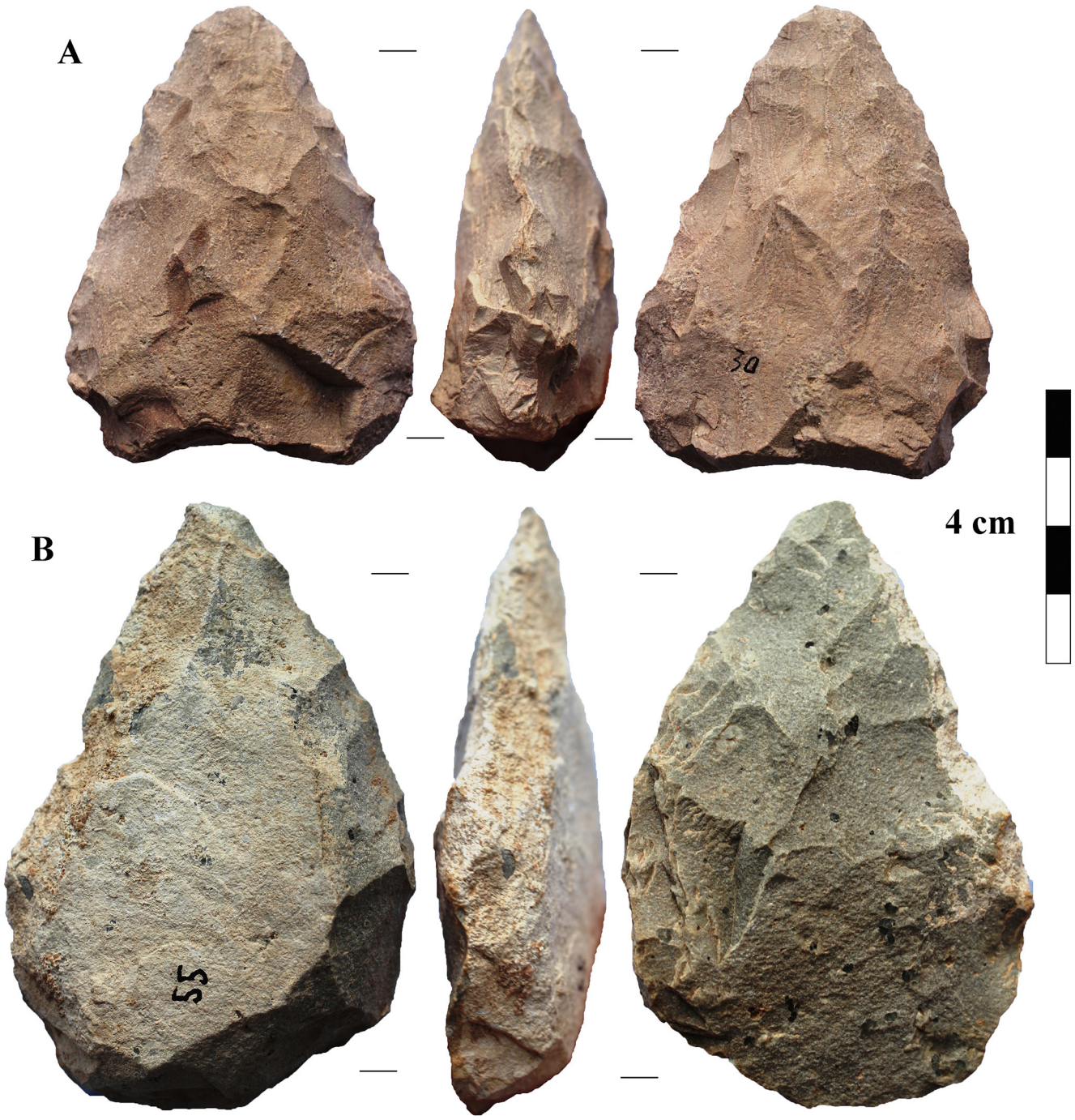

Figure 4. Limestone (A) and rhyolite (B) handaxe from Qana Oasis. Note the high number of flake scars on the relatively small limestone handaxe, possibly a reflection of long distance curation. Note that the rhyolite handaxe was made on a flake blank with the ventral surface still preserved on the proximal part of the biface. Note the freshness of the flake facets on both pieces.

cumulation of a palimpsest of multiple phases of worked material within a relatively stable landscape, free from significant fluvial erosion, or burial by lacustrine or aeolian sedimentation.

The pavement of purple ferruginous quartzite was exploited as a workshop for lithic manufacture, with artifacts occurring across it, perhaps totaling several thousand pieces. The pavement weathers in a variety of forms including blocky and tabular pieces suitable for core and biface blanks as well as rounded forms suitable for hammerstones. The artifacts are a palimpsest of Acheulean handaxes, choppers and picks and Middle Paleolithic Levallois cores, with the Acheulean ones tending to be further from the jebel base and having more rounded edges and facets. Overall artifact density is highest at the foot of the jebel.

Artifact types in the purple quartzite represented at the site include hammerstones, unretouched flakes, large bifacial choppers, picks and handaxes (Figure 11), as well as dis-

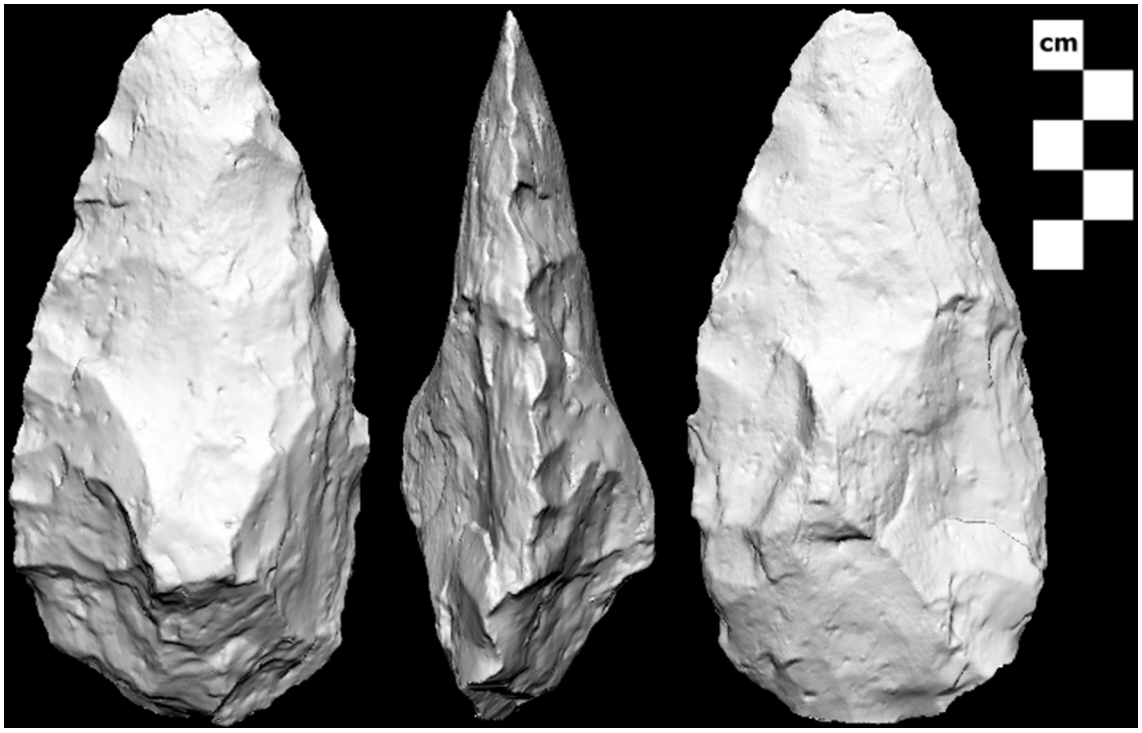

Figure 5. Finely made rhyolite handaxe from QAN-1. Note the symmetry and elongation, the moderately sinuous edge and the thick butt.

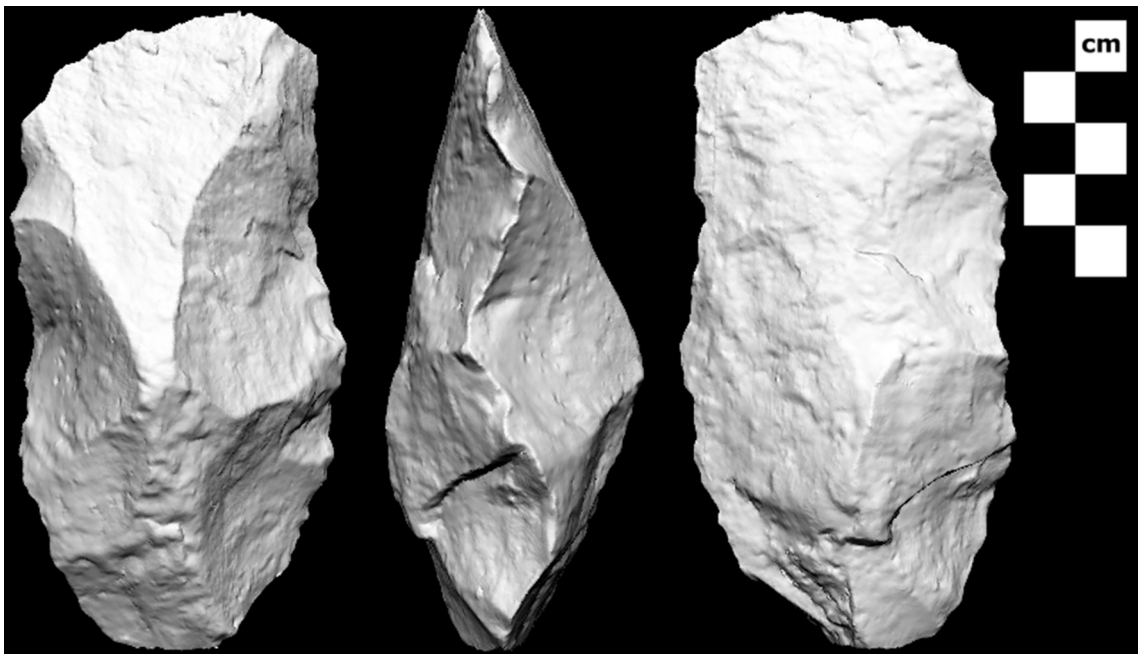

Figure 6. Rhyolite flake cleaver from QAN-1. Note that it is made on a flake blank with the original ventral surface still preserved on the distal end. Note that final shaping is achieved with just a few scars and that the bit is left unretouched.

Figure 7. Two rhyolite cleavers made on flakes from ALM-7. Note the fine marginal trimming on both specimens and that the bit is formed by two dorsal scars of the flake blank in the upper cleaver, and possibly by two ventral surfaces in the lower cleaver.

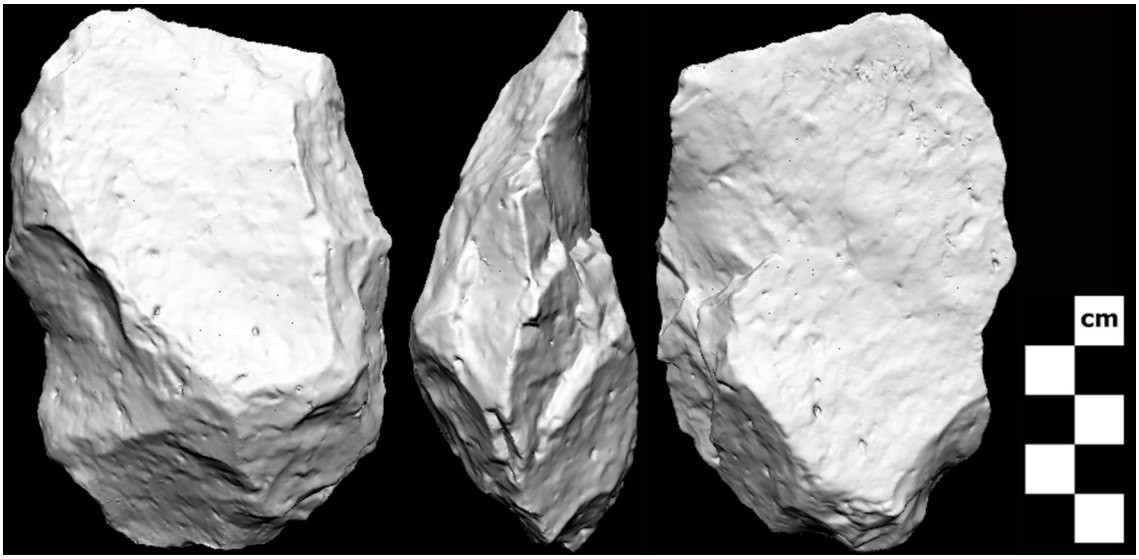

Figure 8. Rhyolite cleaver from ALM-7. Note that it is made on a flake blank, the bit is formed by a single dorsal scar and it is finished with a few marginal scars.

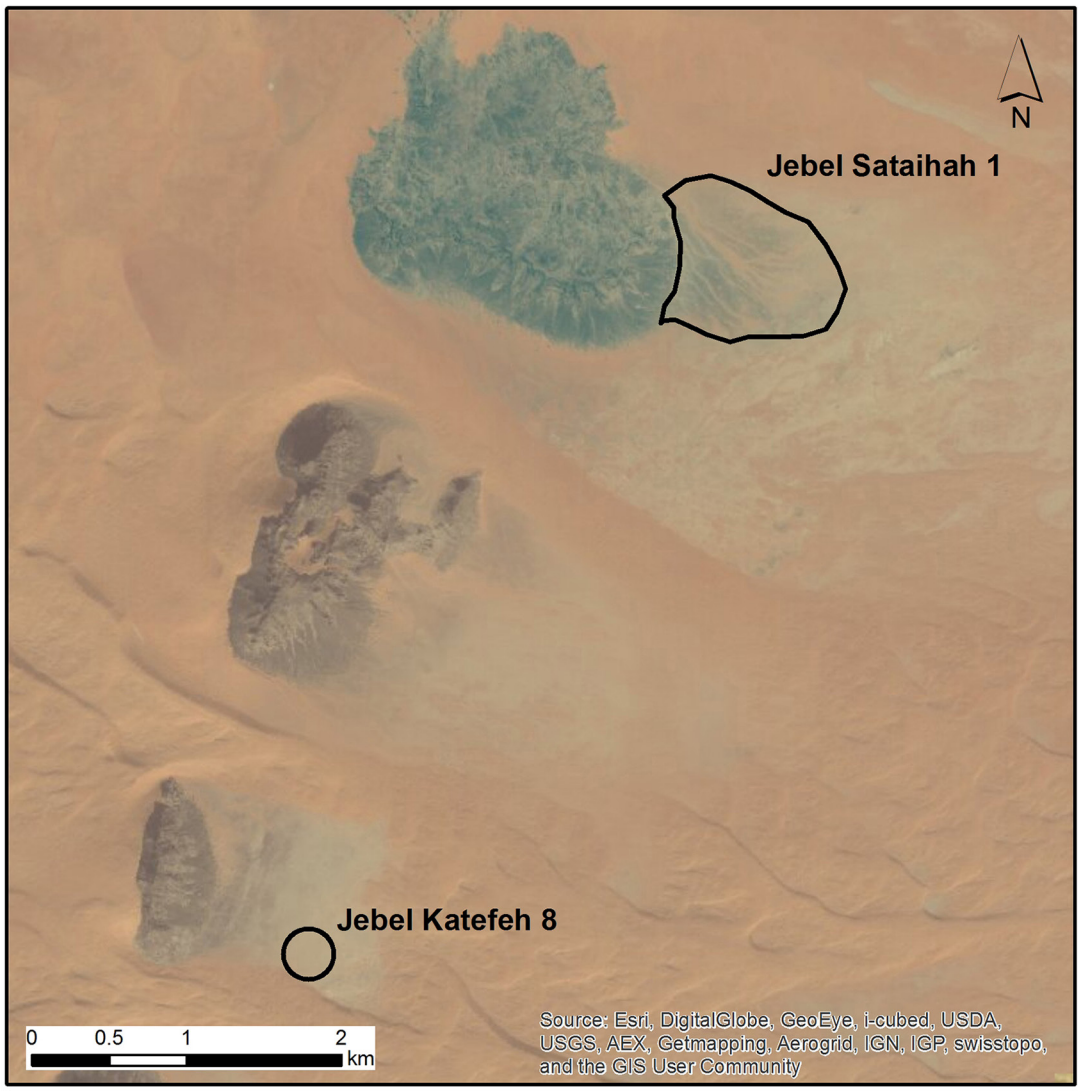

Figure 9. The location of SAT-1 and JKF-8 in the lee of jebels. Note the basin floor on which JKF-8 occurs is not covered by the surrounding dune sand. Note the extent of the pavement on the eastern side of the jebel.

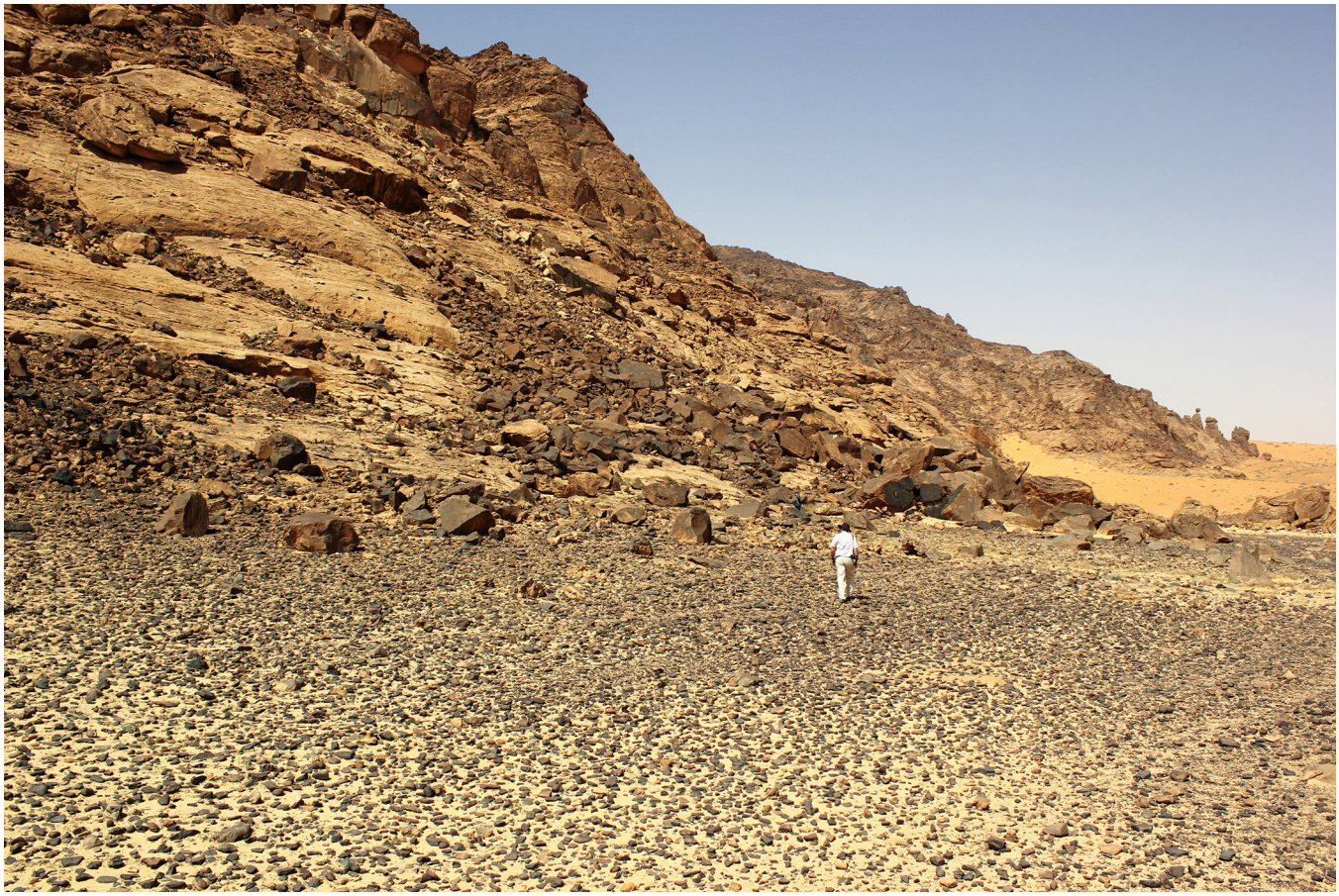

Figure 10. The purple ferruginous pavement at the base of Jebel Sataihah, looking north. Note the abdundance of clasts on the surface.

coidal and Levallois cores. A sample of nine handaxes were collected for further inspection and analysis. The handaxes tend to be rather long and thick and where discernible they are made on slabs, except for one made on a cobble and one made on a flake. The handaxes are neither invasively nor extensively flaked, indicating a least effort strategy in the production of a bifacial edge and the handaxe shape. The workmanship of the handaxes may indicate that many were rejects.

JEBEL KATEFEH 8 (JKF-8)

Jebel Katefeh is the third in the line of jebels that extend southwest from Jubbah, and is situated ca. 3km from SAT-1 overlooking the same endorheic depression (see Figures 2 and 9). Similar to Jebel Sataihah, the eastern flank of Katefeh comprises a large sandstone basin that has formed within the lee of the jebel. Previous studies have identified a series of remnant mounds of cemented lacustrine material overlain by highly weathered and indurated calcrete ca. 800m to the west of the jebel, reflecting the formation of a lake within the basin ~90–50 ka (Petraglia et al. 2012). A Middle Paleolithic occupation site (JKF-1) was found eroding out of a preserved mesa on the eastern side of the shallow basin in front of the Jebel. The basin floor comprises exposed sandstone bedrock partially covered by large rounded pebbles and cobbles of quartz, that have eroded to leave a coarse rounded gravel and which extend beneath the surrounding dunes and mesas and, therefore, predate the Late Pleistocene lake. At the southern end of the basin a scatter of heavily weathered bifaces was found in this gravel (JKF-8), five handaxes and one cleaver, which were all collected.

The bifaces were made on the ferruginous quartzite common around Jubbah, except for one rhyolite handaxe (Figure 12). The flake scar boundaries on the quartzite bifaces are heavily weathered thus precluding technological observations, but the rhyolite biface shows alternate flaking and bold, expanding scars. The nearest known outcrop of rhyolite is 30km to the source again indicating considerable movements across the landscape during the transport of some bifaces.

OFF-SITES

Off-sites, or isolated artifacts, are important indicators of hominin behavior, as they indicate which artifacts were transported and where on the landscape they were used (Foley and Kilmurry 1980). Two isolated bifaces were found during the course of our surveys around Jubbah. One was a handaxe in an interdunal depression adjacent to the Al-Jouf/Hail road (AHR-1), approximately 20km from the eastern edge of the Jubbah palaeolake basin (see Figure 2). At the bottom of the primary depression lies an indurated gypcrete mesa ca. 30m long and 3m in elevation, where

Figure 11. Bifacial handaxe and trihedral pick from SAT-1. Note the paucity of invasive flakes and the rounded scar boundaries.

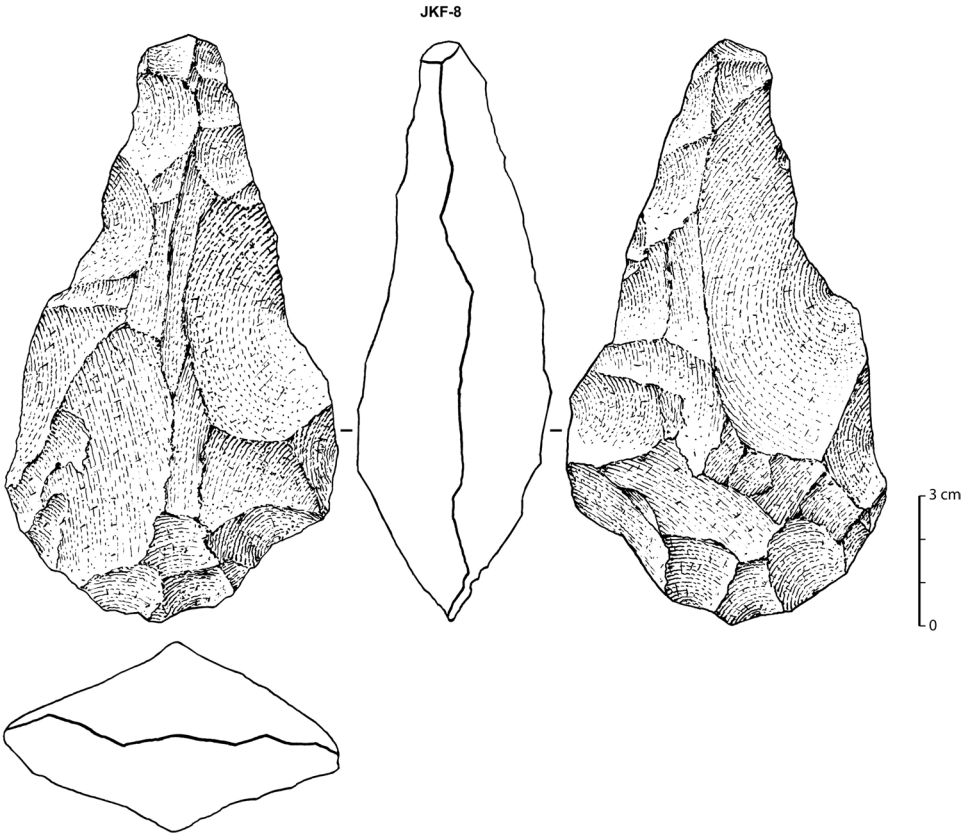

Figure 12. Rhyolite handaxe from JKF-8. Note the bold, expanding flake scars and the relatively high density of scars which may reflect curation during the long distance transport of this piece.

an isolated Acheulean handaxe was found at the base. The gypcrete sediment appears to have formed interdunally, however, the dunes themselves are likely quite old, with a nearby interdunal lake dating to MIS5e (Rosenberg et al. 2013). The handaxe is a finely made specimen on ferruginous quartzite, 16.3cm long and in fresh condition.

The handaxe at HUF1 was found within the Hufayr basin, near the interface between the alluvial braid plain along the eastern face of Jebel Hufayr and a deflated playa surface extending eastwards into the basin (see Figure 2). The artifact was located along the edge of a small (~0.6x3m) incised wadi channel trending SSW-NNE across the basin and no other artifacts occurred in the vicinity. The handaxe is 8.5cm long, made on local fine-grained rhyolite, and in fresh condition (Figure 13).

DISCUSSION

Here we have presented the first Acheulean sites discovered in the Nefud Desert, thereby offering a new source of information about early hominins in the Saharo-Arabian arid belt. Acheulean hominins were present at an alluvial fan (QAN-1) and in large endorheic depressions on the leeward sides of jebels where lakes likely formed (ALM-7 and JKF-8), or where raw material outcrops were exposed (SAT-1). Many more Acheulean localities are likely buried beneath the large dunes and deep lacustrine deposits that have accumulated elsewhere, including around the Jubbah paleolake.

Although only four small Acheulean sites and two off-sites have so far been identified in the Jubbah region, the range of locality types exemplifies patterns of landscape use documented elsewhere (e.g., Goren-Inbar and Sharon 2006; Langbroek 2004; Pope and Roberts 2005; Potts et al. 1999; Shipton 2011, 2013). SAT-1 is associated with a raw material outcrop and is clearly a workshop site, with a high diversity of artifact types, but a relatively low proportion of bifaces. Two off-site localities consist of lone handaxes indicating these artifacts were preferentially transported and used out on the landscape. JKF-8, ALM-7, and QAN-1 all have high proportions of bifaces in comparison to SAT-1 and are all associated with ancient water sources—small lakes in the leeward depressions of jebels in the case of JKF-8 and ALM-7 and an alluvial fan in the case of QAN-1. The two non-local bifaces transported to these locales (see Figures 4 and 12) suggest hominins were capable of leapfrogging relatively large distances to go between fresh water sources. These sites conform to the general Acheulean pattern of bifaces being preferentially curated and transported to locales with fresh water.

The endorheic basins in the southern Nefud would have facilitated lake formation and been a magnet for Acheulean hominin occupation, as represented by the biface sites on the edges of these basins—SAT-1, JKF-8, and ALM-7. The intermittent occurrence of lakes in the Nefud

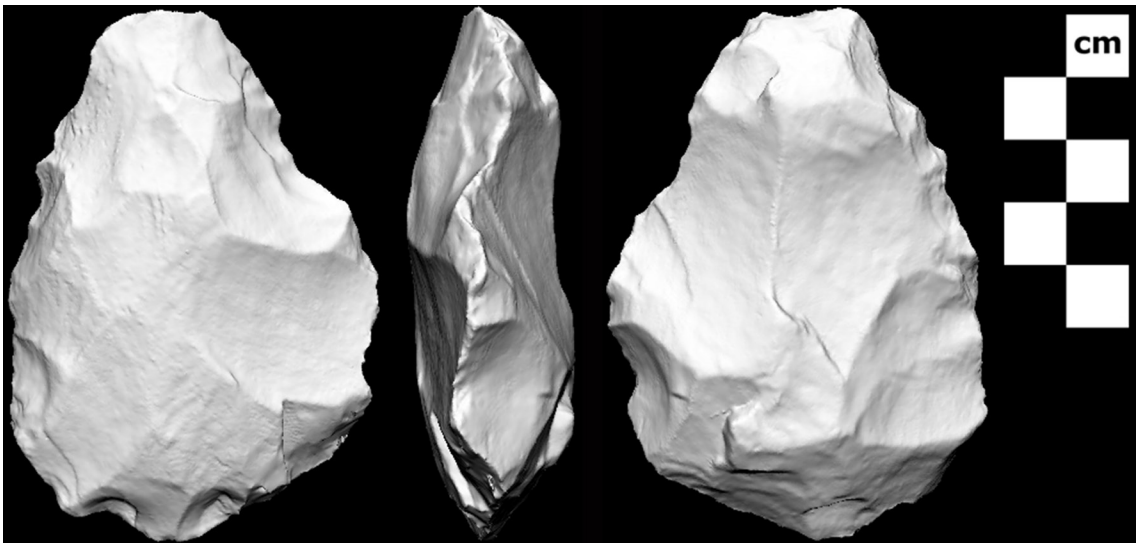

Figure 13. Fine-grained rhyolite handaxe from the off-site HUF-1. Note its small size and relatively high number of scars.

extending into the Middle Pleistocene would have presented opportunities for occupation by Acheulean hominins. The presence of cleavers as a major component of the biface assemblages and the use of large flake blanks at QAN-1 and ALM-7 allies them to the main Arabian Acheulean site complexes of Dawadmi and Wadi Fatima (Petraglia et al. 2010) and to the Levantine site of Gesher Benot Ya'aqov (Goren-Inbar and Saragusti 1996; Sharon et al. 2011). The use of diverse large flake blanks to create the cleaver bit and marginal trimming to shape the pieces is akin to the knapping strategies employed at Gesher Benot Ya'aqov. At Gesher Benot Ya'aqov, Afro-tropical fauna corroborates the hypothesis that this Large Flake Acheulean represents a new wave of Acheulean dispersal from Africa (Martínez-Navarro and Rabinovich 2011). The paleolake Hula deposits at the site of Gesher Benot Ya'aqov indicate hominin occupation there coincided with particularly wet phases in the Levant (Mienis and Ashkenazi 2011; Rosenfeld et al. 2004). Likewise, the large alluvial fan underlying the dunes at QAN-1 and the high level of the gypcrete mesa associated with the Acheulean at ALM-7 suggests the environment may have been far wetter during the Acheulean occupation around Jubbah than at any time since. Most of the Acheulean sites have low artifact numbers with the exception of the palimpsest workshop SAT-1. This is perhaps because the high magnitude climate events necessary to ameliorate this interior region were too infrequent to permit the kind of long term occupation witnessed at Levantine sites (Sharon et al. 2011). It may be that this was a landscape that hominins moved through rather than settled in.

The presence of Acheulean sites in the Nefud opens up new possibilities in our understanding of hominin dispersal routes between Africa and the Indian sub-continent. Plentiful Acheulean sites are known from India from the Early Pleistocene onwards (Pappu et al. 2011), but the dearth of sites between Arabia and the Levant means this dispersal is difficult to trace (see Figure 1). Acheulean sites in the Caucasus and near the southern shores of the Caspian Sea indicate a possible northerly route towards India (Biglari et al. 2004; Lyubin and Belyaeva 2006). However, the Nefud sites reported here suggest the possibility of a southerly expansion towards Mesopotamia. The reported presence of fluvial activity during the Early Pleistocene associated with major paleodrainage systems of the northern Arabian Peninsula raises a series of potential scenarios for riparian dispersal, although the dearth of high-resolution paleoclimatic data from the period makes spatio-temporal precision in paleohydrological reconstructions difficult. It seems likely that during more humid phases of the earlier Pleistocene, drainage could potentially have provided routes for hominins to disperse to or from the Nefud, along the Wadi Sirhan depression in the north, and to the west from the Red Sea coast along the drainage associated with Wadi al Hamd. Significantly, two major drainage systems also may have linked the region to the area of the Paleo-Tigris/Euphrates (Demir et al. 2007), in the form of Paleo Wadi Batin and its associated Dibdibba alluvial fan (Al-Sulaimi and Pitty 1995), and substantial drainage courses now partially buried beneath the Nefud dunes. While it is difficult to determine with any precision relative chronologies of the fluvial activation of these systems, their headwater positions, all draining either from the north-western highland region of the peninsula, or from highlands adjacent to Wadi Sirhan, may support a broad level of synchronicity in their activation (particularly in the case of Wadi's al Hamd and Batin, where the headwaters both derive from the same area). However, this is largely suppositional at present, and further securely dated paleohydrological as well as archaeological evidence is required to test these possible avenues for hominin dispersal.

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