Middle Stone Age and Early Holocene archaeology in Central Sudan: the Wadi Muqadam geoarchaeological survey

Article

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1. INTRODUCTION

The presence of the Nile Valley combined with the changing palaeoclimates of the Sahara (e.g. Drake *et al*. 2011) provide an intriguing landscape and palaeoenvironmental context to hunter-gatherer archaeology in Sudan. The Nile Valley, the Sahara Desert, and the western Red Sea coast fall within Sudan's borders and highlight the potential of its archaeology to inform understanding of the Out of Africa dispersals of the Early and Late Pleistocene (e.g. Van Peer 1998; Rose 2004a; Bailey 2009), because all three of these landscapes have been proposed as dispersal routes for Palaeolithic peoples out of Africa (Stringer 2000; Vermeersch 2001; Drake *et al*. 2011). The presence of key Green Sahara fluvial and lacustrine habitats such as Wadi Howar and the West Nubian palaeolake have also focused attention on Holocene hunter-gatherer strategies for the exploitation of now-arid environments (e.g. Hoelzmann *et al*. 2001; Keding 2006; Jesse and Keding 2007). Yet despite sustained interest in these issues, Palaeolithic and, to a lesser extent, early Holocene research beyond the confines of the Nile in Sudan has been relatively limited in recent times, in contrast to more extensive work along the valley (e.g. Van Peer *et al*. 2003; Rose 2004b; Usai and Salvatori 2005; Osypiński *et al*. 2011). This paper reports on the first phase of a new programme of fieldwork, exploring the distribution and palaeo-landscape settings of Palaeolithic and Holocene hunter-gatherer archaeology along a Saharan tributary of the Nile known as Wadi Muqadam.

1.1 Background

Sudan (defined here as incorporating both the Republic of the Sudan and the Republic of South Sudan) offers an opportunity to explore the impacts of climate, landscape and palaeogeography on hunter-gatherer behaviour during both the Pleistocene and the early Holocene. The variable aridity and wetness of the eastern Sahara in both the Pleistocene and the Holocene allows similarities and differences in the 'desert' landscape exploitation strategies of Palaeolithic and Mesolithic groups to be evaluated, while the role of Sudan in Pleistocene hominin dispersals can also be explored.

Usai and Salvatori (2005, 475) have emphasised significant gaps in the prehistoric sequences of central Sudan when compared to the north of the country, covering both the Palaeolithic and the early Holocene. This situation has been markedly improved along the Nile in recent times, particularly for Holocene prehistory, through their Is.I.A.O el-Salha project (e.g. Salvatori *et al*. 2011; 2014; Figure 1). The project identified *c*. 200 sites, from the Palaeolithic through to the Historical period, although preservation was highly variable and the majority of sites lacked stratified deposits (Salvatori *et al*. 2011, 179-180). Three aspects of the project are particularly noteworthy with regards to our own investigations:

(i) a series of radiocarbon dates associated with Mesolithic and Neolithic phases (Salvatori *et al*. 2011, tables 1 and 2);

(ii) the identification of an early and middle Holocene palaeoswamp to the west of Omdurman and the Nile, fringed by Mesolithic and Neolithic sites, and probably fed by seasonal Nile flooding and higher regional water availability during the Holocene African Humid period (Cremaschi *et al*. 2006; Salvatori *et al*. 2011, 205);

(iii) a characterisation of Mesolithic and Neolithic pottery based on new stratified sites, particularly at el-Khiday (Salvatori 2012; Salvatori *et al*. 2011, 195-200). While the el-Salha project has generated extensive new data, Salvatori *et al*. (2011, 208) note that their model's wider applicability can only be demonstrated by further work, particularly in light of the current lack of other well-stratified Mesolithic and Neolithic sites in central Sudan (dal Sasso *et al*. 2014, 139). Initiating such further work, and seeking evidence for early Holocene occupations at greater remove from the Nile Valley, was the first goal of the geoarchaeological survey of Wadi Muqadam (Figure 1) reported in this paper. Surveying Wadi Muqadam was of particular interest in light of the ACACIA project's (e.g. Keding 2006; Jesse and Keding 2007) key survey of the Wadi Howar region and characterisation of changing environmental conditions and shifting subsistence, settlement and material culture patterns through the Holocene. In the specific case of the West Nubian palaeolake, Hoelzmann *et al*. (2001) documented predominantly hunter-gatherer subsistence patterns and a sedentary or semi-sedentary existence along the margins of the West Nubian palaeolake during its larger, coherent phase (*c*. 6300–5300 ^{14}C yr BP [*c*. 5200–4100 cal yr BC]). This was followed by increasing aridity in the palaeolake environment, prior to abandonment of the area. The specific presence of Mesolithic and possibly Neolithic sites has previously been noted in Wadi Muqadam to the north west of Omdurman: the 1997 Omdurman to Gabolab SARS survey identified a number of sites on gravel beds close to the wadi channel. These were characterised by pottery, flaked and groundstone artefacts, molluscs, freshwater snails and fish-bones (Mallinson 1998, 43).

Figure 1 about here

Sudan also occupies an intriguing geographical position with respect to the African Palaeolithic and the dispersals which took hominins, both archaic and modern, out into Asia and Europe (Gamble 1993). This intrigue stems from current debates as to the areas occupied, and ultimately moved beyond, by hominins during the Old World dispersals of, respectively, the Early Stone Age (ESA; most likely *H. ergaster*) and the later Middle Stone Age (MSA; *H. sapiens*). Discussions have primarily focused on the Nile Valley and Delta, en-route to the Levant (Van Peer 1998; Vermeersch 2001), and the Bab-el-Mandeb Straits and the Red Sea coast, separating the Horn of Africa from the Arabian Peninsula (Rose 2004a; Bailey 2009; Armitage *et al*. 2011), although recent consideration has also been given to the potential role of Green Saharan routes (Drake *et al*. 2011; 2013). Sudan lies to the north west of both the Bab-el-Mandeb Straits (although it has an extensive Red Sea coastline) and the key ESA/MSA landscapes of East Africa (Ethiopia/Kenya/Tanzania; Clark, 1992), and is, therefore, an important region for testing the relative importance of the three different dispersal routes (Beyin 2006).

Despite this, published Palaeolithic research in Sudan has been relatively limited in recent years (but *cf*. Marks 1990; Idris 1994). The main other exceptions include: Van Peer's excavations at Sai Island in the Nile (Van Peer *et al*. 2003; Figure 2), which documented a sequence of inter-stratified Acheulean and Sangoan assemblages, overlain by Lupemban-related Nubian Complex material; Osypiński *et al*.'s (2011) excavations of Middle Palaeolithic-type material in a Late Palaeolithic context at Affad 23, in the Southern Dongola Reach; Nassr's (2014) survey of late cutting tool sites along Wadi Elhudi and Wadi Abu Adar in the lower reaches of the Atbara river;

Rose's (2004b) analysis of the MSA Station One site in the extreme north of Sudan (Figure 2; there is a much richer series of Palaeolithic sites across the border in Egypt; e.g. Van Peer and Vermeersch 1990; Van Peer 1998; see Rose *et al*. 2011, fig. 1 and table 1); and the re-dating of the hominin calvaria from Singa to the late Middle Pleistocene (Woodward 1938; McDermott *et al*. 1996; Figure 2). The 1997 SARS survey from Omdurman to Gabolab identified 12 Acheulean handaxes in Wadi Muqadam, to the north of our own survey area (Mallinson 1998; Smith 1998). Prior to this more recent attention, Marks (1968a, b and c) and Guichard and Guichard (1968) reviewed Acheulean, Middle Palaeolithic/Mousterian, Khormusan and Halfan industries in Nubia, from the Egyptian border to Firka, while Chmielewski (1968) reported Early and Middle Palaeolithic sites near Arkin (Figure 2: site 3).

A key earlier survey was Arkell's (1949a) review of the Old Stone Age (Palaeolithic) of Sudan, which documented a range of Acheulean and Tumbian (= Sangoan) assemblages along the Nile and Atbara valleys (Figure 2), while the University of Khartoum's archaeological expedition to the Middle Nile Valley in 1977 recorded handaxes and Levallois artefacts (Callow, unpub. man.; Figure 2: sites 9, 13 and 19). The clear outcome of this research is evidence for multi-period Palaeolithic occupations in Sudan, but also a very limited appreciation of the presence, or absence, of Palaeolithic activity beyond the immediate surroundings of the Nile (see also Nassr 2014, fig. 1). This latter issue is particularly important in light of current appreciations of palaeoclimatic variability in the Pleistocene and the extension of the Green Sahara concept prior to the Holocene (Osborne *et al*. 2008; Drake *et al*. 2011), both of which emphasise the potential for Palaeolithic occupations in areas of Sudan beyond the Nile. Evaluating this potential was the second key goal of our investigations.

Figure 2 about here

2. METHODOLOGY

Wadi Muqadam (Figure 1) is a left bank Nile tributary with headwaters in the semi-desert some 70km west of Khartoum. It then flows 300km north to join the Nile near Korti (Figure 2). Currently Wadi Muqadam is an ephemeral channel and only experiences significant flow following heavy rainfall, which is associated with northward movement of the African monsoon in the northern hemisphere summer. However, during wetter Saharan climate phases the monsoon was enhanced by increased insolation, moving much further north. Thus not only was rainfall higher but the wet season would have been much longer. This increased water supply activated rivers, and there is evidence from nearby Wadi Howar (another Saharan tributary to the Nile that flows into it 230km to the north of our study area) that flow was perennial during the early to middle Holocene (Pachur and Kröpelin 1987; Kuper and Kröpelin 2006):

"[In Lower Wadi Howar] diverse deposits indicate a chain of wadi sections and pools enabling intermittent river activity and overflows of one sheet of water into the next after seasonal or episodic flooding"

(Kröpelin 2007, 30)

Lakes in northern Sudan were also perennial during this period, suggesting extensive rainfall 800km further north than at present (Abell and Hoelzmann 2000). Pollen records from these lakes indicate that vegetation responded to this ameliorated environment with savanna woodlands dispersing 600km further north in response to

the increased rainfall (Ritchie and Haynes 1987). This suggests that during prolonged wetter climate phases, such as the early to middle Holocene and parts of MIS 5, Wadi Muqadam would most likely have experienced perennial flow and the surrounding environment would most likely have been a wooded savanna. Therefore, the palaeohydrology of the wadi responds to climatic changes in the Sahara Desert itself, in marked contrast to the Nile. The archaeological record should reflect this contrast, making the wadi a potentially important location for field survey.

To this end, a study area (Figure 1) was selected to cover the headwaters of Wadi Muqadam (from 15° 10’ to 15° 57’ N and from 31° 20’ to 32° 15’ E). This was to the south of the area of Wadi Muqadam covered in the previous SARS survey (Mallinson 1997; 1998). The region includes residual gravel terraces formed as Wadi Muqadam cut down into the Nubian Sandstone bedrock, along with several small (1–4km diameter) palaeolake basins, characterised by flat surfaces with small desiccation cracks, composed of silts and clays. Candidate sites for fieldwalking investigation were identified based on our palaeohydrological interpretation using a combination of multispectral Landsat Enhanced Thematic Mapper (ETM+) imagery, higher spatial resolution Google Earth imagery and digital elevation models (ASTER GDEM and SRTM3). The multispectral ETM+ images were processed to show the distribution of clays and hydrous minerals using band ratio methods (Jackson 1983). In the study area, this method successfully picks out areas which have accumulated clays and, when in conjunction with digital elevation data, can be used to map basins which may have held palaeolakes during previous wetter climate phases. An example of the image products used to find candidate sites in the study area is shown in Figure 3. In addition to palaeolake basins, we also targeted the riparian zone at points along the

Wadi Muqadam channel. Previous research has demonstrated that archaeological sites tend to be concentrated in riparian and palaeolake contexts in the Sahara (Reynolds 2006; Drake *et al*. 2011). However, not all sites were identified using satellite interpretations of the palaeohydrology. Whilst evaluating the Google Earth imagery we identified a number of possible tumuli cemeteries that we also investigated. Furthermore, when driving between selected locations we stopped at sites that were remote from any fluvial or lacustrine landforms in order to determine if archaeology was only associated with these features or was more widely distributed across the landscape. In total, 14 candidate sites were surveyed during fieldwork (Figure 1). Sites ND-36-B/9-R-100 and 101, ND-36-B/9-P-100 and ND-36-B/9-U-100 and 101 are in the basin of a palaeochannel that drains east through the Jebel Baroka region into the Nile, and are located immediately to the west of the early–mid Holocene palaeoswamp environment and associated sites mapped by Cremaschi *et al*. (2006).

Figure 3 about here

Reconnaissance fieldwalking surveys were undertaken at these candidate sites, with the archaeological methodology following those of Finlayson and Mithen (2007) in Jordan and Barker *et al*. (2007) in Libya. Artefacts were identified, categorised and photographed in the field, and were not removed from the sites. Flaked lithic artefacts were recorded and classified according to existing technological modes (e.g. Foley and Lahr 2003) and regional industry and artefact types (e.g. Van Peer 1998) to enable comparison with extant records from Sudan (e.g. Arkell 1949a; Marks 1987; Salvatori *et al*. 2011) and regions to the north and north west (e.g. Clark 1980; Van Peer 1991; Foley *et al*. 2013; Scerri 2013) and to the south and south east (e.g. Clark

1988). Pottery decorations were cross-referenced from the field survey's photographic record with identified types in the Wadi Howar and West Nubian Palaeolake regions (Hoelzmann *et al*. 2001; Jesse 2004), the Mesolithic and Neolithic types identified at el-Khiday (Salvatori 2012; Dal Sasso *et al*. 2014), and to the earlier material from Jebel Moya (Caneva 1991; see also Brass and Schwenniger 2013).

3. RESULTS

The site codes (after Hinkel 1977), settings and geomorphological background for each of the 14 surveyed sites, the majority of which were located close to fluvial and lacustrine landforms, are summarised in Table 1. The presence/absence of the major artefact categories (lithic and non-lithic) identified at each of the sites through surface reconnaissance is summarised in Table 2. Unmodified blades (typically proximal fragments) and flakes were found at nearly all of the sites, while retouched flake and blade tools, including unifacial and bifacial points, notches, denticulates and scrapers, and cores (Levallois, disc, blade and bladelet) occurred more occasionally. The most frequent period-diagnostic pieces consisted of Levallois cores, flakes and points and unifacial/bifacial points (MSA), and bladelet tools (early Holocene). The flaked lithic technology, therefore, primarily spanned modes 3 (Middle Stone Age/Middle Palaeolithic) and 5 (Microlithic), with the majority of the material assigned to mode 5. Holocene ground stone artefacts included grinding stones, quern stones and stone rings, and were frequently associated with pottery fragments, both with and without surface decoration. Small ostrich eggshell fragments, typically < 30mm, were also infrequently identified, but no other archaeological faunal remains were identified at any of the sites.

Table 1 about here

Table 2 about here

3.1 ESA archaeology (mode 2):

A single diagnostic Early Stone Age (ESA) artefact was identified: a thick, cordiform handaxe, associated with a gravel bar of the Wadi Muqadam at site ND-36-B/13-N-101. The handaxe was heavily water rolled, and was undoubtedly derived from an earlier surface. The absence of other ESA technology was notable, particularly in light of the rich Acheulean and Sangoan site of Khor Abu Anga at Omdurman (Arkell 1949a; Figure 2: site 10).

3.2 MSA archaeology (mode 3):

The Levallois cores included the classical centripetal flaking method (Van Peer 1991, fig. 3.3; Rose *et al*. 2011, fig. 2; Plate 1), with no evidence of Nubian Core types (Van Peer 1991, fig. 3.1–2) or of other diagnostic MSA artefacts (e.g. Aterian points). While two possible tanged or shouldered pieces were identified (site ND-36-B/13-O-106), these were not diagnostic (particularly in light of Scerri's [2013] argument that MSA tanged tools met a functional requirement and that their widespread appearance across northern Africa reflects technological convergence not a shared tradition). The cores were typically produced on relatively thin, tabular raw materials, and were usually less than 100mm in maximum dimension (length and width). This likely reflects local raw material limitations as well as the size requirements of the Levallois blanks, and is also in-keeping with Levallois flake core shapes and sizes documented previously in Nubia (e.g. Marks 1968a, 209, 222, 246 and figs 12d, 18b). The dorsal

scar patterns on the Levallois points (particularly at site ND-36-B/9-P-100; Plate 2) were of the preferential unidirectional-convergent type (Rose *et al*. 2011, fig. 2). Both bifacial and unifacial points were identified, particularly at site ND-36-B/13-O-106 (Plate 3).

Plate 1 about here

Plate 2 about here

Plate 3 about here

While surface collections always carry the potential risk of confusing MSA Levallois for later prehistoric core working techniques (Crassard 2009, 152), it was notable that the Levallois pieces were typically more abraded than other lithic artefacts found at the same sites. While we argue that condition should never be a primary dating tool for surface collections (but *cf*. Hardaker 2011), the association of the most abraded categories with the strongest candidates for diagnostic pieces (a single biface and the prepared core [Levallois] artefacts) was noteworthy in light of their typo-technological interpretation as ESA and MSA artefacts. The disc cores may also have been of MSA age, given the associated presence of Levallois cores and flakes at a number of sites, but it is recognised that they can occur throughout the majority of the African Plio-Pleistocene archaeological record (Barham and Mitchell 2008, 114-115).

The richest occurrence of MSA archaeology was at the palaeolake surface site ND-36-B/13-O-106, where the range of points (bifacial, unifacial and Levallois; Plate 3)

would seem likely to reflect animal hunting in this landscape. The geomorphology of this site (Figure 4) includes gravel ridges left by streams that once flowed into the basin, suggesting that this was an important local palaeohydrological feature. These ridges are up to 1m high, up to 4m wide and composed of fine to coarse gravel (2-60mm), overlying the flat silt/clay palaeolake surface. More generally the MSA artefacts were associated primarily, but not exclusively, with palaeolake margins, suggesting some shared landscape preferences with those of the early Holocene hunter-gatherers. Similar associations, between Middle Palaeolithic occupations and Pleistocene lake episodes, were also observed by Wendorf *et al*. (1987) at Bir Tarfawi.

Figure 4 about here

3.3 LSA archaeology:

One of the few diagnostic blade cores to be identified was relatively large in size (the three blade scars were each *c*. 20 x 60mm), and was the strongest candidate for a Later Stone Age artefact identified during the survey.

3.4 Terminal Pleistocene/Holocene archaeology (mode 5):

Backed bladelets, bladelet cores and bladelet core rejuvenation flakes were strongly suggestive of a terminal Pleistocene or early Holocene age. Although there were relatively few chronologically diagnostic Holocene lithics, the repeated spatial association of relatively fresh flake cores and unmodified/retouched flakes and blades with pottery and ground stone artefacts was strongly suggestive of Holocene ages for this material. A characteristic range of flake and blade-based retouched tools were

identified: scrapers, denticulates, notches, segments and piercers. The most diagnostic piece was a large lunate-shaped 'orange wedge' from site ND-36-B/14-P-100, of likely terminal Pleistocene or early Holocene age (after Marks 1987, fig. 3w and 4p, r and s). Very few complete blades were identified, suggesting their regular snapping and re-working, although other taphonomic factors cannot be ruled out. The general absence of diagnostic blade and bladelet cores was notable given the numbers of blade fragments observed. While limitations in raw material availability may have resulted in the extreme exhaustion of blade/let cores, the casual production of flakes and blades on irregular cores is supported by the nature of those cores which were found. Interestingly a combination of less patterned cores and skilfully made backed tools, using blade-like blanks, was also identified in the earlier Mesolithic phases at el-Khiday (Salvatori *et al*. 2014, 249). The general presence of blades was also noteworthy since Khartoum Mesolithic tools have previously been argued to be predominantly made on flakes, with blade production virtually unknown (Arkell 1949b; Marks 1987; but *cf*. Salvatori *et al*. 2014).

Pottery fragments occurred on over half of the sites (Table 2), although diagnostic pottery was less frequent and the overall character of the pottery samples was suggestive of mixed assemblages. Diagnostic pieces were identified on the basis of surface decoration. It has previously been noted in reference to Sudanese pottery that over-reliance on motif appearance rather than on the tools used to produce them can be problematic (Brass and Schwenniger 2013, 5). However, as it is not possible to identify the full range of those tools, an approach emphasising surface motif appearance can still be useful. The most frequently occurring decorations in our sample were:

- Dotted packed zigzag (made with a cord-wrapped implement producing the dashes; Plate 4b);
- Criss-cross pattern, combined with undecorated portions (Plate 4c).

Parallels with existing types were not clear-cut, but the dotted packed zigzag pattern may be compared to examples in Arkell (1949b, plates 75-76), Jesse (2004, fig. 3.3; packed zigzag, site Dreizack 95/2), and Salvatori (2012, fig. 16; rocker stamp drop decorations in a fan-like arrangement). Salvatori (2012, 410-414 and table 1) noted a consistent increase in rocker stamp drop decorations in the second phase of the el-Khiday site 16-D-5 (second and third quarters of the seventh millennium cal. BC), while Jesse (2004) associates the packed zigzag patterns with the Dotted Wavy Line (DWL) and Laqiya Horizon in Wadi Howar (*c*. 5200–4000 BC). However Jesse (2010, 230) has also noted that dotted zigzag patterns and horizontal lines of impressed dots and dashes are ubiquitous in the early Holocene (10^{th} and 9^{th} millennia BP [7^{th} and 8^{th} millennia cal. BC]) and not suitable for further differentiation.

Stone rings were also identified (Plate 5), along with grinding stone fragments. A small stone bead (Plate 6) was recovered at site ND-36-B/13-O-100, although its association with the other material at the site was uncertain.

Plate 4 about here

Plate 5 about here

Plate 6 about here

Holocene archaeology occurred at all of the surveyed sites. However it was most frequent either on higher ground overlooking palaeolakes, or around palaeolake margins, reflecting the importance of resource (e.g. game) observation and acquisition locations for Holocene hunter-gatherers. It occurred in lower densities on alluvial terraces and along channel margins. This raises the question of whether the apparently lower density of Holocene archaeology in alluvial settings along Wadi Muqadam reflects a genuine behavioural preference for lake-focused occupations, or rather the greater extents of alluvial channel margins: in other words, is a comparable amount of archaeology simply dispersed over a larger geographical area? The higher ground overlooking the channels and palaeolakes was also associated with tumuli of Holocene age, the largest concentration of which was located at site ND-36-B/9-U-100 and contained over 580 tumuli (Figure 5 and Plate 7). The specific chronology of these monuments currently remains unknown. While Salvatori *et al*. (2014, 248) have suggested post-Meroitic ages for the tumuli cemetery at site 16-C-2, the association of tumuli with older periods, such the Kerma phase in the region of the 4th and 5th cataracts, has also been suggested. Surface artefact finds were typically not distributed within or immediately adjacent to these burials.

Figure 5 about here

Plate 7 about here

4. DISCUSSION

The identified archaeology suggests favourable environmental conditions along the Wadi Muqadam headwaters in parts of both the early Holocene and the MSA (sub-stages of MIS 5?), as previously suggested further downstream for the early Holocene on the basis of *Tilapia spp*., *Pila wernei* and *Limicolaria cailliaudi* (Fuller 1998). During these periods hunter-gatherers exploited landscapes associated with both palaeochannels and palaeolakes, though they were not exclusively tied to these water sources, and when found near to palaeohydrological landforms there was an apparent preference for the latter. In these areas, sites were clearly associated with palaeolake margins, being either immediately adjacent, or on higher ground overlooking the palaeolake basins.

With regard to Pleistocene hominin dispersals, the character of the Wadi Muqadam Palaeolithic archaeology permits a preliminary exploration of modern humans and the MSA in central Sudan during the late Middle/Late Pleistocene. The associations of archaeology and palaeolakes clearly demonstrate the scope for living away from the Nile Valley at various different periods (Osborne *et al*. 2008 would suggest MIS 5e and Drake *et al*. 2013 both MIS5e and 5a, while Armitage *et al*. 2011 have identified wetter phases in southern Arabia in late MIS 6, 5e and 5a). Van Peer (1998, S120) has previously characterised the Middle Palaeolithic record of the Lower Nile Valley and adjacent deserts as consisting of the Nubian complex and the Lower Nile Valley complex (but see also Scerri *et al*.'s [2014, 208] critique of existing nomenclature and definitions of industrial units). The former is characterised by Nubian Core (Levallois) methods of point production (alongside classical Levallois methods of flake manufacture) and by distinctive tool types including bifacial foliates, Nubian endscrapers, Nazlet Khater points and truncated-faceted pieces. By contrast the Lower

Nile Valley complex is characterised only by Classical Levallois methods, with point-production methods unknown. Van Peer (1998, S115) also notes that from MIS 5e onwards the Nubian complex is found beyond the Nile Valley, in contrast to the Lower Nile Valley complex which remains, as its name suggests, restricted to the river valley. By contrast the Nile record in central Sudan has a more limited later MSA record, with Arkell (1949a) primarily documenting Acheulean (ESA) and Tumbian (= Sangoan; late ESA/early MSA material). However Van Peer *et al*. (2003) recorded Lupemban-related Nubian Complex material (overlying inter-stratified Acheulean and Sangoan assemblages) at Sai Island, while Osypiński *et al*. (2011) identified Middle Palaeolithic-type material at Affad 23. Nassr (2014) has also reported MSA material along the lower Atbara River. Finally Rose (2004b, 205) has argued that the Middle Palaeolithic (= MSA) industries of Sudan (e.g. the Nile-focused sites reported by Marks 1968a, b) are, with the exception of Station One, distinct from those of Kenya and Ethiopia. The exception of Station One is based on the presence of small bifacial foliates and ovates with flat, invasive retouch which (along with small unifacial points, sidescrapers and naturally-backed crescents) are argued to be reminiscent of East African late MSA sites (Rose 2004b, 211). This led Rose to conclude that:

"With the exception of Station One, eastern Sahara, and Sai Island assemblages, there is no compelling archaeological evidence demonstrating an early Upper Pleistocene movement of anatomically modern humans northward through the Nile Valley."

(Rose 2004b, 212)

Does our material from Wadi Muqadam support or challenge this picture? The MSA samples are reminiscent of the Lower Nile Valley complex (and the occasional finds from the University of Khartoum's archaeological expedition to the Middle Nile Valley; Callow, unpub. man.) in terms of Levallois core types. There is an absence of Van Peer's (1998) distinctive Nubian Complex elements, which have also been characterised by Scerri (2013, table 6; Scerri *et al*. 2014, table 1) at Kharga Oasis, Sai Island and BT-14 (e.g. Nubian point methods and long thin bifacial foliates; e.g. Scerri 2013, fig. 3). Specifically in terms of core reduction, the absence of Nubian Type cores might be suggestive of limited connections between the Wadi Muqadam region and northern Sudan/southern Egypt (following Rose 2004b). However caution should be exercised in the use of single Palaeolithic artefact types to infer diffusion or dispersal, rather than technological convergence (e.g. Will *et al*. 2015). The apparent paucity of ESA material (e.g. Acheulean and Sangoan) along Wadi Muqadam, in contrast to sites along the Nile of central Sudan (Arkell 1949a) and along the lower Atbara River (Nassr 2014), might also suggest different settlement histories in central Sudan between the ESA (Nile and Atbara-focused?) and the MSA (extending into the Sahara, as represented by Wadi Muqadam?).

Although unifacial and bifacial points were identified in selected Wadi Muqadam sites, these were not as diagnostic as the bifacial foliates demonstrated at a small number of other locations in northern Sudan (e.g. Rose 2004b, fig. 6a; Scerri 2013, fig. 3; Figure 2). While the distinctive Station One artefacts (Rose 2004b) have been linked to the sub-Saharan MSA of Kenya and Ethiopia (Clark 1988, fig. 6; Rose 2004b; Beyin 2006), unifacial and bifacial points occur elsewhere across northern Africa (e.g. at Arkin 5 near the Sudan/Egypt border; Chmielewski 1968), and it is thus

difficult to evaluate either northern or southern connections on the basis of the Wadi Muqadam examples. Their occurrence on sites along the wadi does, however, suggest hominin range expansion into currently arid landscapes during mesic environmental episodes (see also Rose's [2004b, 213] discussion of bifacial foliates in Oman).

Detailed chronological evidence for our Holocene material was limited, reflecting the surface character of the archaeology, the narrow range of pottery surface decorations and paucity of parallels with well-dated types, and the lack of stratified deposits. The dotted packed zigzag pattern might suggest occupations from the seventh millennium (in light of the el-Khiday dates from site 16-D-5; Salvatori 2012) through to the fifth millennium cal BC (in light of the dates for the Dotted Wavy Line and Laqiya Horizon in Wadi Howar; Jesse 2004), but these should be treated with caution. Nonetheless the character of the lithic cores and the backed tools and the presence of grinding stones and stone rings, combined with those packed zigzag pattern decorations, also suggest an earlier Holocene (Mesolithic) presence in light of the dated sequences from the el-Khiday sites (Salvatori *et al*. 2011; Salvatori 2012) and the Wadi Howar region (Keding 2006).

It is perhaps noteworthy that dates for the DWL and Laqiya horizons in the Wadi Howar, spanning the late 6th and 5th millennium BC (after Hoelzmann *et al*. 2001, 206–207 and fig. 11; Jesse 2004), are slightly younger than the dates for the second phase at el-Khiday site 16-D-5, although the lack of stratified sites thus far in our Wadi Muqadam survey do not permit an assessment of whether western or eastern (or both) connections are present. Nonetheless the apparent absence of later pottery styles such as the Leiterband and Halbmond-Leiterband (Jesse and Keding 2007) in our

newly identified sites is potentially noteworthy since Hoelzmann *et al*. (2001) associate those pottery phases with increasing aridity in the western Nubian palaeolake environment, prior to abandonment of the area. Jesse and Keding (2007) note that perennial water sources become more restricted throughout the Wadi Howar region as a whole during the Leiterband and Halbmond-Leiterband phase, although savannah-type vegetation persists, prior to the increasing aridity of the third millennium cal BC (associated with geometric patterns and mat-impression pottery). This raises the interesting possibility of a different palaeoclimatic regime in Wadi Muqadam, perhaps a more rapid onset of arid conditions? However such an interpretation must remain speculative prior to further fieldwork.

The co-occurrence of pottery, grindstones (wild plant food exploitation; Keding 2006) and flaked stone artefacts on the majority of Wadi Muqadam sites (Table 2), and their greater frequency on higher ground overlooking palaeolakes or around palaeolake margins, is in-keeping with Jesse and Keding (2007), who associated the Dotted Wavy-Line pottery phase with hunter-fisher-gatherer subsistence patterns and a sedentary or semi-sedentary existence close to watering places. This is also in-keeping with Salvatori's (2012) more general characterisation of the Khartoum Mesolithic as a pottery-producing hunter/gatherer/fisher occupation along the Nile Valley (see also Arkell 1949).

In terms of both periods, the mixture of early/mid Holocene and MSA archaeology in Wadi Muqadam is comparable to the recently reported Middle Palaeolithic and Neolithic sites associated with the Mundafan palaeolake in southern Saudi Arabia (Crassard *et al*. 2013). The Mundafan Middle Palaeolithic assemblages have been

suggested to date to wet periods of MIS 5, and to reflect a lacustrine adaptive focus in Arabia. It is possible that site ND-36-B/13-O-106 in the Wadi Muqadam represents a glimpse of a comparable strategy in Sudan.

The preliminary fieldwork conducted to date has also highlighted future research questions and aims, in particular:

(i) extending the survey westwards into, e.g. Wadi el-Malik, to test evidence for changing archaeological signatures on a wadi-specific and/or east–west transect pattern;

(ii) conducting further systematic surveys at the sites identified in Wadi Muqadam to date, map and quantify artefact distributions;

(iii) coring palaeolake sediments to assess chronology and palaeoenvironmental conditions.

5. CONCLUSIONS

The fieldwork reported here has made a first tentative step towards meeting current gaps in knowledge regarding both Pleistocene and early Holocene hunter-gatherer occupations of the currently arid environments of northern Africa (Drake *et al.* 2011; Groucutt and Blinkhorn 2013). The detection of MSA archaeology along Wadi Muqadam indicates the presence of hominins, presumably early modern humans, in regions of central Sudan beyond the main Nile Valley during a key period. These regions are to the west of the Bab-el-Mandeb Straits, and the chronological and spatial relationships with possible dispersals into Arabia and the Levant and/or across the Sahara are currently unknown. The rich Holocene record in Wadi Muqadam similarly demonstrates that the area's resources supported Mesolithic hunter/gatherer/fisher

occupations, with a comparable archaeological signature to the Wadi Howar region (Keding 2006), although the specific chronology cannot yet be resolved in terms of the regional context. For both periods, the demonstrated presence and distribution of archaeologically important palaeolakes, in particular, along Wadi Muqadam suggests a hydrological landscape in which, during favourable environmental conditions, a relatively stable hominin settlement would be feasible. Such contexts, alongside the MIS 5 riparian corridors and savannah grasslands mapped by Scerri *et al*. (2014, fig. 2) across north Africa, provide support for Green Saharan dispersal models, and for routes not tethered to major perennial rivers such as the Nile.

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