

Neolithic pastoralism in marginal environments during the Holocene wet phase, northern Saudi Arabia

Eleanor M.L. Scerri^{1,2}, Maria Guagnin^{3,2}, Huw S. Groucutt^{1,2}, Simon J. Armitage^{4,5}, Luke E. Parker⁴, Nick Drake⁶, Julien Louys⁷, Paul S. Breeze⁶, Muhammad Zahir⁸, Abdullah Alsharekh⁹, Michael D. Petraglia².

¹School of Archaeology, 36 Beaumont Street, Oxford, University of Oxford, OX1 2PG, UK.

²Department of Archaeology, Max Planck Institute for the Science of Human History, Kahlaische Strasse 10, D-07745 Jena, Germany.

³Freie Universität Berlin, TOPOI Excellence Cluster, Hittorfstraße 18, 14195 Berlin, Germany

⁴Centre for Quaternary Research, Department of Geography, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, UK.

⁵SFF Centre for Early Sapiens Behaviour (SapienCE), University of Bergen, Post Box 7805, 5020, Bergen, Norway.

⁶Geography, King's College London, Strand, London, WC2R 2LS, UK.

⁷ Australian Research Centre for Human Evolution, Environmental Futures Research Institute, Griffith University, Brisbane, Australia.

⁸ Department of Archaeology, Hazara University, Mansehra, 21300, Pakistan.

⁹Department of Archaeology, King Saud University, Riyadh, Saudi Arabia.

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Introduction

The transition from hunting and gathering to food producing economies in Arabia took the form of a shift to mobile pastoralism. Domestic livestock appears to have been introduced in the 7th millennium BCE (Drechsler 2007), when northern Arabia experienced ameliorated environments during the Holocene wet phase (Engel et al. 2012; Dinies et al. 2015). However, crop cultivation and other features traditionally

used to define the Neolithic do not seem to have been practised until the Bronze Age (see for example Magee 2014, Preston et al. 2012). This is in stark contrast to the Fertile Crescent, where the Neolithisation process was set in motion by increasingly sedentary groups, culminating in the control and domestication of both plants and animals (Bar-Yosef 2001). The architectural remains of sedentary communities - dwellings, storage facilities, and communal property - are highly visible in the archaeological record and have become iconic for the Neolithic of the Levant. In the ecologically more marginal areas of the Jordanian Badia, Neolithic communities adapted other economic strategies. Here, settlements were occupied seasonally, and subsistence was based on caprine herding, supplemented by hunting and opportunistic agriculture. Nevertheless, architectural remains attest to the construction and use of substantial dwellings throughout the Neolithic (Henry et al. 2003, Martin & Edwards 2013; Rollefson et al. 2014; 2016).

The Neolithic of Arabia is still poorly known, although the character of Neolithisation in this region has been the subject of considerable recent discussion (e.g. Crassard & Drechsler 2013 and references therein). Excavated sites are almost exclusively known from the Gulf coast, Oman and Yemen (see Magee 2014), although the Neolithic is also widespread in interior northern Arabia (Groucutt & Petraglia 2012), if currently not well studied. Neolithisation models have therefore had to infer population dynamics across vast distances and suggest a migration of Levantine herders during the Holocene humid period (Drechsler 2007; 2009).

In northern Saudi Arabia, the site of Al Rabyah in the Jubbah oasis features a lithic assemblage similar to Epipalaeolithic assemblages in the Levant (Hilbert et al. 2014). Similarly, the assemblage from the Jubbah oasis site of Jebel Qattar-101 contains el-Khiam and Helwan points, akin to those recorded in Pre Pottery Neolithic assemblages in the Levant, but produced by a rather different manufacturing method (Crassard et al. 2013a). The lithic record therefore provides tentative evidence for population interactions between Arabia and the Levant, although it remains unclear whether they are the result of population movements, or cultural diffusion.

Northern Arabia is also rich in rock art. In Shuwaymis, on the northern edge of the lava fields and wadis of the Harrat Khaybar, just south of Nefud Desert, Neolithic

imagery indicates that indigenous hunters adopted cattle herding (Guagnin et al. 2015). The rock art in the Jubbah oasis, on the other hand, while seeming to belong to the same engraving tradition, shows clear differences in content, particularly in a much lower frequency of cattle depictions. Here, the rock art is suggestive of a dynamic Neolithisation process in which local groups changed their subsistence patterns at different rates, and depictions of domestic goats potentially provide links to the caprine pastoralism typical for the Jordan Badia (Guagnin et al. 2017a).

Recent fieldwork in the Jubbah oasis led to the first discovery of a major Neolithic site at Jebel Oraf, where 170 hearths were found clustered along the edge of a palaeolake (Guagnin et al. 2017b). Two of the hearths were radiocarbon dated to around 7,200 thousand years ago (ka) and one of the excavated hearths also yielded tooth fragments of an adult *Bos* sp., probably domestic cattle. Both hearths appear to be the result of a single, small fire, and the site may have been used seasonally by pastoralists (Guagnin et al. 2017b). The complete absence of structural remains at this site is striking. This is in contrast to Neolithic sites in the Levant, which, with the single exception of the PPNB site of Azraq 31 in Jordan near the border with Saudi Arabia (Betts, 1989), all have structural remains.

Here we report the discovery of the site of Alshabah (field code WNEF16_6), a large hearth field located in an interdunal depression in the western Nefud Desert. The presence of numerous hearths at Alshabah with faunal remains and a substantial lithic assemblage, combined with an absence of structural remains allows the detailed investigation of desert Neolithic mobility patterns in northern Arabia. This permits an assessment of the role of the Nefud Desert in providing the connections between Arabian and Levantine Neolithic populations implied by material culture (Crassard et al. 2013a; Hilbert et al. 2014; Guagnin et al. 2017a).

Site description

Alshabah is located in a depression between two dunes and situated on the flank of a dune that slopes gently downwards towards a nearby ephemeral lake thought to date to the early Holocene (Breeze et al. 2017) (Figure 1; Figure 2a). The basin contains eroded remnants of older palaeolake sediments, which by reference to other

palaeolakes in the area (Rosenberg et al. 2013) and occasional scattered handaxes and large flakes in the basin, probably date to the Middle Pleistocene.

Low density fresh quartz and chert lithic artefacts were found along the eastern margins of the playa and on the slope above it. Deflated material from the eroding palaeolake outcrops, including ferruginous sediment clasts and lacustrine chert, are scattered across the basin floor. This material was used to construct hearths which are found in three major groups (Figure 2b, c).

Figure 1 Here

Here, we focus on the northernmost and the densest concentration of hearths, which we label Alshabah Area A (Figure 2). In Area A, 125 hearths were recorded using a DGPS system over an area of approximately 150 metres (north-south) by 80 metres (m) (east-west) (Figure 1). The hearths are simple, oval shaped surface features, typically half a metre in diameter, consisting of rocks collected from the immediate landscape. Many are highly eroded. It is likely that additional hearths once existed at the site but have now been completely eroded, with their clasts dispersed downslope. Wind erosion of the unprotected soft sediment between hearths has led to the subsequent localised spreading of hearth stones. It is therefore likely that additional hearths once existed at the site but have now been completely eroded, with their clasts dispersed downslope. However, the recovery of refitting lithics and a dense concentration of ostrich eggshell, in one case probably representing a single egg, demonstrate the integrity of the recorded deposits and features and the lack of long distance movement of material within the main hearth cluster.

Figure 2 Here

We conducted test excavations on three of the hearths in Area A, together with a systematic collection of artefacts, ostrich eggshell and bone fragments. The test excavations indicated a relatively shallow stratigraphy in the hearths, ranging from 0.3 - 0.5 m and featuring charcoal and ash lenses. At the shallow end of this range, a single burning horizon was observed. The hearths were surrounded by bone fragments, grindstone fragments and lithics (see technology, below). Two of the

hearths were also surrounded by ostrich eggshell fragments. Burned hearth stones were taken from hearths for optically stimulated luminescence (OSL) dating and radiocarbon samples collected in the form of charcoal recovered from the hearths and associated bone. The combined results of dating the hearths, analysis of the lithics and fauna from Alshabah offers the chance to shed new light on the Neolithic of northern Arabia.

Lithic Technology

A total of 862 lithic artefacts over 1 cm in size and grindstone fragments were recovered during the systematic surface collection over Area A (Table 1). The lithics were found at a moderate to high density (i.e. sometimes up to >5 per m²), in close association with the hearths. This stands in contrast to the surrounding landscape where only occasional lithics were found.

The lithic artefacts were made from an array of raw materials, including different types of quartz, quartzite, chert and sandstone. The majority of the raw materials are pebbles procured from fluvial sediments or a conglomerate setting. An exceptional raw material was an extremely fine-grained tabular chert derived from a flat seam. Quartz ranges from clear crystal quartz to coarse grained to pink veined forms. Quartzites range from very fine to coarse grained types. Cherts range from extremely high quality (in knapping terms) to poor quality locally derived lacustrine chert. On the basis of mineralogy, grain size and colour, raw material variation within clasts is high. Some of these raw materials are rare and consisted of single blocks or artefacts, while others are more abundant. Quartz and low quality lacustrine chert are known to occur locally throughout the area; quartzite of unknown origin is relatively frequent. The higher quality cherts are from unknown sources and potentially procured quite far from the site given that the local environs are characterised by sandstone bedrock underlying dunes. Variation in the size of raw material pebble/cobble size was also high (0.9 g-864 g), although all appear to be small clasts.

Technologically, the lithic assemblage is homogenous and not mixed with Palaeolithic artefacts. Flakes and cores are both typically small (\bar{x} =6 g, σ =13 for

flakes, \bar{x} =35 g, σ =103 for cores), and often feature some cortex, reflecting the frequent use of small pebbles.

Table 1 Here

Knapping was conducted on site, as shown by the variety of lithic forms, including knapping waste and the presence of refitting flakes and cores (Figure 3). Reduction intensity and recycling at the site is also high, but not extreme, as indicated by the weight differential between flake products (\bar{x} =10 g), core management flakes (\bar{x} =8 g) and cores (\bar{x} =35 g).

Analysis of the cores and flakes allows a reconstruction of the technological character of the assemblage. The cores, primarily globular and multiplatform in type, demonstrate a rather *ad hoc* character to lithic reduction. With respect to the earlier stages of manufacture, there are some indications of more structured, often radial, flaking (Figure 3c & 3e). Radially flaked quartz cores are flaked on one surface from a cortical platform surface. In contrast, multiplatform cores are more reduced, with more flake scars than the radial cores, and are flaked across all surfaces. Two cores also feature a degree of distal and lateral preparation prior to flaking (Figure 3g).

Analysis of the debitage indicates the presence of single platform/microblade (*sensu lato*) production. While two artefacts can be described as microblades, this laminar component is modest (Figure 3d), as indications of blade production are also limited from the analyses of cores and flake dorsal scar patterns. Therefore, while there is a certain consistency to lithic reduction at the site, such as the general lack of platform preparation, there is also some variation in the knapping methods being employed. The single platform/microblade production is somewhat concealed by cores being subsequently worked down and the products often removed from the site. However, it is also possible that the laminar component was introduced to the site at a different temporal phase of (albeit brief) occupation. This aside, the dominant character of the assemblage is clearly the production of flakes, rather than the production of blades/microblades. The use of the bipolar technique is evidenced by the presence of six splintered pieces and a possible anvil (Figure 4a). Cores and flakes bearing traces of bipolar flaking are all very small (\bar{x} =2.5 g), suggesting that the technique was used

to maximize the flaking of the small pebble cores. As with other features of the assemblage, this is consistent with an important influence of small raw material package sizes.

Figure 3 Here

Figure 4 Here

A total of 6.7% of the assemblage is retouched. Most of the retouched pieces are broken or seemingly reused in some way. The most common retouched artefacts are thick flakes retouched continuously along a lateral or distal edge ('scrapers', see Figure 4g). The laterally retouched pieces tended to be somewhat crudely retouched compared to the end retouched flakes. Other retouched artefacts include six large points (Figure 4b) and slugs (*limaces*), which may be classified as exhausted scrapers. A single, broken polished grindstone axe was recovered at the site. Battering damage suggests it was reused as an anvil (Figure 4d, see also 3D model Figure S1).

Perhaps the most striking group of retouched artefacts found at Alshabah were pieces that can be described as tabular scrapers (Figure 4c, see also 3D model Figure S2), all of which were made from the fine-grained chert originating from a thin, bedded seam. These tabular scrapers are thin, with a completely flat, wholly cortical and unmodified dorsal surface, indicating a single removal to produce a blank. The flake blank was then steeply retouched using pressure flaking at the margins (Figure 4c). In one case the scraper was cortical on both faces, attesting to the very narrow character of the seam. Unfortunately all of the four tabular scrapers found were broken at the narrow end, where the haft would have been. Removal of these scraper flake blanks has parallels in a fluted-like piece (Figure 4f, 3D model Figure S3), possibly a core, which is made of the same raw material. The fluting-like removal attests to the high level of skill by the knappers and the ability to produce very thin flakes. These tabular scrapers have parallels across the Levant and other regions of Arabia (e.g. Quintero et al. 2002; Gebel, 2013). They are most commonly associated with the Chalcolithic and early Bronze age (Rosen, 1983), but also occur in late Neolithic contexts (Rosen, 1984). They appear to be functionally related to pastoralism, and reflect the shearing of animals such as goats (e.g. Henry et al. 2017).

The absence of small points consistent with being arrowheads is also a striking feature of the assemblage. No arrowheads were found across the whole basin. The lithic assemblage from Alshabah instead seems focussed on ‘domestic’ tasks, a hypothesis supported by the presence of numerous grindstone fragments of various sizes (Table 1). Some of these fragments were very large blocks (with a volume of ~36-54,000cm³), suggesting that the grindstones they represent could not be transported off site. All the grindstones were made of pale yellow sandstone visually similar to sandstone outcropping immediately adjacent to the site. Smaller grindstone related artefacts include a possible grinder, a lozenge shaped object that may have been used by being rocked from side to side (Figure 5b). The edges of this object are smooth on the presumed grinding surface, while the top and bottom remain rough. Other sandstone objects include a possible loom weight fragment (Figure 5a), and a flat paddle-shaped piece (Figure 5c).

Fig 5 Here

Faunal remains

Several bone fragments were found on the surface and eroding from the hearths. The faunal remains were typically highly weathered and fragmented, and the majority of finds could not be identified beyond probable medium- to large-bodied mammals. The only exception to this was a single ulna fragment. Given its relatively poor preservation and the difficulties in distinguishing goat or sheep from this element (e.g. Prummel & Frisch 1986), we attribute the ulna to *Caprinae* gen. et sp. indet.

Chronology

The chronology for Alshabah Area A was established using radiocarbon and OSL dating techniques. The timing of hearth firing was determined via OSL dating of four heated rocks from separate hearths, following the method of Armitage and King (2013). In addition, a single charcoal sample from immediately underneath a hearth was radiocarbon dated, as were two uncalcined bones collected from the surface of Area A. Summary sample data and ages are presented in Table 2 (see also Supplementary Information and Figure S4).

Of the four OSL samples extracted from hearths, and which directly date hearth use, three are consistent with the age of the charcoal samples from Hearth 101 (7.24 ± 0.07 cal. BP). The remaining OSL sample (PD26 from hearth 101) displays no anomalous luminescence characteristics, but is inconsistent with the remaining OSL samples and the radiocarbon sample for Hearth 101. Consequently, the age for sample PD26 is regarded as incorrect and excluded from our analysis. The two uncalcined bones yield radiocarbon ages somewhat younger than the other ages from this site. Because these samples were not fired to a high temperature in antiquity and hence are age determinations on bone apatite, some offset between them and the charcoal and OSL sample ages is not unexpected (Zazzo & Saliège, 2011; Zazzo et al. 2012). Overall, the chronological work conducted at Alshabah Area A firmly dates human activity at the site to between 6.5 ± 0.7 and 7.3 ± 0.9 ka. This age range indicates that the site was occupied towards the end of the Holocene Wet Phase, when the Alshabah basin probably held a small, possibly seasonal, lake.

Table 2 Here

Discussion

The above analyses produce several key insights into the site of Alshabah, which suggest that it was used by Neolithic pastoralists. First, the site appears to have been occupied between 6.5 ± 0.7 and 7.3 ± 0.9 ka, towards the end of the Holocene wet phase. Records from Tayma, ~50 km west of the site, indicate that this is after the peak humidity of the Holocene wet phase in the area (Engel et al. 2012; Dinies et al. 2015), but a marl bed at Al Rabyah, Jubbah, dating to 6.4 ± 0.4 ka (Clark-Balzan et al. *in press*) indicates the continued availability of water in basins in the region. The overall trend towards aridification, leading to significant changes in vegetation and particularly a reduction in grasslands (Dinies et al. 2015), would have emphasized the importance of interdunal basins such as Alshabah in the mobility strategies of pastoralist groups. Such basins would have provided both grazing and access to freshwater, for at least part of the year. In this context, the presence of caprines at Alshabah is significant. The herding of caprines at southern Levantine sites such as Ayn Abu Nukhayla, Beidha, and Wadi Faynan in southern Jordan is well attested after about 10 ka (see Martin & Edwards 2013 for an overview). It is therefore likely

that the remains of Caprinae found at Alshabah, some 400 km south east of these well-known sites, are also likely to have been domestic. The presence of tabular scrapers, which have been linked to sheep shearing through use wear analyses elsewhere, may support this argument (Barket & Bell, 2011).

Arrowheads are absent in the lithic assemblage, indicating that hunting maintenance activities did not form part of the site activities. This is unusual, given that arrowheads were found at contemporary pastoralist hearth sites in the Jubbah oasis (Guagnin et al. 2017b), and given that hunting with bow and arrow is well attested in the rock art into the Bronze Age and later periods (Guagnin et al. 2017a). The lithic assemblage recorded at Alshabah may therefore be indicative of a more complex settlement pattern with multi-purpose camps in oases, and seasonal herding camps in interdune depressions where resources were more seasonal. Although grinding stones are common at Alshabah, evidence for the use of grains was not observed during excavations and inadequate phytolith counts were recovered for analysis. Moreover, blades are infrequent at the site and none of the lithic tools showed silica sheen. Thus, at present there is no evidence for the growing or harvesting of cereals at Alshabah. The weight of evidence therefore indicates that subsistence at Alshabah was likely based on caprine herding and foraging. Whether grinding stones were used for the manufacture of ground stone tools, or used for the processing of pigment or the processing of vegetable matter remains unclear.

The discovery of a possible loom weight suggests that the activities at Alshabah may have extended beyond herding and knapping. Together with the presence of grinding stones, the possible loom weight may indicate some form of longer term occupation, possibly extending to weeks and months rather than days. No structural remains are visible at any of the Arabian hearth sites that are currently known, suggesting that any form of shelter must have been extremely lightweight and ephemeral. Furthermore, the apparent random distribution of hearths may support repeated short-term occupations of small communities or family groups, relating to access to pasture and/or water. Similar seasonal movements driven by regional rainfall patterns and availability of pastures have also been described for the Late Neolithic in eastern Jordan (Meister et al. 2017).

Whether these camps were seasonal camps that acted as satellites to more substantial base camps (which have yet to be discovered), or whether they represent typical pastoral camps remains to be determined. In any case, it seems clear that these communities were well adapted to their surroundings. The lithic assemblage shows a generally consistent approach to reduction that was well adapted to the use of small clasts of raw material. The lack of arrowheads, the absence of distinctive southern Arabian forms such as trihedral points, the paucity of bifacial shaping, and differences with assemblages from the Levant which emphasised blade/microblade production also indicate that the people responsible for the Alshabah lithic assemblage had formed their own traditions within their particular environmental context. The diverse lithic raw materials are consistent with highly mobile communities accessing different geological exposures, perhaps aided by periodic exchange of particular materials, such as the high quality chert used to produce the tabular scrapers.

Consideration of Alshabah in broader geographical terms indicates that the site may reflect Neolithic subsistence strategies that are typical of the sand seas and deserts of the Arabian Peninsula. A similar hearth site was recently excavated in the Jubbah Oasis (Guagnin et al. 2017b) and eleven further sites are reported in the western Nefud (Breeze et al. 2017). Similar sites with hearths, and Neolithic stone technology have also been reported from central Saudi Arabia and from the Empty Quarter (Crassard et al. 2013b; Reeler & Al Shaikh 2015) but still await further investigation. Hearth sites therefore appear to form an element of the Arabian Neolithic that is specific to marginal environments during the Holocene wet phase and may form part of a wider economic strategy that maximizes exploitation of these areas.

The presence of caprines and lithics with affinities to Levantine industries in the oasis of Jubbah (Crassard et al. 2013a; Guagnin et al. 2017b) are more broadly indicative of continued connections between Arabian and Levantine populations throughout the Neolithic. Given their ability to exploit interdune corridors it is possible that contact was maintained across the Nefud Desert, potentially along similar routes that were still used by caravans in the 19th Century AD and provided a vital connection between the Levant and the Nejd (Euting 1896). However, despite similarities in lithic technology and subsistence, the Neolithic of Alshabah shows an adaptation to local resources and environmental constraints that is unique to pastoralists of the Nefud

Desert. Future research in the Nefud should seek to further understand the mobility strategies and socio-economic organisation of these marginal pastoralists, in particular because they may have played a key role in the Neolithisation of the region.

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Figures:

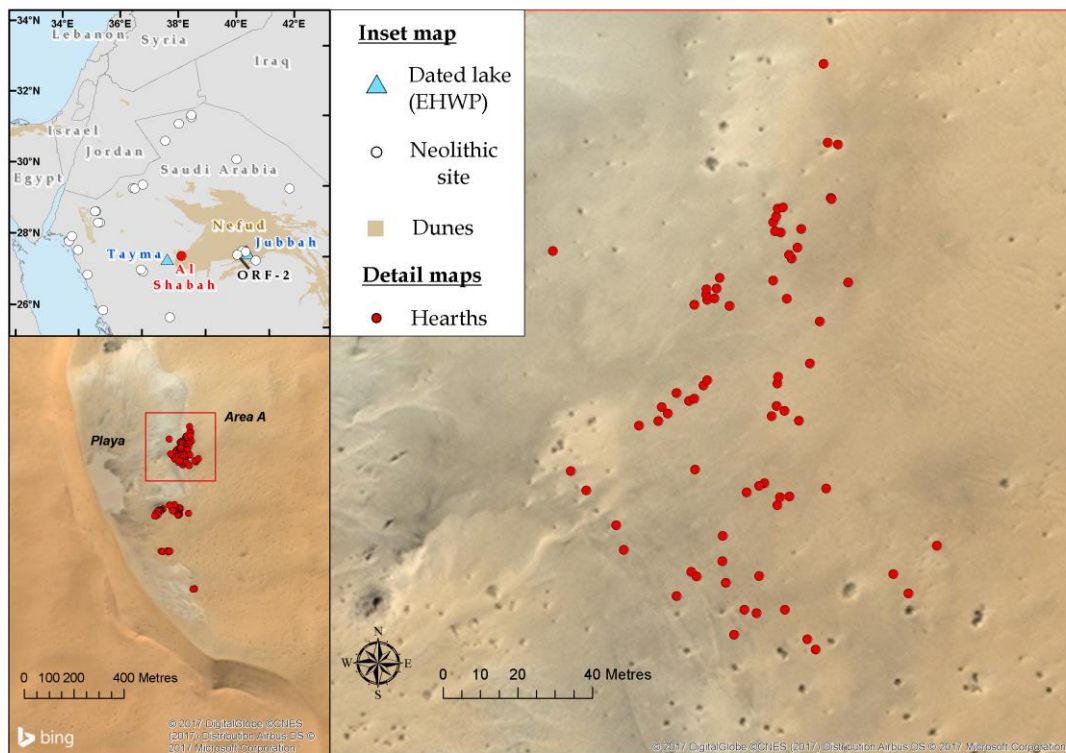


Figure 1: Map of Alshabah: Top left shows the site's location within Arabia, together with other Neolithic sites in the region. The bottom left shows the site's location in relation to the playa and modern dunes, with hearths marked in red. On the right is a detailed map of Area A.

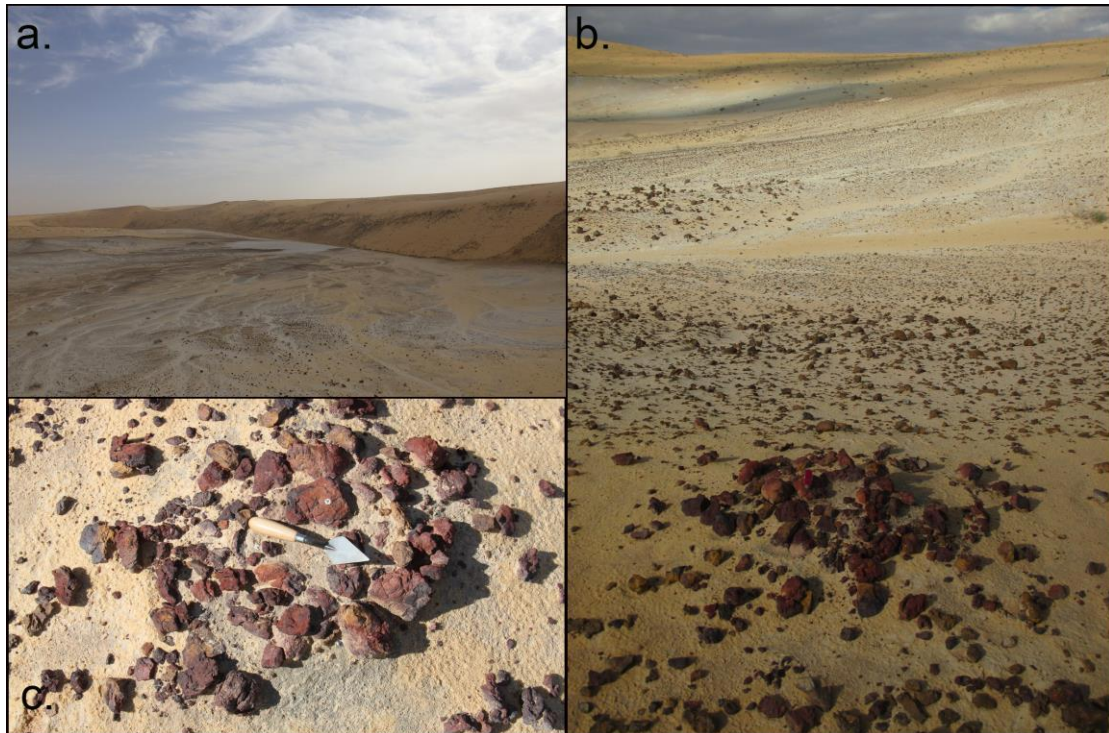


Figure 2: Views of Alshabah. a: playa beneath the site; b: example of a hearth together with the surrounding landscape on a pavement-like surface of deflated material; c: example of a hearth.

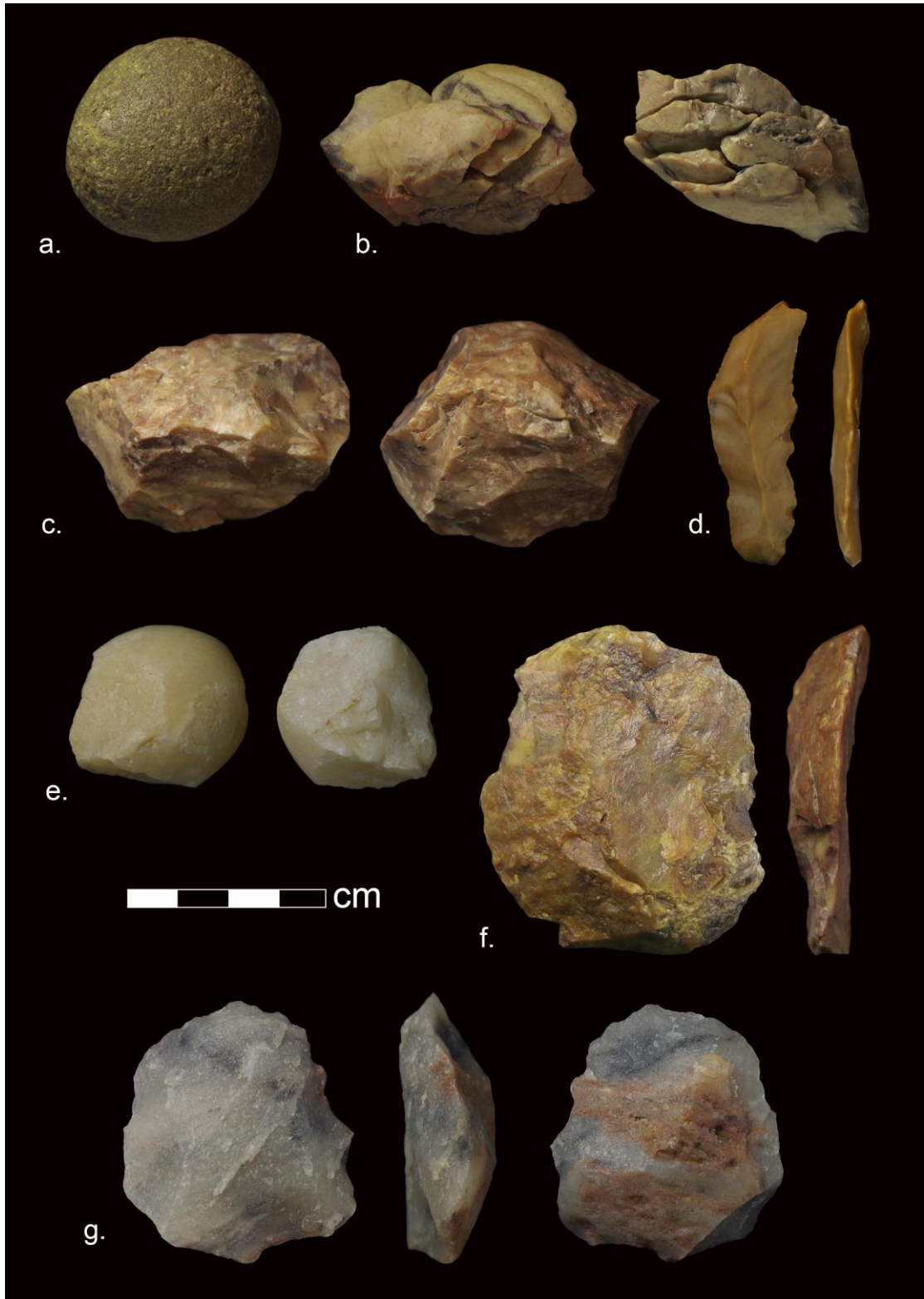


Figure 3: Cores, flakes and refitted sequences from Alshabah. a: Hammerstone; b: refitted quartzite core; c: radial core; d: flake blade; e: split quartz radial core; f: flake; g: distal and laterally shaped quartz core.

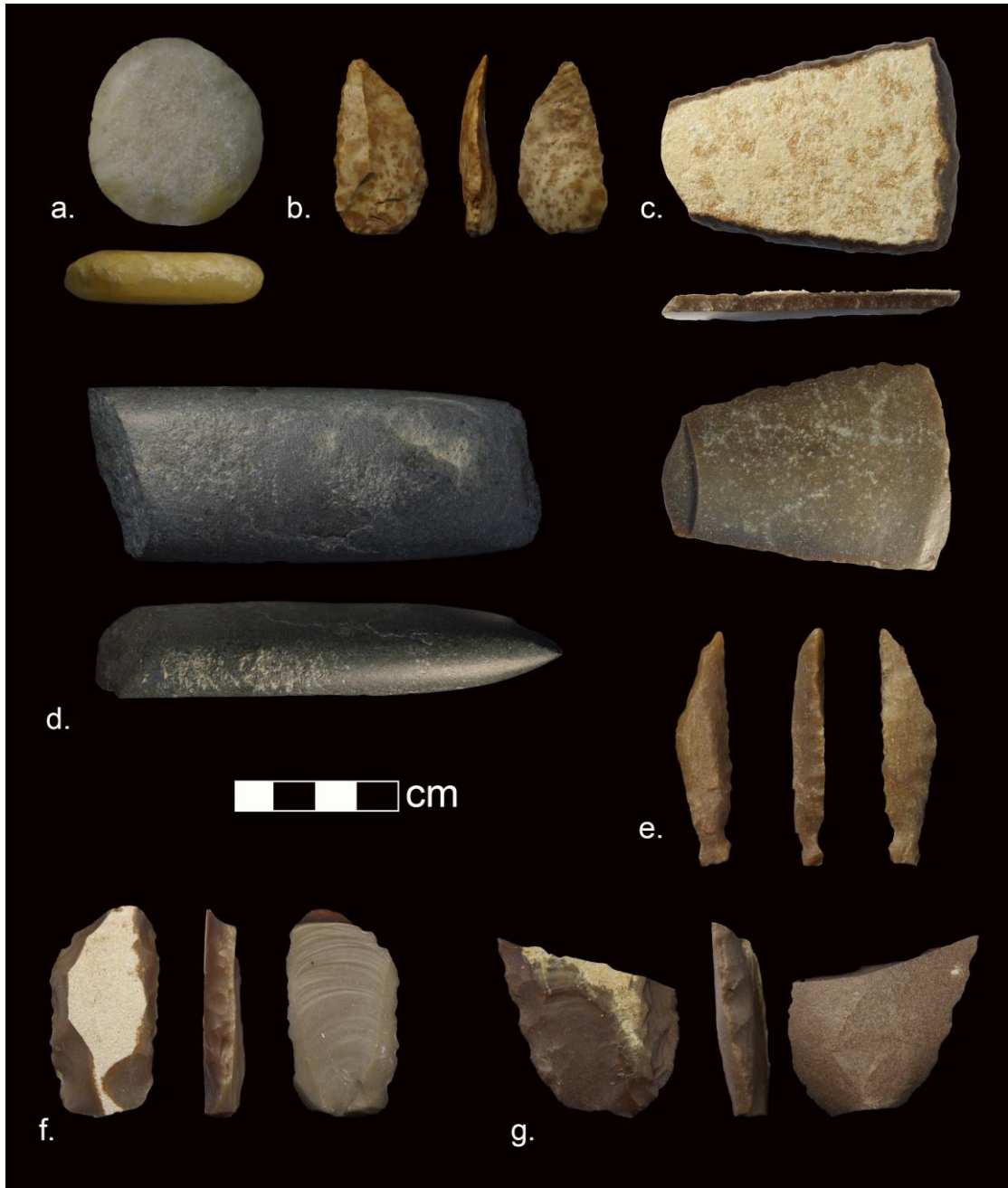


Figure 4: Retouched pieces and anvils from Alshabah. a: possible quartz anvil; b: retouched point; c: tabular scraper (broken); d: broken polished axe reused as an anvil; e: shouldered retouched pointed flake; f: fluted object; g: broken double-sided scraper.

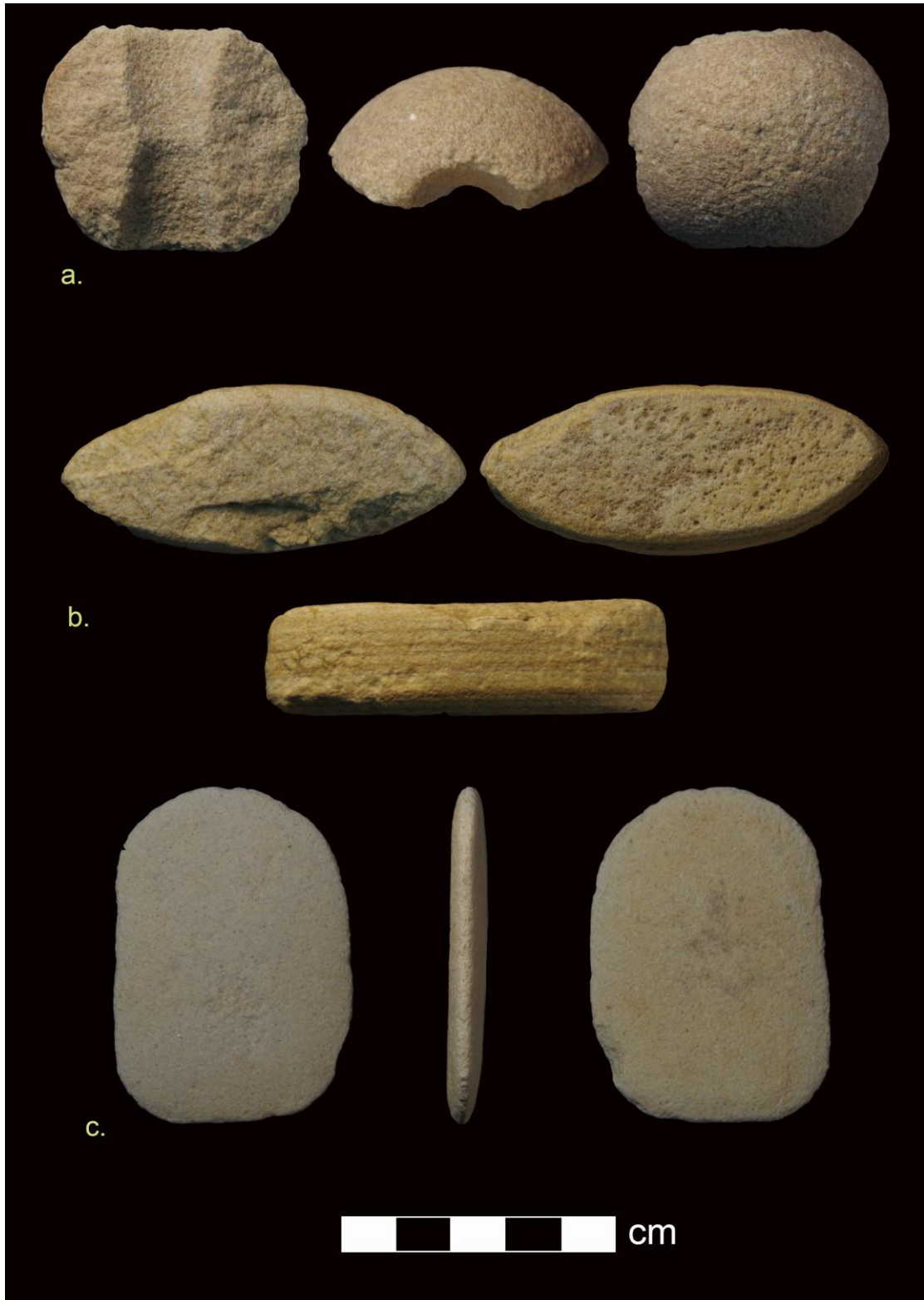


Figure 5: Sandstone artefacts found at WNEF16_6. a: Possible loom weight fragment; b: grinder; c: flat paddle-shaped piece, possibly used as a small grinding surface or an anvil for bipolar flaking.

Tables:

Table 1: Collected artefact classes with total numbers and percentages, following methods outlined by Scerri et al., 2014 and Scerri et al., 2016.

Artefact Class	Number	Percentage
Chips and chunks	89	10.3%
Flakes	554	64%
Blades	4	0.5%
Core Management Pieces	8	1%
Retouched Flakes	55	6%
Retouched Blades	3	0.4%
Bifacial Foliates	2	0.2%
Polished Stone Axe	1	0.1%
Grindstone fragments	17	2%
Loom weight	1	0.1%
Cores	122	14%
Hammerstones	4	0.5%
Anvils	2	0.2%

Table 2: Age estimates for samples from Alshabah Area A. Full sample preparation and measurement descriptions are provided in Supplemental Information Sections A (OSL dating) and B (Radiocarbon dating). OSL ages are calendar years before measurement date (2016) and radiocarbon ages are cal. BP. Uncalibrated radiocarbon ages are presented in Supplemental Information Section B. Discarded date is marked with an asterisk.

Context	Material	Lab. code	Method	Age (ka/ka cal. BP)
Hearth 42	Fired rock	PD31	OSL	7.3 ± 0.7
Hearth 69	Fired rock	PD28	OSL	6.5 ± 0.7
Hearth 101*	Fired rock	PD26	OSL	10.6 ± 1.1
Hearth 101	Charcoal	WK44320	Radiocarbon	7.24 ± 0.07
Hearth 104	Fired rock	PD27	OSL	7.3 ± 0.9
Surface	Uncalcined bone	S-ANU52619	Radiocarbon	6.14 ± 0.13
Surface	Uncalcined bone	S-ANU52619	Radiocarbon	6.25 ± 0.05