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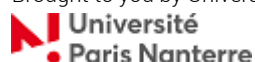
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Tracing Palaeolithic Populations across the Horn of Arabia: northern Oman

Amir Beshkani, Tara Beuzen-Waller, Seolmin Kim, Mathilde Jean and
Martin Sauvage

Credit authorship contribution statement: Amir Beshkani: conceptualisation, funding acquisition, investigation, archaeological and lithic analysis, writing. Tara Beuzen-Waller: conceptualisation, investigation, geomorphological analysis, writing. Seolmin Kim: fieldwork assistant. Mathilde Jean: co-director of the French Archaeological Mission to Central Oman (FAMCO), funding acquisition, project administration. Martin Sauvage: co-director of the French Archaeological Mission to Central Oman (FAMCO), funding acquisition, project administration, field topography.

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Histoire naturelle de l'Homme préhistorique” for the opportunity to join the team as a postdoctoral researcher.

Introduction

- 1 The Arabian Peninsula holds a crucial place in understanding human evolution and migration, as it has acted as a crossroads for populations moving out of Africa and into Eurasia (Marks 2010; Rose and Marks 2014; Petraglia et al. 2020; Bretzke et al. 2022). In recent years, Palaeolithic studies of this region have gained more attention as they provide a unique insight into human expansion patterns (Scerri et al. 2018). Concerning the first Palaeolithic populations in Arabia, two terms are often used to summarise the effect of climate change on the movement of hominin populations in the region: “Blue Arabia” and “Green Arabia” (Petraglia et al. 2019). “Blue Arabia” emphasises the coast as a possible migration route and rejects the idea of modern humans successfully living in ancient Arabia before 55,000 years ago, proposing instead that they only made short migration through the Arabian Peninsula while quickly reaching Southeast Asia (Mellars 2006; Mellars et al. 2013; Stringer 2000). Nevertheless, recent Palaeolithic surveys in coastal zones have not yielded significant evidence of human presence during the Late Pleistocene (Rose et al. 2019). As new Palaeolithic sites were found and excavated in inland zones of Arabia, the hypothesis of “Green Arabia” was put forward (Petraglia et al. 2019), arguing that the availability of diverse ecosystems and water bodies during favourable periods in the Pleistocene was crucial for the repeated expansions of hominins into terrestrial environments (Petraglia et al. 2020; Roberts et al. 2018). Results from a series of comprehensive investigations point to the presence of various Middle/Late Pleistocene localities in the south, center, and east of Arabia (Rose et al. 2011; Delagnes et al. 2012; Crassard et al. 2013; Usik et al. 2013; Crassard et al. 2019; Petraglia et al. 2020; Groucutt et al. 2021; Scerri et al. 2021). Studies on paleoclimate suggest that many of these sites date to periods of higher humidity occurring between approximately 240 to 190 ka or around Marine Isotope Stages 7 (MIS 7), 130 to 75 ka (MIS 5), 60 to 50 ka (MIS 4; early MIS3), and the Early Holocene Climatic Optimum (10 to 8 ka; Parton et al. 2018; Stewart et al. 2020a, 2020 b). New findings from the Palaeolithic rock shelter of Jebel Faya in Sharjah, however, show evidence of human occupation between MIS 7-6 peak interglacial periods, ranging from 210 to 120 ka (Bretzke et al. 2020; Bretzke 2022a, 2022b). Furthermore, archaeological evidence reported from the open-air site of Matafah in southern Oman (Dhofar), attests to the activities of an Upper Palaeolithic hunter-gatherer group during the onset of the Last Glacial Maximum around 30 ka (Rose et al. 2019a). This evidence supports the “Refugia Hypothesis” that was first proposed over a decade ago, postulating the possible existence of demographic reservoirs in isolated regions around the peninsula that could have sustained plant and animal populations during periodic climatic downturns (e.g., Parker and Rose 2008; Rose 2010). These discoveries reveal the need for finer scales of analyses, instead of linking local archaeological records with global climate proxies. To address this insufficiency and to fill the void in Palaeolithic studies in northern Oman, we resumed new fieldwork in 2021–2022, continuing our previous surveys in this region.
- 2 The French Archaeological Mission to Central Oman (FAMCO) was led by Jessica Giraud in 2007, and later by Guillaume Gernez, in the Adam region of north-central Oman.

Since 2021, the FAMCO project has been under the joint leadership of Mathilde Jean and Martin Sauvage, investigating the Bronze and Iron Ages of the area. Studies conducted as part of this research program in the Adam regions of Ad Dakhiliyah Governorate have led to the discovery of a number of archaeological sites spanning from the Neolithic to the pre-Islamic periods (Giraud et al. 2012; Gernez and Giraud 2019; Jean et al. 2021; Sauvage et al. 2022). The discovery and reporting of the first samples of lithic artefacts from the Sufrat Valley in the Adam region in 2010 prompted the development of a research branch of the FAMCO project to investigate the Palaeolithic evidence in the area. In 2013, Stéphanie Bonilauri¹ and members of the project began surveying Palaeolithic sites and, as a result, were able to identify three different localities: one Lower and two Middle Palaeolithic, determined by the presence of representative lithic artefacts or index fossils. In the continuation of Palaeolithic studies, the lead author of this paper conducted Palaeolithic surveys, exploring the palaeodrainage system and old terraces between the towns of Bahla and Bisya in 2016. This fieldwork has led to the finding of new late Middle Palaeolithic evidence with previously unknown lithic technologies, such as the "Epi-Nubian" industry, as well as probable Lower Palaeolithic (LP) techno-complexes with choppers, crude bifaces and large Kombewa artefacts in the Wadi Bahla. During the January 2022 expedition, we pursued our studies in a more coherent way around the Bisya region. We discovered 12 new lithic scatters/localities, ranging in size from a few hectares to several hectares, spanning the Lower Palaeolithic to Neolithic. Additionally, we conducted a test trench near the city of Al-Ma'mur, which revealed a stratified Late Palaeolithic site. Following the research methodology, we present the results of geoarchaeological studies and Palaeolithic surveys, divided into two geographical groups: findings recorded from the Adam region and newly discovered Palaeolithic evidence from the suburbs of Bisya and Al-Ma'mur cities. We will elaborate more on the latter, as they have not previously been published anywhere besides the report to the Ministry of Heritage and Tourism (MHT) of the Sultanate of Oman.

Research methodology

Geoarchaeological studies

- 3 The first step of our research involves a combination of satellite imagery, remote sensing, and ground surveys to identify sites and create a map of the study area. It involves the collection and analysis of sediment samples from stratigraphic layers at the identified localities and archaeological sites.

Archeological survey and excavation

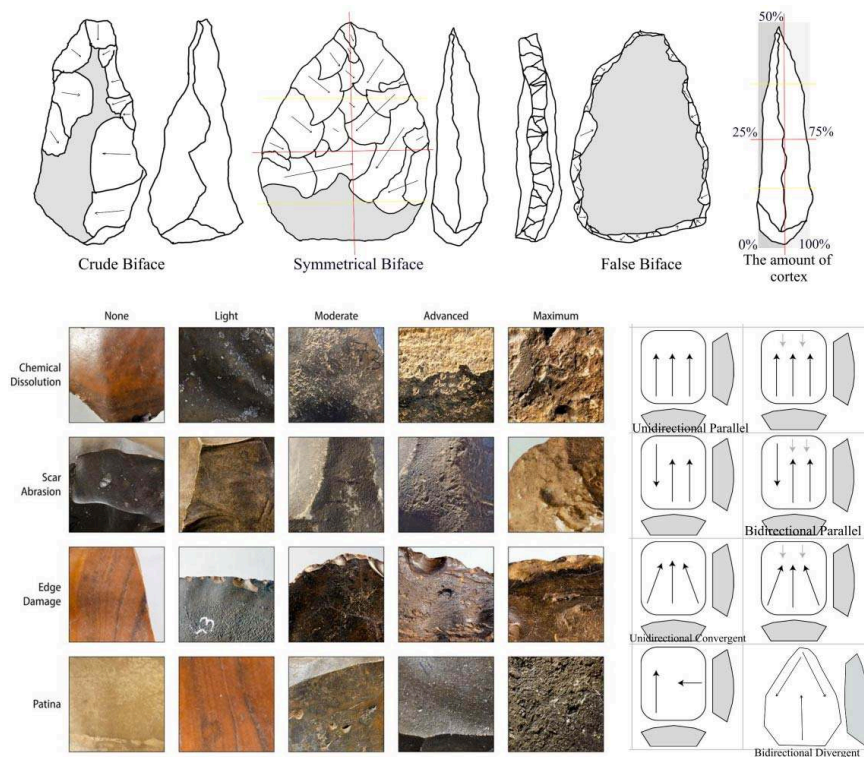
- 4 We used a total station to accurately record the spatial location of artefacts and visualise the distribution and relationships of the artefacts scattered on the surface, notably at the Al-Ma'mur 1 site.

Lithic attributes and statistical analysis

- 5 Attribute analysis involves identifying techno-typological characters, measuring the length, width, thickness, and amount of cortex on the artefacts, morphology, and raw material properties. Our analysis focused also on the mechanical and chemical damage

aspects, notably weathering. Weathering refers to the physical and chemical processes that alter the surface of an artefact over time due to exposure to environmental factors such as temperature, moisture, wind, and sunlight. In addition to techno-typological studies, we used the degree of weathering and surface alteration on stone tools as a way to gain a more comprehensive understanding of the relative age and cultural context of the artefacts (fig. 1). Our statistical analysis follows the nonprobability sampling method. We refrained from collecting a large number of lithic artefacts in the absence of archiving place. Although we acknowledge that this sampling can introduce biases into statistical analysis, we have chosen this method due to the inability to conduct random sampling and the need to collect artifacts based on representative criteria and accessibility.

Fig. 1 – Different techno-typological characters and weathering attributes analysed.



B. Mechanical/Chemical Damage; C. Debitage method of production.

A. A. Beshkani; B. J. I. Rose; C. After Pagli 2013.

Regional setting and summary of the geoarchaeological study

Physical context

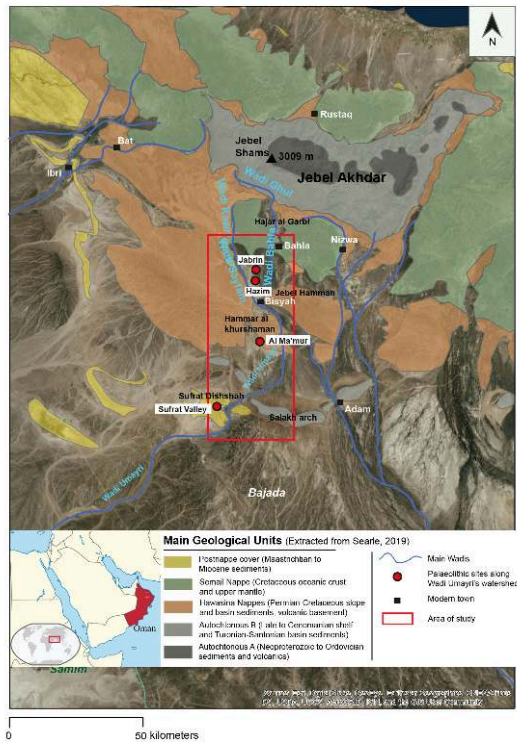
- 6 The study area is located between the modern town of Bahla, situated in the southern Hajar Mountains piedmont's high part, and the archaeological site known as "Sufrat Valley" (fig. 2; mesas at the beginning of the Rub' al-Khali lowlands).
- 7 The northern part of our study area, between Bahla and Al-Ma'mur, is a transitional area between the inner part of the Hajar Mountains (Bahla) and the piedmont area

(Bisya/ Al-Ma'mur; figs. 2–3). It is characterised by a large alluvial plain where Wadi Bahla and Wadi Sayfam are flowing, hereafter called “Bisya alluvial plain” in reference to the modern oasis of Bisya which is fed by the water of both wadis. An amphitheatre of mountains and hills in the northern, western and eastern parts of the plain surrounds the Bisya alluvial plain. Near Bahla, the dark-coloured hills of Hajar al-Gharbi (Samail ophiolites) are rising approximately 1,000 m asl. A similar height is maintained in the west with the Hamrat ad-Duru hills (Hawasina nappes). In contrast, the southeastern parts with Jebel Hammah and Jebel Khatmah (Hawasina nappes) do not exceed 570 m asl (Béchenec et al. 1986). The southern part of our study area is a transition zone between the piedmonts and the lowlands. The most important relief is the anticlinal chain of the Salakh Arch (1,000 m above sea level at Jebel Salakh), the last southern mountain fold before hundreds of kilometres of reg and the Rub' al-Khali basin connect. The Sufrat Valley archaeological site is located at the western flank of the Salakh Arch, in low marly mesas with flat-top summits locally called *sufrat*. The main mesa is the Sufrat Dishshah, overlooking the inner valley within the sufrats and the Wadi Umayri (Wadi Umayri) floodplain. The Wadi Umayri is the southern extension of the confluence between Wadi Bahla and Wadi Sayfam (see figs. 2–3).

Current climate and quaternary climatic fluctuations

- 8 The Hajar Mountains area experiences a strong rainfall-decreasing gradient from the inner part of the mountains to the lowlands due to the influence of orographic rainfall. In high-elevation areas, mean annual rainfall can reach approximately 300 mm/year (e.g., near Jebel Shams), and the climate can be classified as BSk (semi-arid – steppe – climate) according to the Köppen classification (Beck et al. 2018) or as semi-arid climate according to de Planhol and Rognon's aridity index (1970).

Fig. 2 – Main geological units of the study area.



Limits of the geological units and description extracted from Searle 2019; T. Beuzen-Waller.

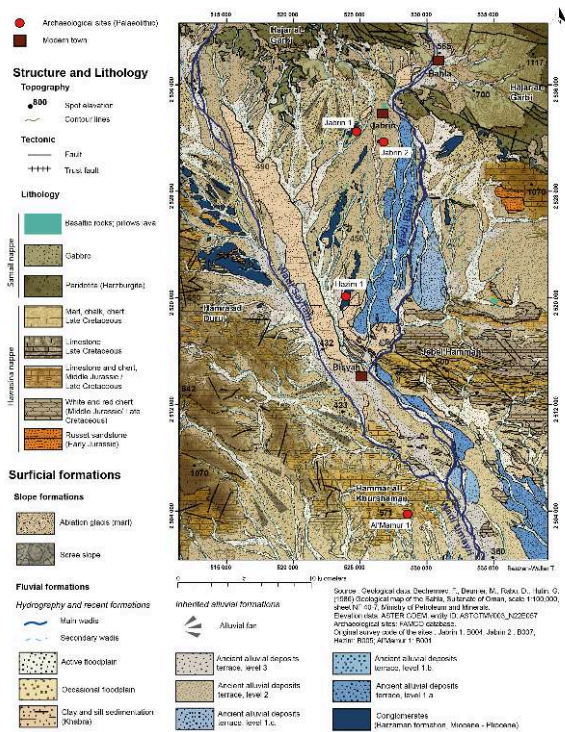
- 9 According to the same index, a climate with a mean annual rainfall below 150 mm/year is considered arid, and hyperarid with a mean annual rainfall below 50 mm/year. Both are included in the BWh group (desertic climate) according to the Köppen classification. The mean annual rainfall gradually decreases from the high to the low piedmont. In Bahla, mean annual rainfall is 100 mm/year, whereas near Adam, only 70 mm/year is recorded (climatic data provided by the data portal of the National Centre for Statistics and Information—Sultanate of Oman (data from 2004 to 2018). However, all main hydro-systems in these areas originate in the inner Hajar Mountains (e.g., Wadi Balha and Wadi Sayfam). Orographic-induced rainfall significantly influences the local environment, particularly vegetation cover. It generates cross-notable geographic disparities in humidity and fluvial dynamics and produces a mosaic of micro-landscapes with specific resources and timely responses to climate fluctuations. These discrepancies must be considered when reconstructing paleoclimatic/paleoenvironmental conditions between the inner Hajar Mountains and their piedmonts.
- 10 In Arabia, Quaternary climatic fluctuations alternated between arid and humid periods, which are not strongly correlated with glacial and interglacial periods. Rainfall variability is primarily linked to the migration of the Intertropical Convergence Zone (ITCZ) and, in Oman, the intrusion of monsoon rainfalls throughout the country, including the Hajar Mountains (Burns 2002; Fleitmann et al. 2003; Fleitmann et al. 2011). During the Pleistocene and Holocene's humid periods, rainfalls reactivated hydro-systems (Hoffmann et al. 2015; Breeze et al. 2016), interior lakes/wetlands (Rosenberg et al. 2012), interdunal lakes, and extended mangrove environments (Berger et al. 2013; Lézine et al. 2017). Increased moisture during pluvial periods

allowed for denser vegetation cover development and facilitated the circulation/occupation of animals and humans in areas that are now barren. In northern Oman and the Hajar Mountains, the best available climatic data are the speleothems from Hota caves. However, their growth relies on sufficient rainfall (~350 mm of annual precipitation; Fleitmann et al. 2003; 2011). As a result, a considerable range of rainfall remains undetectable, and the humidity range or fog that can occur during *khareef*-like seasons and significantly influence vegetation cover is not well understood.

Geomorphological survey in alluvial plain and main formations

- 11 In the southern piedmont of the Hajar Mountains, alluvial plains comprise a series of coalescing alluvial fans from the Pleistocene and Holocene, interbedded with the Barzaman Formation’s conglomerates. This sequence is interpreted as resulting from the uplift and erosion of the Hajar Mountains, forming an alluvial fan (Macklin et al. 2012; Mattern et al. 2022). A sequence of variably cemented conglomerates, thought to range in age from the middle Miocene to the Pliocene, dominates this rock formation. This formation has probably been created by the erosion and uplift of the Hajar Mountains, forming an alluvial fan succession. It forms a large *bajada* extending over distances above 200 km, which bounded the western edge of the Wahiba sands (Maizels 1987).

Fig. 3 – Geology map of the main wadies in the area of study.



T. Beuzen-Waller.

- 12 In this *bajada*, several generations of inherited alluvial fans or fluvial terraces testified that during the humid periods of the Pleistocene, surface flow could extend far downstream, joining the Gulf of Filim or the Umm al-Samim sabkha (Beuzen-Waller

2020). At the scale of a hydro-system watershed, aggradational terraces are mainly located in the upstream part and degradational terraces in the downstream part. In the downstream part of the hydro-systems, the oldest fluvial terraces are better preserved along with the Barzaman Formation. Fluvial remains from the Bisya alluvial plain and the Salakh Arch area testify to the impressive landscape evolution over the last 500,000 years. The Barzaman Formation is highly eroded in the Bisya alluvial plain, while there are remains in the distal part of the Wadi Bahla and Wadi Sayfam floodplain and in an interfluvial position (see fig. 3). Those formations are stable since the beginning of the Quaternary.

- 13 The trunk part of the Bisya alluvial plain shows at least three “orders” of alluvial terraces, ranging from the Middle Pleistocene to the Holocene in (relative) age, and designated respectively, from the older and the higher one as T1, T2, and T3. T1 presents various colour surfaces or degrees of desert varnish; we divided it into T1a, T1b, and T1c (from the higher to the lower ones). According to Blechshmidt et al. (2009), major periods of alluvial deposition and fan building are related to humid phases and a northward shift of the ITZC and monsoonal precipitation. Several fluvial remains along Wadi Andam have been dated through OSL by Blechshmidt et al. (2009) and it reveals major aggradation phases during the Middle Pleistocene, notably during the MIS 15 (621 to 563 ka), MIS 11 (424 to 374 ka), MIS 9 (337 to 300 ka) and most of all during MIS 7 (243 to 191 ka). As far as we know, no age-dating is available for fluvial remains in the Bisya alluvial plain, but according to similar patterns between the Wadi Andam fluvial terraces and T1 formations (about +10 m of incision, well-developed desert varnish, large dark pebbles), we assume, as a working hypothesis, that T1 alluvial deposits also date back to the Middle Pleistocene. We further assume that the surface of these formations were stabilised at the beginning of the Late Pleistocene. This assumption, however, requires testing through absolute age dating. Near Adam, recent studies on T2-like alluvial formations (about +3 m of incision, extended palaeoflood plain, desert pavement lighter in colour, rare desert varnish, better sorting; Beuzen-Waller 2020) provide three OSL dates (in the Nordic Laboratory for Luminescence dating): 119 ± 8 ka; 117 ± 9 ka, and 98 ± 10 ka. Those chronometric data validate a phase of alluvial aggradation during the MIS 5 (130 to 80 ka) even if those pluvial periods are not well registered by the Hota cave speleothems (Fleitmann et al. 2003; Fleitmann et al. 2011).
- 14 Finally, several recent studies supported the possibility of fluvial aggradation during the Holocene Humid Period (Fuchs and Buerkert 2008; Urban and Buerkert 2009; Beuzen-Waller et al. 2022). We thus suppose that at least part of the T3 deposits are related to a Holocene aggradation phase. Hence, this formation is likely unsuitable for preserving Palaeolithic remains. The estimation of the depositional age of T3 deposits from the Bisya alluvial plain has been initiated and is still ongoing.

Knapping raw materials availability

- 15 The southern region of the Hajar Mountains provides an abundance of knappable rocks and lithic raw materials, such as chert and basalt, suitable for producing stone tools. These outcrops are easily accessible due to differential erosion and deflationary processes. The Jabrin 1 site (B004) is located on the conglomerates of the Barzaman Formation which consists of cemented boulders of peridotite or gabbros. The artefacts

found on the top of this formation are made of basaltic materials. It is suspected that the pillow lava formations, located 250 m away from the sites, may have been exploited. The Al-Ma'mur and Sufrat Valley archaeological sites contain a wealth of chert artifacts. Chert outcrops can be found in abundance in many formations of the Hawasina nappes and in the so-called neo-autochthonous post nappe cover, either in veins, screes on slopes, or nodules. The Al-Ma'mur 1 site is situated on chalky limestone; micritic limestone with chert nodules of the "Sid'r" Formation (Béchenec et al. 1986), a "Si1 LC-Si2" member. The Sufrat Valley archaeological sites' mesas are from the "Fiqa" Formation (Aruma Group), specifically "Kfql" and "Kfq" members. "Kfql" is described as "bioclastic calcarenite and calcirudite, slumped chalk, subordinated green marl," and "Kfq" as "greenish to yellowish shale, whitish marl, and chalk" (Wyns et al. 1992). Chert nodules and veins have been identified within calcarenite units. The chert is brown to grey, homogeneous fine material with few fractures. Outcrops can be found at the top of all mesas where the highest density of artefacts has been registered (in some places 80 artefacts/sq. m). The Fiqa Formation is also a key regional seal unit for Oman's Cretaceous hydrocarbon reservoirs (Al Rawahi and Dunkley Jones 2019), making the Sufrat Valley archaeological sites vulnerable to oil surveys.

Palaeolithic records from the Adam region

- 16 In the 2013 survey of the Sufrat Valley, regional surveys by car, on foot, and satellite imagery were employed to identify and target potential Palaeolithic sites (Gernez and Giraud 2019). It is estimated that the lithic artefacts can be found over an area of about 10 sq. km suggesting that the Sufrat Valley area has been extensively occupied by Palaeolithic populations over time. This intensive occupation is likely due to the abundance of accessible chert outcrops.

Lower Palaeolithic localities in the Sufrat Valley

- 17 Our knowledge and understanding of the Palaeolithic of northern Oman has greatly improved over the past ten years. The primary studies, concerning the Lower Palaeolithic techno-complexes in northern Oman, include a techno-typological analysis of the artefacts found from the southeastern foothills of the Sufrat Dishshah to the lowlands of the valley between the Sufrat Dishshah and the other sufrats (*suftrat*: local name for mesas; Bonilauri et al. 2015). The Palaeolithic area called the Sufrat Valley can be generally divided into two distinct zones, depending on the topography, lithic scatter density, and the relative age of the lithic industries. The lower slopes of the Sufrat Dishshah display few artefacts with Lower Palaeolithic techno-features, while the flat-topped elevation of the sufrats are characterized by numerous artefacts displaying Middle Palaeolithic techno-features. From the sufrats, one can get a view of the main watercourses within Wadi Umayri. The study of the reduction sequence, the techniques employed to set up the cutting edge, as well as the physical and chemical evidence on the surface of some artefacts, such as intense weathering and the extent of the edge's erosion and damages, have led to the conclusion that the handaxes found on the slopes of the Sufrat Dishshah belong to the oldest phase of human occupation in the Adam region (Bonilauri et al. 2015). Although these industries may not be as old as the

Acheulean handaxes reported from East Africa, they are still characterised by certain techno-typological features that are present in the Acheulean techno-complex. Furthermore, the production of these handaxes is marked by a combination of large, elongated flakes and a few flake cores, which usually have one striking platform and a single flaking surface, and different percussion methods encompassing hard to soft percussions (Bonilauri et al. 2015).

Middle Palaeolithic localities in the Sufrat Valley

- 18 Around the Sufrat, the Middle Palaeolithic techno-types are marked by an abundance of Levallois cores, indicative of the manufacture of different contours and morphologies of flakes. Furthermore, recurrent Levallois techniques, including centripetal, bidirectional, convergent, and unidirectional methods, are seen in the Middle Palaeolithic industries (Bonilauri et al. 2015). During the 2016 field season, a brief visit to the Sufrat area was made in which diagnostic cores with "Epi-Nubian" techno-features were identified, and a small number of them were then collected (Beshkani et al. 2017a). This technology of elongated point production can be summarised under the concept of the Levallois configuration. However, a number of techno-morphological characteristics make these collected cores different from the previously reported Middle Palaeolithic cores at Sufrat, demonstrating a specific sequence of reduction. The additional studies have yet to be fully published, which is largely due to the disruption caused by gas and oil exploration and drilling activities in the area of sampling.

Palaeolithic records from the Bisya region

Lower Palaeolithic localities in the Bisya region

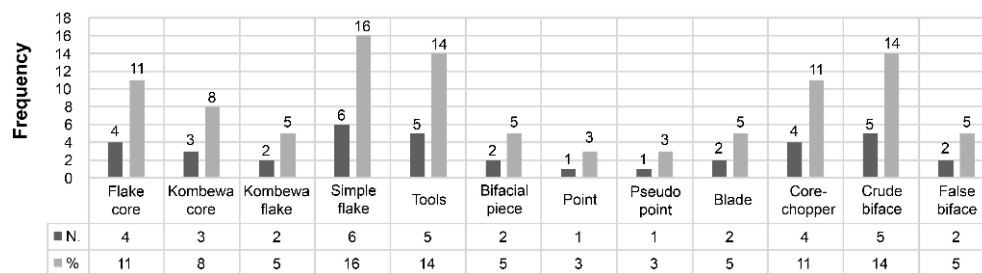
- 19 The Wadi Bahla serves as a connection between the towns of Bahla and Bisya and may be characterised by a series of Pleistocene terraces belonging to the Barzaman Formation. The lithic industries found in this area are distinct from those in the Adam region, both technologically and morphologically. In contrast to the Palaeolithic sites in the Sufrat region, where fine-grained cherts and flints are prevalent, the stone tools found on the Barzaman Formation are primarily made from coarse-grained and volcanic rocks like basalt.

Jabrin 1

- 20 In 2016, our study revealed the production of large flakes utilising the Kombewa method. These artefacts were primarily produced from large basalt boulders sourced from the Barzaman Formation. Specifically, at spot Jabrin 1 (B004), the large Kombewa flakes displayed two opposed bulbs of percussion or two ventral faces (Beshkani et al. 2017b). Additionally, some of these large flakes were used as cores for the production of a second Kombewa flake. Despite being identified five years ago, this technique of flake production remains unknown and has not been reported anywhere else in Oman. As such, during our 2022 campaign, we focused on studying thirty-seven (n=37) artefacts² collected from the same spot in order to establish a more reliable comparative

chronology (see fig. 4). After an initial analysis, the lithic artefacts found at Jabrin 1 can be broadly categorised into two distinct techno-cultural groups, although most are made of basalt. Roughly 70% of the artefacts collected fall within the techno-features associated with the Lower Palaeolithic period, which have also been reported in other regions of Arabia. These include core-choppers (11%), crude bifaces (14%), and simple flake cores (11%). However, we also observed several instances of more recent artefact types, such as blades (5%) and points (3%), indicating that Jabrin 1 was occasionally visited by later Palaeolithic populations as well. Throughout our survey, we only discovered one small (3 cm) Levallois core with the bidirectional method of production. The core was made of red chert and had undergone significant weathering. It is worth noting that we have excluded any Neolithic chipped stones from our study, which are readily identifiable on the surface due to the distinct colour of their chert material.

Fig. 4 – The techno-types registered from Jabrin 1 (B004).

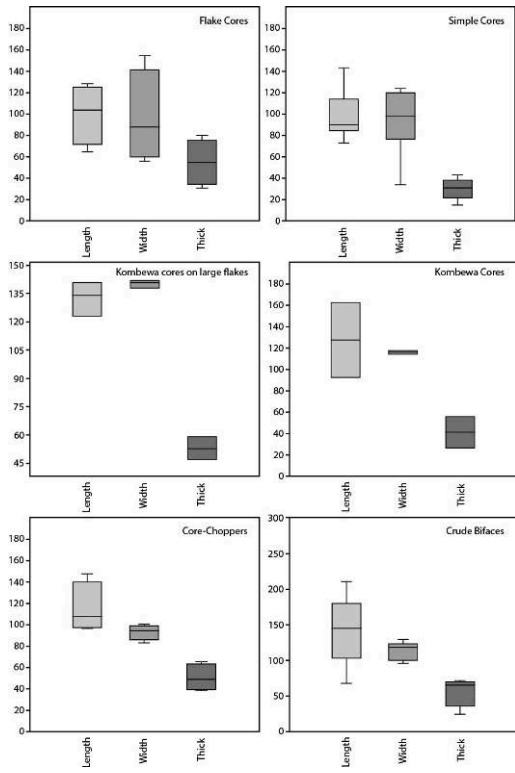


A. Beshkani.

Flake cores from Jabrin 1

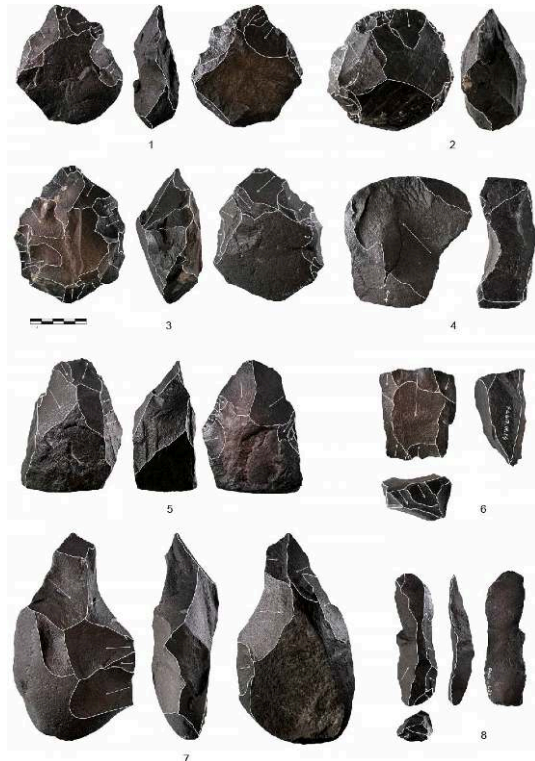
- 21 Based on the recorded flake cores from Jabrin 1, the unidirectional method is the most frequently utilised technique for flake production. However, other methods such as centripetal and bidirectional are also present among the reductional sequences found at this location. At Jabrin, the primary raw material used for making unidirectional cores is large basalt pebbles, some of which are as large as 40 cm. There seems to be little to no core platform preparation. Flakes are typically produced through the use of a hard hammer and direct percussion. Usually, the flake cores undergo partial knapping, with around 30–40% of the cores retaining cortical texture (table 1; fig. 5). The results of metric studies indicate that in Jabrin 1, the widest part of selected pebbles is typically used as the platform, with flakes being released from the narrow surface of the pebble or core.
- 22 About 70% of the cores have a greater width than the length in terms of dimension, leading to the production of wide and relatively round simple flakes. This characteristic can also be observed in the metric analysis of the simple flakes as well. Although the mean dimensions of simple flakes are 94 mm in width and 98 mm in length, approximately 75% of the simple flakes are wider than they are long. Additionally, the average length and thickness of the striking platform of the simple flakes are 68 mm and 28 mm respectively, as shown in figure 5.

Fig. 5 – Metric characters of main techno-type artefacts registered from Jabrin 1.



A. Beshkani.

Fig. 6 – Some artefacts registered from Jabrin 1.



1, 3, 7. Crude biface; 2, 5. Core-chopper; 4. Kombewa core; 6. Bidirectional core. 8. Blade.

A. Beshkani.

Table 1 – Additional data related to the flake cores, Jabrin 1.

Core (ID)	Scars	Cortex %	Scar Abrasion	Edge Damage	Raw material	Patina Face 1	Patina Face 2
L4	Bidirectional	40	Moderate	Moderate	Basalt	Moderate	Moderate
L14	Unidirectional	30	Advanced	Advanced	Basalt	Light	Advanced
L18	Unidirectional	30	Light	Moderate	Basalt	Moderate	Moderate
L17	Centripetal	20	Light	Light	Basalt	Light	Light

Table 2 – Additional data related to the simple flakes, Jabrin 1.

Flakes (ID)	Dorsal Scars	Striking Platform	Cortex %	Shape	Scar Abrasion	Edge Damage	Raw material
6	Semi-Cortical	Cortical	40	Ovate	Moderate	Moderate	Basalt
L6	Cortical	Plain	50	Semicircle	Light	Moderate	Basalt
L12	Centripetal	Plain	30	Triangular	Advanced	Advanced	Basalt
L15	Cortical	Plain	50	Semicircle	Moderate	Moderate	Basalt
L16	Centripetal	Dihedral	0	Triangular	Moderate	Moderate	Basalt
L20	Unidirectional	Plain	0	Triangular	Light	Light	Basalt

- 23 The analysis shows that simple cortical flakes have a slightly higher rate of cortex compared to the flake cores from Jabrin 1. This suggests that the reduction sequence was short, and the production system has not progressed beyond the production of a limited range of simple flakes (e.g., three or four flakes). Therefore, we can estimate a significant correlation between the unidirectional flake cores and simple flakes (table 3). The majority of collected artefacts are somewhat in good physical condition with an edge damage rate of occasionally advanced. The fact that these artefacts were found on Barzaman conglomerate with a small amount of physical damage suggests they probably were not exposed to surface flow and have not been rolled several times. It is worth noting that artefacts with Lower Palaeolithic techno-features exhibit different patterns of weathering on each side, which indicates that they have been lying on the ground on one side for an extended period of time. Specifically, the surfaces in contact with soil are characterised by a yellowish patina, while the sides facing the sun are glossy and exhibit desert varnish.

Table 3 – Minimum, Maximum and Mean of the flake cores and simple flakes, Jabrin 1.

	Length	Width	Thickness
Flake Cores			
Minimum	65	56	31
Maximum	128	154	80
Mean	100	96.25	55.50
Flakes			
Minimum	73	34	15
Maximum	143	124	43
Mean	98	94	30.16

Kombewa cores on large flakes from Jabrin 1

- 24 Large Kombewa flakes are divided into two technical categories, including primary large flakes that possess two bulbs of percussion which are also used as cores for producing flakes, and secondary flakes that have a lenticular profile which are the result of that production (see Beshkani et al. 2017b). While the primary large Kombewa flakes are elongated in shape in certain instances, the secondary flakes have a wide morphology. The average length and width of large Kombewa flakes, without any secondary flakes (large blanks), are 127 mm and 116 mm respectively. The mean thickness of these flakes is approximately 41.5 mm. Conversely, the large Kombewa flakes that were utilized as cores have a greater thickness (mean 53 mm) and width (140.3 mm) compared to the large blanks, as presented in table 4. The disparity in dimensions between these two sub-groups may imply a reduction in the size of the Kombewa cores to produce secondary flakes.

Table 4 – Supplementary metrics evaluation of the Kombewa flakes and the Kombewa cores, Jabrin 1.

	Length	Width	Thickness
Flake Cores			
Minimum	123	138	47
Maximum	141	142	59
Mean	132.66	140.33	53
Flakes			
Minimum	93	114	27
Maximum	162	118	56
Mean	127.50	116	41.50

- 25 The average striking platform width of the large Kombewa flakes is approximately 63 mm, while their thickness is around 47 mm. The platforms appear to be plain and show no signs of preparation. Kombewa cores may be partially cortical in certain instances, with two distinct patinas, a yellowish colour on one side and desert varnish on the other.

Core-choppers and crude bifaces from Jabrin 1

- 26 Around 30% of the assemblage collected from Jabrin 1 (fig. 4) consists of artefacts based on shaping (Façonnage), including crude bifaces (14%), partial bifaces (5%), and core-choppers (11%). This frequency is significant when compared to other techno-types. These artefacts, not only in terms of their mechanical/chemical damages, notably weathering, but also from a technological perspective, have many technical similarities with industries attributed to the Lower Palaeolithic, which have been reported from neighbouring regions such as southern Oman (Rose et al. 2019b, p. 31. TH.501a), central Arabia and Yemen (Amirkhanov 1994; Djebel Tala 1 and 2, Al-Garb VII). The metric characteristics of the collected core-choppers and crude bifaces have been summarised in tables 5–7. These two techno-type artefacts are manufactured exclusively from

basalt pebbles. According to the metric examination, the core-choppers and crude bifaces have an identical mean thickness of 55 mm. However, the bifaces are almost 3 cm longer in dimension than the core-choppers.

Table 5 – Metric units, analysis of Core-choppers and crude Bifaces, Jabrin 1.

	Length	Width	Thickness
Core-Choppers			
Minimum	97	84	39
Maximum	148	101	66
Mean	115.5	93.75	51
Flakes			
Minimum	68	96	24
Maximum	211	129	71
Mean	142.2	113	55.2

Table 6 – Supplementary metrics data related to the core-choppers, Jabrin 1.

Core-Choppers (ID)	Length mm	Width mm	Thickness mm	Cortex %	Scar Abrasion	Edge Damage	Patina Face 1
2	117	84	56	50	Light	Moderate	Advanced
L5	100	95	43	60	Moderate	Advanced	Advanced
L7	97	95	66	20	Moderate	Advanced	Advanced
L8	148	101	39	40	Light	Moderate	Moderate

Table 7 – Supplementary metrics data related to the crude bifaces, Jabrin 1.

Crude Bifaces (ID)	Length mm	Width mm	Thickness mm	Cortex %	Edge Damage	Patina Face 1	Patina Face 1
L2	112	104	41	10	Moderate	Advanced	Advanced
L3	149	129	48	40	Light	Moderate	Advanced
L13	211	118	71	30	Light	Moderate	Advanced
L19	138	118	69	30	Moderate	Advanced	Moderate
L23	145	96	64	40	Moderate	Advanced	

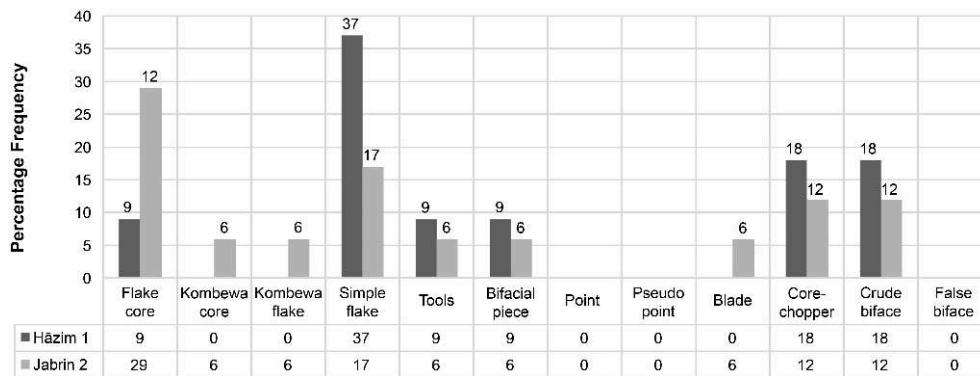
- 27 Upon examining tables 6–7, it becomes evident that core-choppers have a greater amount of cortex compared to other techno-types since their reduction is limited to only one edge. In contrast, crude bifaces have less cortex as they undergo multiple removals from both sides, resulting in a longer sequence of reduction than core-choppers.

Hazim 1 (B005) and Jabrin 2 (B007)

- 28 In 2022, our survey included visits to additional locations in the Wadi Bahla, aimed at gaining a better understanding of the diversity of lithic industries present on the Barzaman fluvial conglomerates. As previously stated, we purposely refrained from extensive artefact collection until we have the necessary storage in the region. All the surveyed ancient terraces of the Barzaman Formation displayed strong evidence of LP techno-type lithic technology. After discovering several heavily weathered and

significant stone artefacts on one of these terraces, we collected only 11 artefacts from a 100 × 100 m isolated location, which we have named Hazim 1 (B005). Additionally, we collected 17 representative artefacts from one isolated hill registered as Jabrin 2. This small hill is actually a portion of an ancient terrace that has not been completely buried under recent deposits. This hill is located approximately 2.7 km southeast of Al Maha petrol station³ in a straight line, and its area does not exceed an oval of 150 × 100 m, with a height of about 9 m from the surface. However, it has a significant density of stone artefacts, with approximately 3 artefacts per square meter, which are technically similar to those found at Jabrin 1.

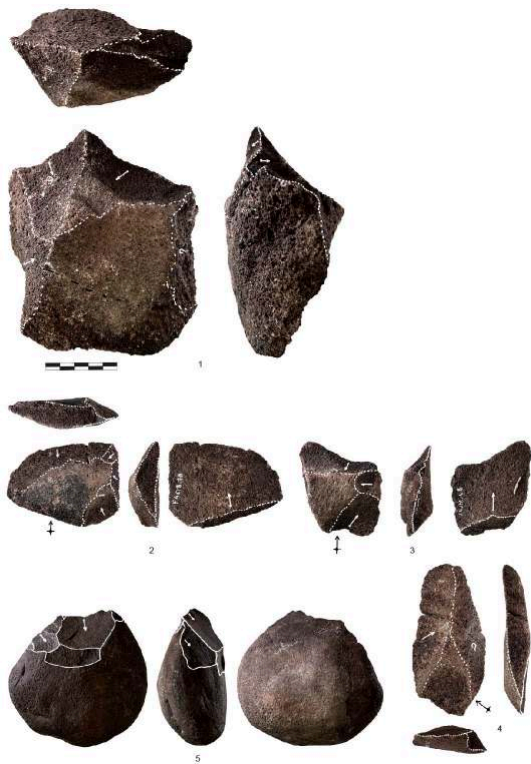
Fig. 7 – Percentage of the techno-types registered from Hazim 1 and Jabrin 2.



A. Beshkani.

- 29 Although the discovered stone artefacts on the Barzaman Formation along Wadi Bahla are mixed, we can draw some preliminary conclusions. For instance, we have observed the absence of Middle Palaeolithic techno-types, such as those reported from the Sufirat locality or the newly discovered locality at the delta of Wadi Halar (B008) located 4 km west of Bisya.

Fig. 8 – The representative artefacts registered from Hazim 1 (B005).

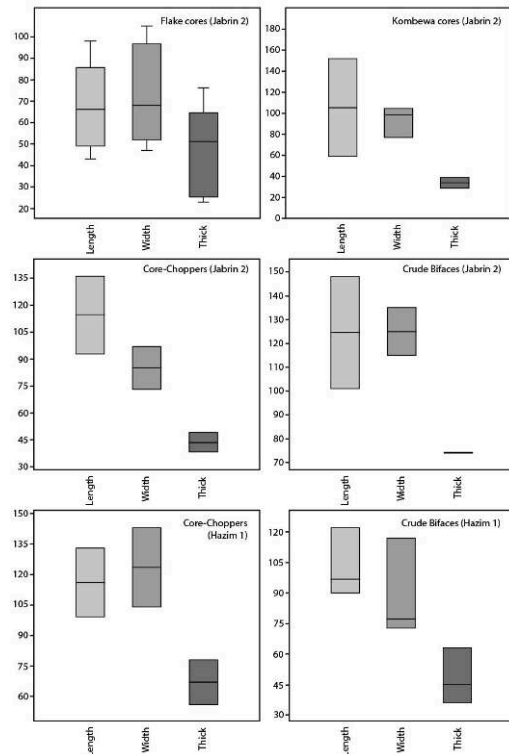


1. Flake core; 2-4. Flakes; 5. Core-chopper.
A. Beshkani.

- 30 According to our preliminary observations, the production of triangular flakes, including point production, is almost absent at these two new spots (fig. 7). However, the distribution of crude bifaces and core-choppers is relatively similar, with about 12% at Jabrin 2 and 18% at Hazim 1. Additionally, we have observed a percentage similarity in the distribution of bifacial pieces and retouched artefacts at both spots. Flake production is also significant in both locations, with Hazim 1 having a rate of 37% and Jabrin 2 having a rate of 17%. Our observations are confirmed by the presence of flake cores with a considerable rate, which stands at 9% for Hazim 1 and 29% for Jabrin 2. Despite the similarities between the Jabrin 2 and Hazim 1 spots, there are also some differences in terms of the variety of techno-types present. At Jabrin 2, we have registered Kombewa cores and Kombewa flakes, though in small amounts (6% each). This value may be a result of the important density of Kombewa artefacts at that point, given the small area of this hill. However, this techno-type was not seen among the assemblage of Hazim 1. Additionally, a very limited number of thick basalt blades were registered at Jabrin 2, highlighting another difference with the Hazim 1 spot. One notable difference between the Jabrin 2 and Hazim 1 spots is the significant amount of weathering observed on the artefacts collected from the latter (fig. 8). These artefacts are heavily weathered, with mechanical and chemical damage that has caused them to become porous and difficult to identify in terms of their technical characteristics such as point of percussion, negative scars, and cracking ripples.
- 31 Jabrin 1 and Jabrin 2 localities, on the other hand, are not only similar in terms of the assemblage techno-types but also in the degree of weathering among the artefacts. If we assume that there is a correlation between the amount of weathering and the age of

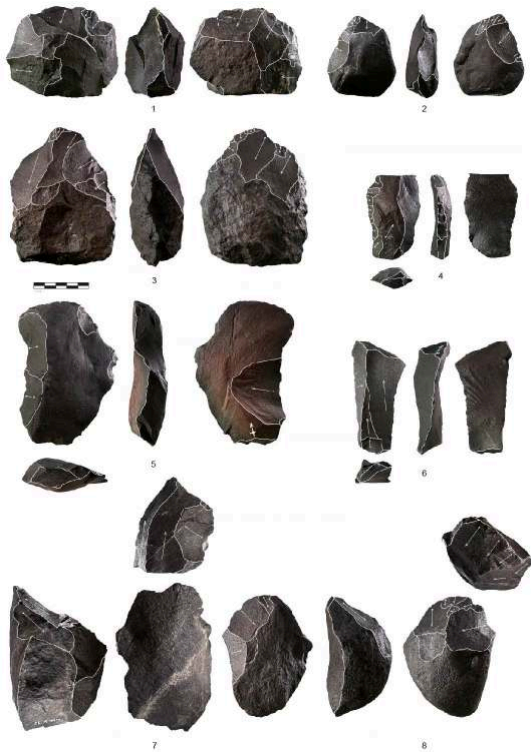
artefacts, which is typically the case based on the lithic records in Oman, then it could be argued that the industries discovered at Hazim 1 represent the oldest lithic artefacts found in the northern part of Oman. Based on the metric measurements (fig. 9), the flake cores collected from Jabrin 2 have an average length of 70.6 mm, an average width of 67.3 mm, and an average thickness of 48.6 mm. In comparison, the Kombewa large flakes have an average length of 105 mm, an average width of 90.5 mm, and an average thickness of 34 mm. These metric measurements indicate that the artefacts from Jabrin 2 are about 2 cm smaller than those from Jabrin 1, while the techno-types and proportions are almost identical between the two sites. Similar to Jabrin 1, the crude bifaces at Jabrin 2 are made from elongated pebbles, while spherical pebbles are often chosen for making core-choppers and chopping tools (fig. 9)

Fig. 9 – Metric units of main techno-type artefacts registered from Jabrin 2 and Hazim 1.



A. Beshkani.

Fig. 10 – The representative artefacts registered from Jabrin 2.



1–3. Core-chopper; 4. Kombewa (core) on large flake; 5. Side scraper; 6. Blade; 7–8. Flake core.
A. Beshkani.

Palaeolithic records from the Al-Ma'mur region

- 32 Al-Ma'mur is a residential area located about 15 km south of Bisya, in the Wilayat of Bahla⁴. During the 2022 surveys, we uncovered a series of new Palaeolithic localities on various slopes of Jabal Hammat, located approximately 3 km northwest of the village (fig. 11). These spots exhibit distinct lithic industries, particularly the “heavy blades”. The Hammat relief is part of a low mountain range that stretches from the northwest to the southeast, consisting of several formations such as the “Sid'r Formation” composed of sedimentary rocks, micritic limestone, calcirudite, shale, and fine-grained Jurassic brown chert in tablet form and the “Guwayza Formation”, which formed in the late-Jurassic/early-Cretaceous and shares similar characteristics. The availability of chert raw material in these outcrops over time may have been a factor in attracting prehistoric populations to repeatedly return to the area.

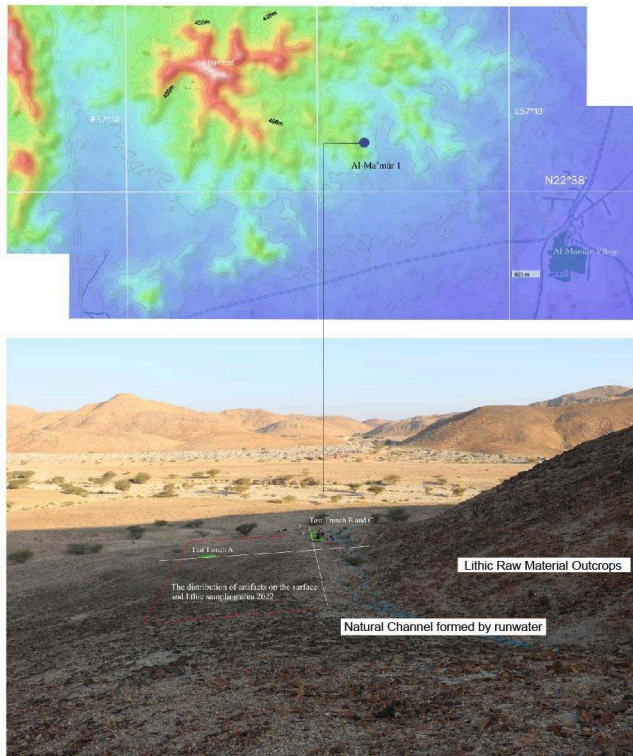
Al-Ma'mur 1 site: systematic artefact collection

- 33 After conducting a preliminary study on different isolated lithic artefacts, we identified a lithic workshop with a high concentration of blade industry produced from the local brown chert. We selected this area due to its potential to contain stratigraphic information. A systematic collection of lithic artefacts was conducted on a gridded surface using a total station to precisely record the location and distribution of the artefacts, as depicted in figure 11. Additionally, we excavated three test trenches

measuring 2×1 m each, where we discovered almost 50 artefacts (n=51) including heavy blades and blade cores from two separate layers.

- 34 The site has been named after the nearby town, Al-Ma'mur 1. This discovery is significant in the study of Palaeolithic localities on the southern piedmonts of the Hajar Mountains of Oman.

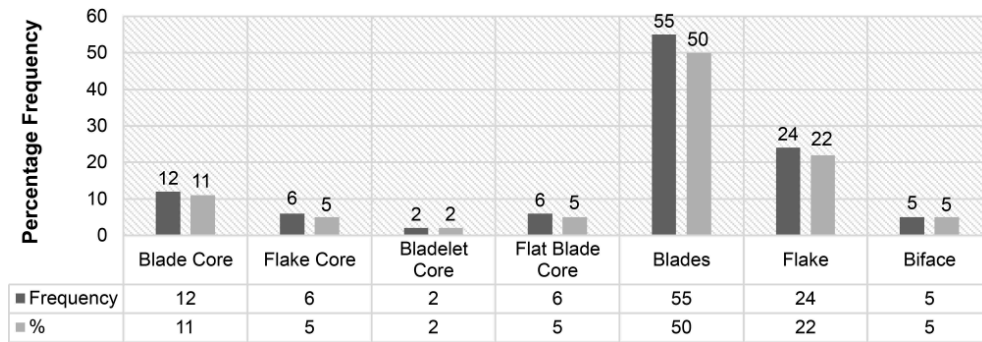
Fig. 11 – The location of Al-Ma'mur 1, test trenches, and terrace where the artefacts were systemically registered.



A. Beshkani.

- 35 A total of 282 artefacts were registered and their positions were marked from this flint knapping workshop using a total station. However, due to time constraints, we were only able to provide a database for 110 artefacts, which are summarized in table 8. Initial analysis shows that around 50% of the registered artefacts from the surface belong to the blade production system, while flakes, with approximately 24 specimens, account for 22% of the 110 registered artefacts (fig. 12).
- 36 Only 5% of the artefacts were identified as flake cores, indicating that a portion of the production system was focused on flake production, although some of the flakes may also have been produced in the preparation phase of the blade cores. Furthermore, five bifaces or partially bifaces artefacts were discovered with these blades and registered (figs. 13–16). These bifaces are made from local chert and are technologically distinct from the heavy bifaces discovered in Jabrin 1 (B004) or Jabrin 2 (B007). Bifacial artefacts from the region are currently under further examination and further details regarding their technical-functional aspects will be provided in a future publication.

Fig. 12 – The techno-types of artefacts result of systematic collection from the Al-Ma'mur 1 site.



A. Beshkani.

37 One of the most significant preliminary findings of our study is the identification of two distinct blade production methods based on the artefacts collected from the surface. The blade cores can be categorised into two configurations: volumetric (semi-pyramidal) and flat. While approximately 11% of blade cores exhibit the volumetric configuration, not all blades in this collection were produced using this method. Interestingly, 5% (n=6) of the blade cores were flat in configuration. These two different methods resulted in the production of two distinct types of blades. The blades derived from the flat cores tend to have a lower average thickness compared to the other group. Conversely, the blades produced using the volumetric method display knapping accidents, such as a significant number of hinged termination or overpassed items.

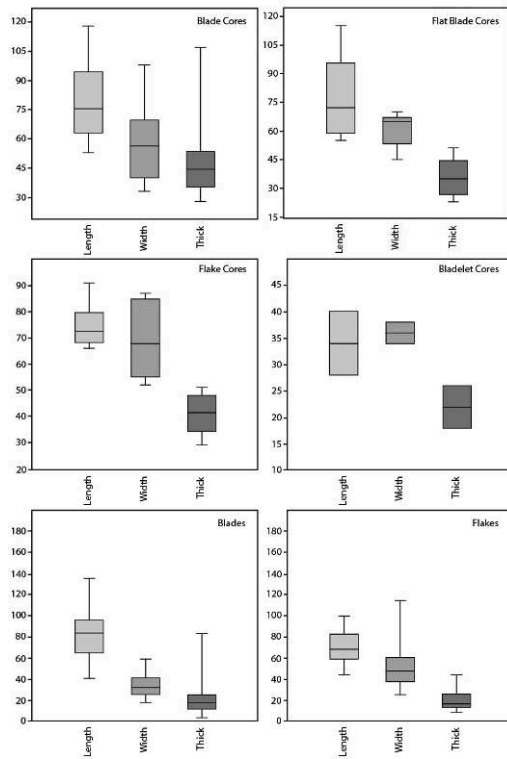
Fig. 13 – Different techno-types registered from surface Al-Ma'mur 1.



1. Elongated flake; 2–4. Blade; 5–6, 8–10. Unidirectional blade core; 7. Bidirectional blade core; 12. Axe?; 11,13. Biface.

A. Beshkani.

Fig. 14 – Metric units of main artefact techno-types registered from Al-Ma'mur 1, surface collection.



A. Beshkani.

- 38 The surface collection from Al-Ma'mur has shown that the blades are on average 20 mm longer than the registered flakes (fig. 14; table 8). Additionally, the blades have an average thickness of 21.4 mm, which is 3 mm thicker than the average thickness of the flakes (18.9 mm).

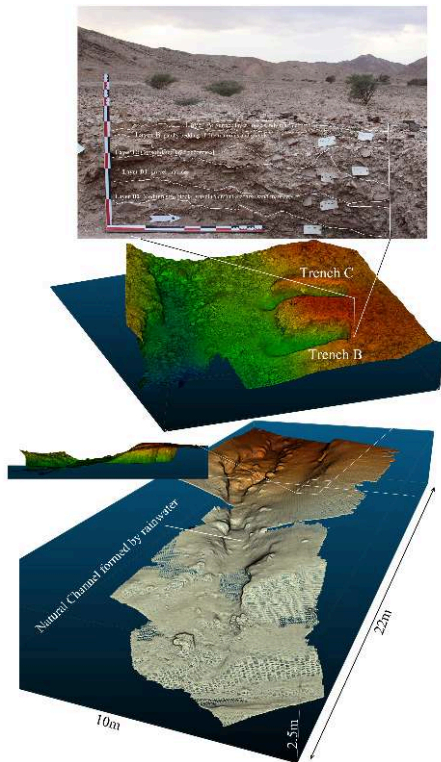
Table 8 – Extra metric units related to the blades and flakes registered from the surface, Al-Ma'mur.

	Length	Width	Thickness
Blades (N=55)			
Minimum	41	18	4
Maximum	135	59	83
Mean	84.2	34.5	21.4
25 prcntil	65	26	12
75 prcntil	96	41	25
Flakes (N=22)			
Minimum	43	24	7
Maximum	99	114	43
Mean	68.7	49.4	18.9
25 prcntil	58	36.75	11.75
75 prcntil	82	59.25	24.5

Excavation at Al-Ma'mur 1 site

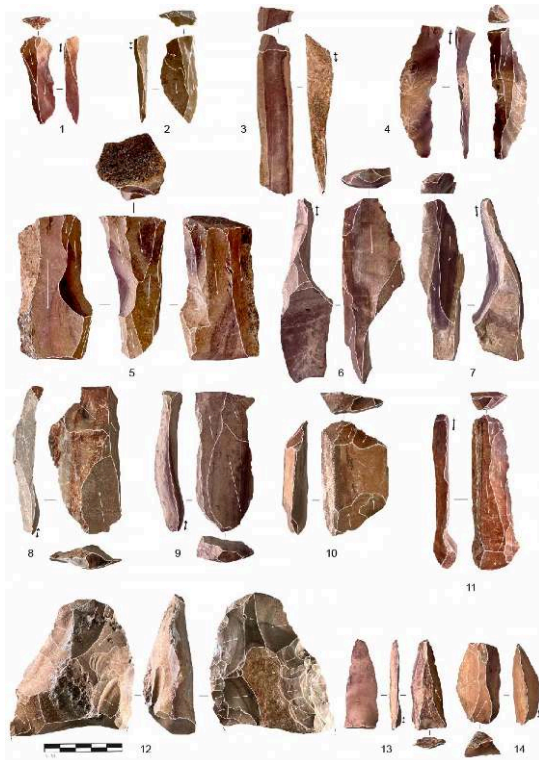
- 39 In order to understand the probable stratigraphic sequence of the site and to identify the depth and character of the cultural deposits, three small 2 × 1 m areas were tested. The first, called test trench A, was located in the center of the sampling area, where the lithic artefacts were collected from the surface. No cultural layer was identified in this spot. Two further test trenches, B and C, were located at the junction of the terrace, where the artefacts are scarred by the hillside slope cut by a small natural channel formed by rainwater (fig. 15). Test trenches B and C are quite similar in terms of sediment to those in trench A, which means containing four layers labelled A, B, C and D. Layer A was fine yellowish sand starting immediately below the surface; layer B contained small gravel and tablet-shaped rocks; layer C was a hard and compacted whitish conglomerate sediment named the Breccia layer, and layer D, which resembled layer B but contained larger pieces of rocks. A total of 14 artefacts, including a bifacial piece, were found in trench B, most registered between the depths of 10 to 20 cm below the surface (layers A and B). In the third test trench, a number of lithic artifacts were documented at the interface of layers A and B (on the surface of layer B), with an average depth of 15 cm from the surface, including flakes and unidirectional elongated blades. Among the notable discoveries in the breccia clast of test trench C is a blade core that was found from a depth of about 30 cm below the surface (fig. 16.5). A total of 33 lithic artefacts were recorded from layers A and B, while only two artefacts were found below layer C during the 2022 field season. As the mission came to its end in 2022, excavation was stopped and the site Al-Ma'mur 1 was closed, with trenches B and C reaching a depth of around 85 cm.

Fig. 15 – Location of test trenches B and C and their stratigraphy, Al-Ma'mur 1.



A. Beshkani.

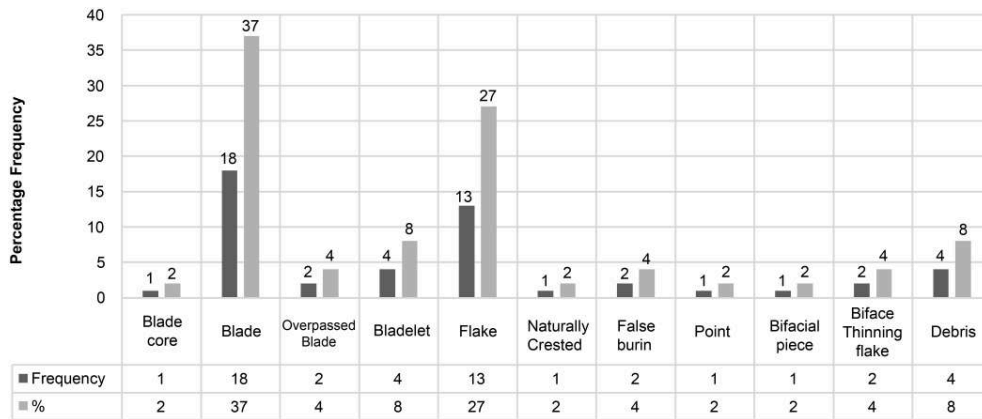
Fig. 16 – Lithic artefacts from the excavation at Al-Ma'mur 1 site.



1, 13. Small blade; 2, 8, 14. Elongated flakes; 3–4, 9, 11. Blades; 6–7. Heavy blade; 10. Cortical flake; 5. Unidirectional blade core; 12. Biface (broken).

A. Beshkani.

Fig. 17 – Frequency of techno-types from excavated trenches, Al-Ma'mur 1.



A. Beshkani.

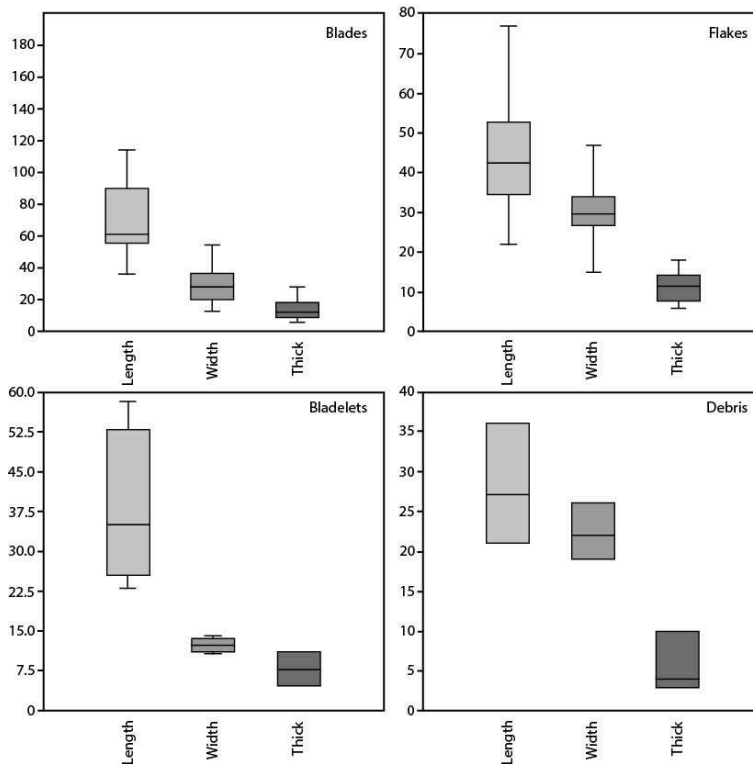
40 At Al-Ma'mur 1, the majority of the recorded artefacts, both on the surface and from the excavation, belong to two main categories: blades and flakes. These two techno-types account for approximately 70% of the recorded artefacts. Upon comparing the metric characteristics of the surface and excavation artefacts, it was observed that the blades and flakes found on the surface are, on average, 1 cm longer than those found during the excavation. The average length, width, and thickness of blades from the

excavation are 70.6, 28.5 and 13.5 mm respectively, while the corresponding values for flakes are 44.0, 30.1 and 10.6 mm (fig. 18).

- 41 We also recorded a total of 26 cores from our sampling area at Al-Ma'mur 1 (fig. 11), of approximately 1,000 sq.m. (30 × 35 m), where blade cores are significantly present at 16% according to figure 12. However, from the excavation, we only found one blade core in test trench C, unearthed around 30 cm below the surface. The blade core had a volumetric configuration and unidirectional blades released from a single platform. The striking platform did not have any preparation, and the flaking surface showed common knapping accidents such as overpassed negative (fig. 16.5). We suppose the blade core found in test trench C is similar to the blade cores registered from the surface. According to figure 12, only five bifaces were recorded from the sampling area on the terrace, which accounts for a low percentage (5%) of this type of artefact. Despite the low occurrence of bifaces on the surface, one was found in test trench B, approximately 20 cm beneath the surface (layer B). This biface, which measures 108 mm in length, 55 mm in width, and 49 mm in thickness (fig. 16.12), was broken and exhibited a different morphology of retouch and cutting-edge preparation compared to the bifaces found on the surface. Interestingly, some bifaces found on the surface of Al-Ma'mur 1 exhibited bidirectional laminar production before transforming into bifacial artefacts (figs. 13-16).

Table 9 – Additional measurement of the artefacts registered at Al-Ma'mur 1 test trenches B and C

	Length	Width	Thickness
Blades (N=18)			
Minimum	36	13	6
Maximum	114	54	28
Mean	70.61	28.55	13.55
25 prcntil	55.25	20.25	9
75 prcntil	89.75	36.5	18.25
Flakes (N=18)			
Minimum	22	15	6
Maximum	77	47	18
Mean	44.05	30.11	10.66
25 prcntil	34.5	26.75	7.75
75 prcntil	52.75	34	14.25

Fig. 18 – Metric characters of artefacts registered from the Al-Ma'mur 1 excavation.

A. Beshkani.

- 42 A noteworthy observation related to the artefacts discovered from the surface and those unearthed from the test trenches is the lack of any formal tools or retouched artefacts. At the Al-Ma'mur 1 site, the blade industry appears to be devoid of typical tools like various types of burins, backed bladelets, scrapers, or small projectile points. This dearth could be attributed to the sampling technique or the limited size of the sampled area during the 2022 excavation season. We intend to further investigate the matter of tool production and bifacial artefacts in this region during our upcoming fieldwork in 2023.

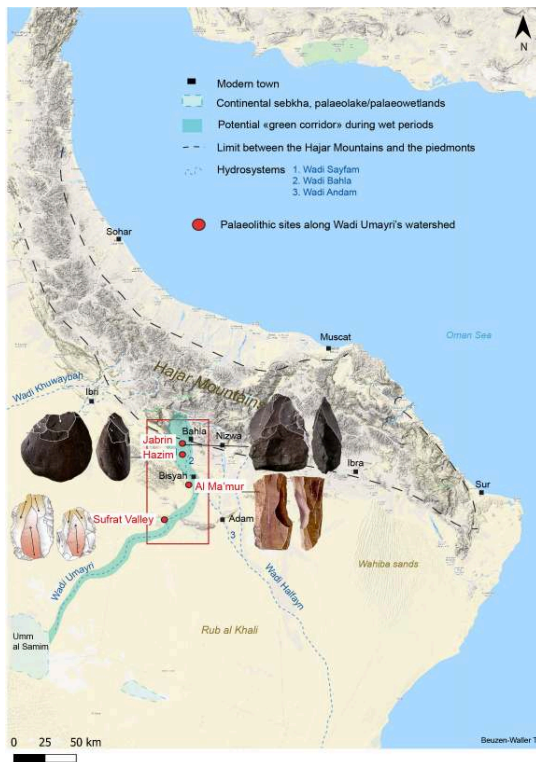
Discussion/Conclusion

- 43 Investigating Palaeolithic populations in the Horn of Arabia, including northern Oman and particularly on the southern piedmont of the Hajar Mountains, is a relatively new endeavour. Even though most of the evidence gathered so far has been from surface findings, significant strides have been made to further the study of Palaeolithic cultures in the region over the past few years. Recent discoveries at Jebel Faya rock shelter indicate that Palaeolithic cultures have been present in eastern Arabia for at least 250,000 years (Bretzke et al. 2020a). Moreover, it is now known that the presence of Palaeolithic human occupation in the region, together with the Hajar Mountains, was not necessarily tied to major humid periods, which contradicts popular narratives of “wet” and “dry” states (Woor et al. 2022).

The Wadi Umayri watershed: a green corridor?

- 44 The Wadi Umayri, a significant hydro-system located in the southern piedmont of the Hajar Mountains, runs along multiple Palaeolithic localities and sites, including Jabrin 1 (B004), Hazim 1 (B005), Jabrin 2 (B007), Al-Ma'mur 1 and the Suftrat Valley. The Wadi Umayri is sourced from the inner Hajar Mountains and, like many other wadis, has various names based on the section within its watershed. The main tributaries of the upstream part of the Wadi Umayri watershed are the Wadi Ghul, which turns into Wadi Bahla from Bahla Oasis, and Wadi Kawr, which transforms into Wadi Sayfam near Al-Ghafat Oasis. In terms of lithology, the upstream part of the Wadi Umayri watershed is mainly composed of massive limestone from the Wasia 'Ws2' group and biolithoclastic limestone and dolomite from the Kawr "MF" group. In both systems, well-developed karst features have been identified like the Hota cave in 'Ws2' limestone (Fleitmann et al. 2003) and polje of Hayl Al Ajah or Sint in "MF" biolithoclastic limestone/dolomite (Mateiciucová et al. 2020). Karst landforms have great geoarchaeological potential because they can provide a protected environment (Balbo and Iriarte 2014) as demonstrated in the Sint polje by Mateiciucová et al. (2020), and karstic areas are hydrologically favoured and may have functioned as a catchment or buffer zone for hunter-gatherers (fig. 19).

Fig. 19 – Wadi Umayri, one of the major catchment zones during the Pleistocene humid periods and the location of Palaeolithic areas mentioned in the text.



Adapted from Beuzen-Waller T. 2020.

- 45 The southern piedmont of the Hajar Mountains provides numerous opportunities for obtaining knappable rocks, with outcrops readily available along Wadi Bahla, Wadi Sayfam, and throughout the Wadi Umayri watershed. The Suftrat Valley is a particularly

appealing stopover point for groups moving along the Wadi Umayri corridor due to the abundance of attractive outcrops in the area. At the downstream end of the Wadi Umayri palaeoflood plain lies the Umm as-Samin sabkha, which is one of the largest sabkhas in the Arabian Peninsula, covering an area of approximately 3,000 sq.km. During humid periods of the Pleistocene and the Holocene, Umm as-Samin likely functioned as an interior wetland or lake, like other sabkhas of interior Oman (Rosenberg et al. 2011; Rosenberg et al. 2012). Wadi Umayri, with its karstic environment in the upstream part, extended floodplains crossing areas rich in knapping raw materials, and the Umm as-Samin palaeolake/wetlands downstream, has the potential to be a major green corridor during humid periods of the Pleistocene.

Establishing a relative chronological framework for Palaeolithic discoveries in northern Oman

- 46 Our research findings indicate that the earliest Palaeolithic cultures in the studied area exhibit variability and can be differentiated into two distinct lithic industries probably associated with Lower Palaeolithic populations. The assemblages recovered from Hazim 1 (B005) likely represent the earliest occupation of the region. These assemblages are characterised by a high frequency of choppers, crude bifaces, and thick flakes, which are typical of the earliest Palaeolithic industries in this region. Additionally, the evidence recovered from Jabrin 2 (B007) and Jabrin 1 (B004) likely represents a later stage of this cultural phase. These assemblages are characterised by the emergence of new flaking techniques, such as the Kombewa technique, along with the continued production of choppers and crude bifaces.
- 47 It is possible that the second technological development in northern Oman is associated with the Acheulean phase, as cordiform or sub-cordiform handaxes with symmetrical profiles are produced during this period. The handaxes found in the Sufrat area are consistent with this phase. During this time, there is a trend toward the production of symmetrical bifacial artefacts like the site of An Nasim (Scerri et al. 2021), which are sometimes made on large flakes used as blanks, demonstrating another aspect of technical similarity with handaxes found at other sites (Barzilai et al. in this volume). Based on our field observations in northern Oman, we have found that the technological change observed in the lithic industries is accompanied by an abrupt shift from the use of volcanic rocks replaced by cherts and flints. Additionally, some of the handaxes and bifacial artefacts found in the region share similarities in their production techniques with those reported from certain Lower Palaeolithic localities in southwest Oman, Yemen, and Saudi Arabia, such as those found in Wadi Fatimah (Petraglia 2003; Petraglia et al. 2012). Therefore, it is clear that the earliest human occupations in northern Oman were not characterised by a monolithic culture or a homogeneous technological phenomenon. Instead, our findings suggest the existence of different cultural and technological phases, highlighting the need for further research in this area.
- 48 The Sufrat Valley has provided significant evidence of Middle Palaeolithic assemblages, particularly in the form of cores with Levallois configuration and Nubian(ish) techno-features (Beshkani et al. 2017a). One of the main technical characteristics of the collected cores from the Sufrat Valley area is the possession of a distal median ridge with an angle of less than 90 degrees, which is formed by two intersecting scars visible

on the flaking surface (Hallinan et al. 2022). The reduction sequence of these cores is focused on the distal portion and resembles Nubian technology. However, it is improbable that the observed Nubian(ish) techno-features are a direct outcome of interactions with classic Nubian technology in southern Oman (Rose et al. 2019b) or the Nile Valley (Vermeersch 2002; Van Peer, Vermeersch, and Paulissen 2010). Instead, they are more likely may be attributed to a later derivative technology (i.e. 'Epi-Nubian'), and/or the result of interactions between Arabian-Levantine cultures. Similar evidence has been reported from the Emirates (Scott-Jackson, Scott-Jackson and Rose 2010; Scott-Jackson et al. 2014), North Arabia (Hilbert et al. 2017; Crassard et al. 2019), and even more distant regions such as the inner plateau of Syria (Bonilauri et al., this volume). Additionally, further studies are currently in progress on new localities at the reliefs overlooking Fell village and Wadi Sayfam between Bisya and Al-Ma'mur, as well as an older terrace at Al-Ma'mur 1 itself, which also shows Middle Palaeolithic characteristics.

- 49 The presence of Upper Palaeolithic culture in central and southern Arabia is quite scarce, and the southern piedmont of the Hajar Mountains is no exception. Although blade industries have been discovered at Al-Ma'mur from layers A and B they have yet to be dated and do not appear to belong to the Upper Palaeolithic, based on a comparative study with blade and geometric bladelet industries from the Dhofar region (Rose et al. 2019a). The production system and metric analysis, as well as the similarity of knapping accidents among a significant portion of blades and blade cores from the surface at Al-Ma'mur, suggest a closer connection to what is known as the Kheshabian industry in the south of Arabia (Hilbert 2014; Hilbert et al. 2015). However, this does not necessarily imply a complete similarity between the blade industries of the North and the Dhofar region. The Kheshabian industry is divided into three groups, with sub-groups A and B utilising flint nodules in their production system, whereas group D exhibits a preference for tablet-form flints in terms of raw material selection. No examples of chert nodule use as a blade core have been observed at the Al-Ma'mur 1 site, where the main source of raw material is chert in the form of tablets due to the nature of the depositional layers. Analysis of the blade industries discovered at Al-Ma'mur 1, both on the surface and from the stratigraphic layers, suggests, at this stage, an association with multiple techno-cultures. The blade industry present in layers A and B of the Al-Ma'mur 1 excavation is likely representative of Late Palaeolithic Heavy Blade production reported even from the Dqum area (Jagher et al. 2008; Jagher and Pümpin 2010). Furthermore, surface collection indicates that a portion of the collected blade cores and blades may be indicative of Upper Palaeolithic cultures in northern Oman.

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NOTES

1. UMR 7194: « Équipe I - Dynamique des premiers peuplements humains » Muséum national d'Histoire naturelle, Département de Préhistoire.
2. Our research team is still refraining from collecting a large number of lithic artefacts, despite the identification of Palaeolithic localities. With the help of the Ministry of Heritage and Tourism, we are striving to ensure the necessary infrastructure is in place for the proper archiving procedure.
3. On the way to Jabrin town from Bisya
4. The area code is 50,220,393.

ABSTRACTS

Abstract. Arabia holds great geographical significance in Palaeolithic studies as the nexus between the African and Asian continents. While researchers have identified various contextual areas from the Middle to Late Pleistocene period in the peninsula's southern, central, and northern zones, some regions such as northern Oman, still need to be explored. This paper is a

synthesis of the French Archaeological Mission to Central Oman's Palaeolithic expeditions (FAMCO). It fills a major geographic gap in terms of mapping the Palaeolithic settlements on the southern piedmont of the Hajar Mountains. Our preliminary surveys around the Adam and Bisya towns in Ad-Dakhiliyah Governorate and test excavation at a stratified Late Palaeolithic site—the first of its kind near the city of Al-Ma'mur—demonstrate a range of lithic industries spanning the Lower Palaeolithic to the Neolithic. By exploring this *terra incognita*, the provided synthesis will broaden our understanding of the distribution of Palaeolithic populations and different lithic production strategies in the Horn of Arabia.

Résumé. La péninsule arabique revêt une grande importance géographique dans les études paléolithiques en tant que lien entre les continents africain et asiatique. Bien que les chercheurs aient identifié divers sites du Pléistocène moyen à supérieur dans les zones au sud, au centre et au nord de la péninsule, certaines régions comme le nord de l'Oman restent encore à explorer. Cet article est une synthèse des campagnes menées par la Mission archéologique française en Oman central (FAMCO) sur le Paléolithique. Elle comble une importante lacune géographique en termes de cartographie des occupations paléolithiques dans les piémonts sud des monts Hajar. Nos enquêtes préliminaires autour des villes d'Adam et de Bisya dans le gouvernorat d'Ad-Dakhiliyah et le sondage effectué sur un site paléolithique récent stratifié – le premier du genre près de la ville d'Al-Ma'mur – démontrent une gamme d'industries lithiques allant du Paléolithique inférieur au Néolithique. En explorant cette *terra incognita*, cette synthèse élargit notre compréhension de la distribution des populations paléolithiques et celle des différentes industries lithiques dans la Corne de l'Arabie.

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Mots-clés: Paléolithique, industries lithiques d'Arabie, Al-Ma'mur I, Monts Hajar, Oman septentrional

Keywords: Palaeolithic, lithic industries of Arabia, Al-Ma'mur 1, Al-Hajar Mountains, northern Oman

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