Lithic Procurement and Provisioning at the Lower Palaeolithic Site of Shishan Marsh 1 in the Azraq Basin, Jordan

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https://doi.org/10.35516/jjha.v18i3.1273

Abstract

Considerations of the landscape, the distribution and quality of resources, distances to outcrops, and proximity to other resources factor into the procurement decision-making by prehistoric foragers. However, the patterns of resource exploitation and utilisation are likely to vary by region, and those exhibited in marginal environments are not fully explored. This report focuses on the nature of lithic procurement and provisioning at the Lower Palaeolithic site of Shishan Marsh 1 in the Azraq Basin, Jordan. It draws upon several lines of evidence, including provenance and use-wear analyses performed on the biface assemblage. The results indicate raw material exploitation occurred at local and non-local distances to the site and the lithics were used for a variety of activities on medium-hard materials. Foragers moved toward the wetlands from significant distances on the surrounding landscape, likely bringing finished tools and, after use, discarding them in relatively good condition. The accumulation over time of ready-to-use tools at Shishan Marsh 1 points to a provisioning of the wetland margins for future needs.

Keywords: Lower Palaeolithic, Acheulean, Levant, wetlands, procurement, provisioning, lithics.

1. INTRODUCTION

The mobility of prehistoric foragers has often been investigated through their lithic economies, most notably the procurement and provisioning of raw materials and tools. The organisation of these activities is subject to the decisions of foragers, which, in turn, are influenced by a host of factors. These include constraints of the landscape, time and distance, and the availability and quality of the raw material. Such inquiry is particularly applicable to hominins of the Palaeolithic who encountered and inhabited a range of environments across three continents.

During the Lower Palaeolithic, bifaces (e.g., handaxes and cleavers) were the hallmark tools of the Acheulean industry. They are often described as versatile and multi-functional, similar to the Swiss Army knife of today. The long bifacial edges and occasionally pointed distal ends of handaxes permit their involvement in a number of subsistence activities and possibly even defence against predators (Rollefson et al. 2006). Indeed, experimental work has demonstrated their efficiency for woodworking, butchery, piercing, digging, and other

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Received on 5/6/2023 and accepted for publication on 23/1/2024.

tasks (Keeley 1980; Key and Lycett 2017; Mitchell 1995; Posnansky 1959; Roe 2006). Moreover, it is suggested that these generalised tools underwent different procurement and manufacture stages than expedient flake-tools or even more specialised tools (Ashton and White 2003; Goren-Inbar and Sharon 2006; Kelly 1988; Kleindienst 1961; Shea 2013). In this capacity, bifaces can contribute significantly to the personal gear of foragers and could be re-sharpened and modified (curated) for further use. Since bifaces are often moved over long-distances and likely retained for extended periods of time, they may serve as good indicators of procurement ranges and forager mobility.

The Acheulean of the Levant is traditionally divided into Early (c. 1.5 ma – 900 ka BP), Middle (c. 900-500 ka BP), and Late (c. 500-200 ka BP) phases, and follows the techno-typological criteria provided by Leakey (1975). The Early Acheulean is characterised by crude bifacial tools, choppers, picks, and spheroids (Sharon 2017). Currently, there are few Early Acheulean sites in the Levant. The best known are Evron Quarry and ‘Ubeidiya (Bar-Yosef and Goren-Inbar 1993; Ronen 1991), located in the Cisjordan. The Middle Acheulean is indicated by large, thick, and elongated bifaces with deep flake scars. Some authors have described this phase as ‘the Large Flake Acheulean’, based on the use of large flakes as blanks for bifaces (handaxes and cleavers), specifically at Gesher Benot Ya‘aqov in the Jordan Valley (Goren-Inbar and Saragusti 1996). Other important sites include Latamne in Syria (Clark 1967), and ‘Uyun al-Qadim and Fjayj in Jordan (Rech et al. 2007). The Late Acheulean is marked by small and refined handaxes and cleavers, and small tools that bear indications of early Levallois technology. This industry is well attested across the Levant, as hundreds of surface and buried sites have been discovered. High quantities of bifaces have been recovered from Nadaouiyeh in Syria (Jagher 2016; Le Tensorer et al. 2007), and at Tabun and Qesem caves, indicating long-term occupation in the Mt. Carmel region.

An important region in the Levant boasting a rich Lower Palaeolithic record is the Azraq Basin (Figure 1). The basin is located in eastern Jordan and contains a mudflat adjacent to an oasis complex of spring-fed wetlands. Within the wetlands is Shishan Marsh 1, a Lower Palaeolithic site with two layers of Late Acheulean occupation (Ames et al. 2022; Nowell et al. 2016). The excavated portion yielded a high concentration of bifaces, all made of chert. Outcrops with exposed chert beds are scattered across the regional landscape and extensive wadi channels transport clasts downstream towards the low elevation of the mudflat. However, the wadis deposit clasts that tend to be significantly smaller than the necessary blank size for the manufacture of bifaces. This observation tentatively indicated that the raw materials for larger lithics, such as bifaces and cores, were procured beyond the wetlands. Furthermore, the lack of substantial debitage related to the manufacture of bifaces in the lithic assemblage suggests they were manufactured off-site before being discarded at SM1. Similarly, at the nearby cotemporary site of ‘Ain Soda in the wetlands, Rollefson and his colleagues (Rollefson et al. 2006 69(2): 65) also observed that, while some local potential sources had been identified, other sources for the bifaces “had not been located and may have come from some distances away”.

In this report, several independent lines of data are collated to discuss the lithic procurement and provisioning strategies at the Palaeolithic site of Shishan Marsh 1. These include evaluations of the typology, use-wear, and provenance of the bifaces. The results indicate that hominins outfitted themselves with bifaces and lithic materials from local and non-local sources and moved them into the wetlands in order to facilitate butchering and to provision the wetland margins. They further showcase the lithic economy and landscape familiarity of hominins at an isolated wetland complex.

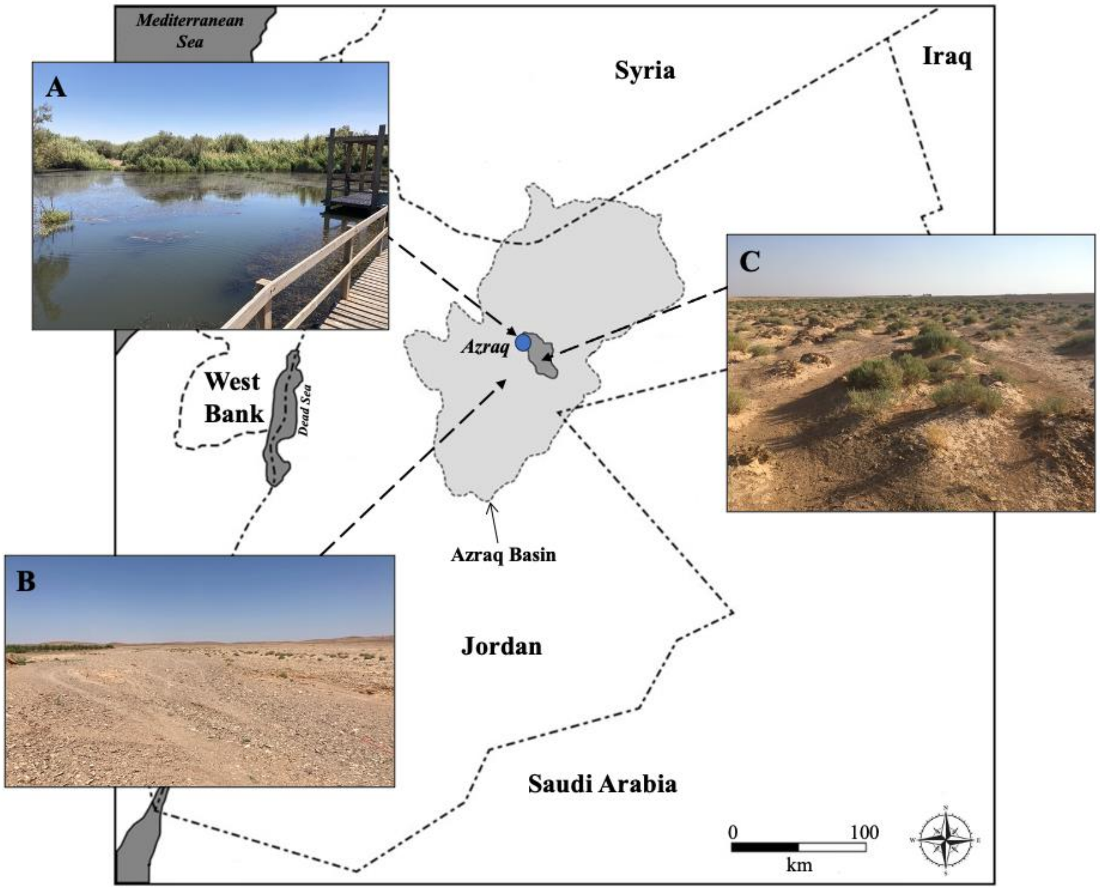

Figure 1: The Location of the Azraq Basin, Jordan. Insets: A) the restored wetlands of the modern Azraq Wetland Reserve, B) the surrounding barren desert landscape, and C) the salty mudflat of Qa' Azraq. Base map redrawn from Maher (2017: 679). Photographs taken by JAB.

2. LITHIC PROCUREMENT AND PROVISIONING

The nature of the landscape plays an important role in shaping foraging strategies (Browne and Wilson 2011; 2013; Potts 1991; Wilson 2007a; 2007b; 2007c). Landscapes are not uniform, nor are they perfectly flat without obstacles. Features of landscapes, including elevation, vegetation type and cover, waterways, prey and predator movement/resting, sightlines, and terrain difficulty and composition need to be documented and considered. Provenance results provide a linear or "as the crow flies" measure of movement, not necessarily the actual route traversed by foragers. This measure does not necessarily reflect the full scale that materials and tools may have been moved across the landscape, nor the time and effort expended. For instance, 10 km through undulating terrain or snow requires more time to traverse than the same distance through level grasslands. The application of various software-based models, namely optimisation, digital elevation, and least-cost path, can help reveal the influence of the landscape (e.g., Browne and Wilson 2013; Byrd et al. 2016; Ekshtain et al. 2017; Wilson 2007b).

The distribution, availability, and quality of raw material is also not uniform within a given region. A relationship between such factors and the resulting types of tools produced was proposed by Andrefsky (1994). Among assemblages from the western United States of America, foragers tended to make informal tools in areas with low quality material and varied availabilities (Andrefsky 1994). Both formal and informal tools were made in areas with high quality materials in high availability, as there is no need to conserve material (Andrefsky 1994). Andrefsky (1994) extrapolates that foragers make formal tools in areas with high quality material, but low availability. These results are not necessarily universal, however, as Brantingham et al. (2000) found that sophisticated (formal) prepared core technology was discovered at the Palaeolithic cave site of Tsagaan Agui, Mongolia, where there is a high abundance of low quality raw material. This suggests that tool technology is not always constrained by raw material quality (Brantingham et al. 2000).

Time and distance, as frequent corollaries, are important factors influencing the scale of foraging ranges. Ethnographic studies have routinely observed hunter-gatherers predominantly forage within 2 hours or a 5-10 km radius of their camp (Hill and Hawkes 1983; Hitchcock 1982; Lee 1979; Vickers 1989), particularly groups targeting vegetation, with slightly farther distances for hunting parties. For example, Nukak (Columbia) adults make roundtrips that average 8.4 km (Politis 2006), and Pume (Venezuela) travel 11.4 km when hunting and 1.6 km when gathering (Greaves 2006). Similarly, Hadza (Tanzania) women walk an average of 5.5 km and Hadza men 8.3 km while foraging (Marlowe 2010). GPS-assisted studies of 1431 documented hunting trips by Hadza foragers indicated that 98% were <10 km (Raichlen et al. 2014). In fact, most predictive models also indicate that, based on caloric return rates, the effective foraging radius (for food resources) is approximately 5-7 km (Kelly 2013). Based on these observations, the range of 5-10 km is often termed "local". Herein lies a large issue for archaeologists—not all the sites that contain tools are camps or home bases, nor is it often known if a camp was used, much less where it is located. Instead, many sites seemingly represent butchering, ritual, or other task-specific locales. Non-local procurement is less categorised than local, as the terms regional, supra-regional, long, and extreme are often used and subsequently conflated or used synonymously. Binford (1982) describes an area beyond the foraging radius as the logistical radius (related to logical mobility), which is exploited by task groups who remain away from the camp at least one night before returning with provisions. A notable rubric is provided by Kandel et al. (2016) which describes local (0-5 km), regional (6-20 km), and supra-regional (21-100 km) procurement ranges for hominins of the Middle Stone Age of southern Africa. While the distances (km) themselves will offer comparisons, other factors (e.g., terrain, availability, hominin species) suggest that more work is required to elucidate the relationship between them and range terminology.

Kuhn (1992; 1995; 2004) outlines three forms of provisioning strategies: individual, place, and activities. Provisioning an *individual* relates to how foragers will outfit themselves with personal gear, a specific toolkit that can be carried on their person for anticipated tasks. Since individuals are mobile, artefact utility and transport cost must be considered. Provisioning a *place* pertains to how foragers stockpile raw materials, blanks, cores, or even tools for later reduction and anticipated use, often at strategic points on the landscape or at their camp. It is an effort to create more available sources of raw materials within the extent of their territory and decreases the necessity of future mobility. Lastly, provisioning *activities* involve little or no planning and occurs only when the need is encountered. This low-cost strategy eliminates the risk of overproduction and is suitable in landscapes with well-known or abundant raw materials. The applied provisioning strategies can depend on the types of tools intended for manufacture, not necessarily the quality or availability of raw material, but need not be mutually exclusive. A visit to a source may lead to the manufacture of finished implements of one tool type and of cores that are transported to the camp to make other types. Such patterns were documented among the *Alyawara* of Australia by Binford and O'Connell (1984), where members manufactured special "men's knives" at the source and also collected blanks to make more expedient tools at the camp. Raw material quality and availability were not the overriding factors influencing the decisions to employ different provisioning strategies, but rather because "different perceived costs were associated with different demands for different tools within the system" (Binford and O'Connell 1984 vol. 40/3: 428). Perhaps it should be expected that different tool types or combinations in an assemblage suggest different procurement or provisioning strategies. It is important to note that many lithic tool types were likely used for multiple purposes despite their names implying singular functions.

3. CONTEXT OF STUDY

3.1. Landscape of the Azraq Basin

The Azraq Basin is a distinct hydrological catchment area situated predominantly across the Central Plateau and Northern Basalt Plateau of northeast Jordan (Figure 1). It encompasses a very small portion of northwest Saudi Arabia and extends northward into southern Syria. The geology is a patchy mosaic of sedimentary and igneous rocks, which are mostly covered by alluvium and aeolian sediments (Abed 2018; Bender 1974). The underlying sedimentary formations of the Belqa Group, namely the Muwaqqar Chalk-Marl (MCM), Umm Rijam Chert-Limestone (URC), and Wadi Shallala Chalk (WSC) contain bedded and nodular chert among beds of limestone (Figure 2). In the northwestern portion of the Azraq Basin, the sedimentary formations are overlain by the Jebel al-Druze basalt plateau of Oligocene-Pleistocene age (al-Malabeh 1994; Cordova 2007; Ilani et al. 2001).

At the centre of the Azraq Basin is a salty mudflat, Qa‘ Azraq (*qa‘* is Arabic), roughly 75 km^2 in size that is a dry, yet seasonally flooded flat surface and contains the lowest elevation in the basin (Figure 1) (Abed 2018; Ames and Cordova 2015). Qa‘ Azraq is also a large catchment for input from several large wadis (seasonal streams) namely the Butm, Enoqiyya, Hayat, al-Masayil, Rattama, Rajil, and Usaykhim channels (Figure 3). The northern and western areas of the Azraq Basin receive more precipitation than the southern and eastern areas due to the encroaching influence of the Mediterranean Westerlies (Copeland 1988; Cordova 2007). As a result, the wadi channels in the southern and eastern areas have an extended duration of seasonal flow, as water percolates through fissures and keeps the water table elevated (Abed 2018; Enzel et al. 2008). During winter, the rainwater causes Qa‘ Azraq to fill, though most, and sometimes all, of this water is evaporated during the summer (Abed 2002; el-Naqa et al. 2007). Today, the surrounding landscape is dry and barren with a general lack of vegetation due to anthropogenic modification (e.g., water over extraction, tree-cutting, brush removal) and overgrazing by livestock herds (Figure 1) (Nelson and Lane 1974; 1985).

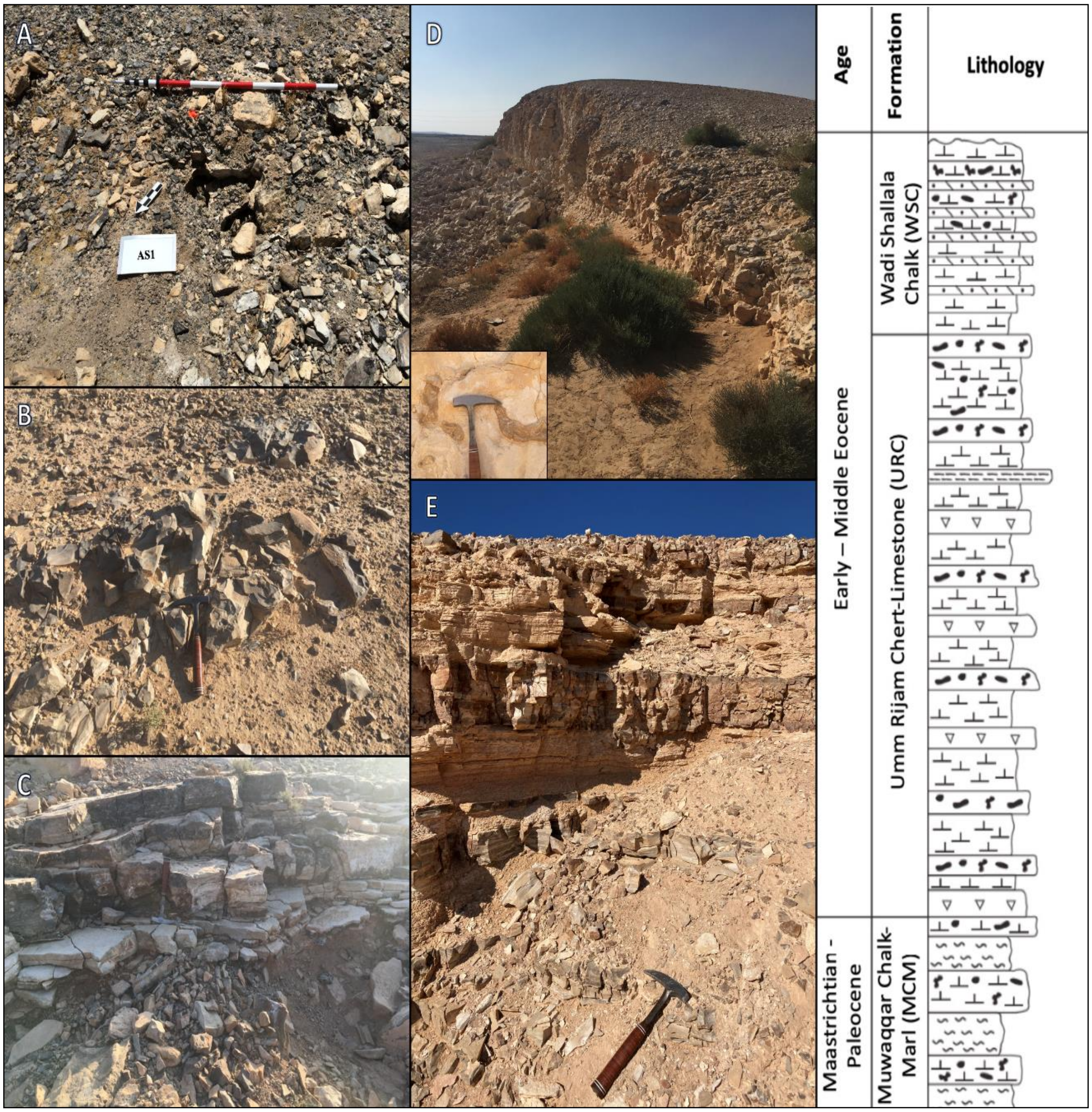

Figure 2: Chert sources of the central Azraq Basin. A) URC formation: A, B, C, E. WSC formation: D. See Beller (2023) for extensive source descriptions. Far left shows a strip log of the marine formations in the Azraq Basin. The diagram is redrawn and modified from Sánchez de la Torre et al. (2019).

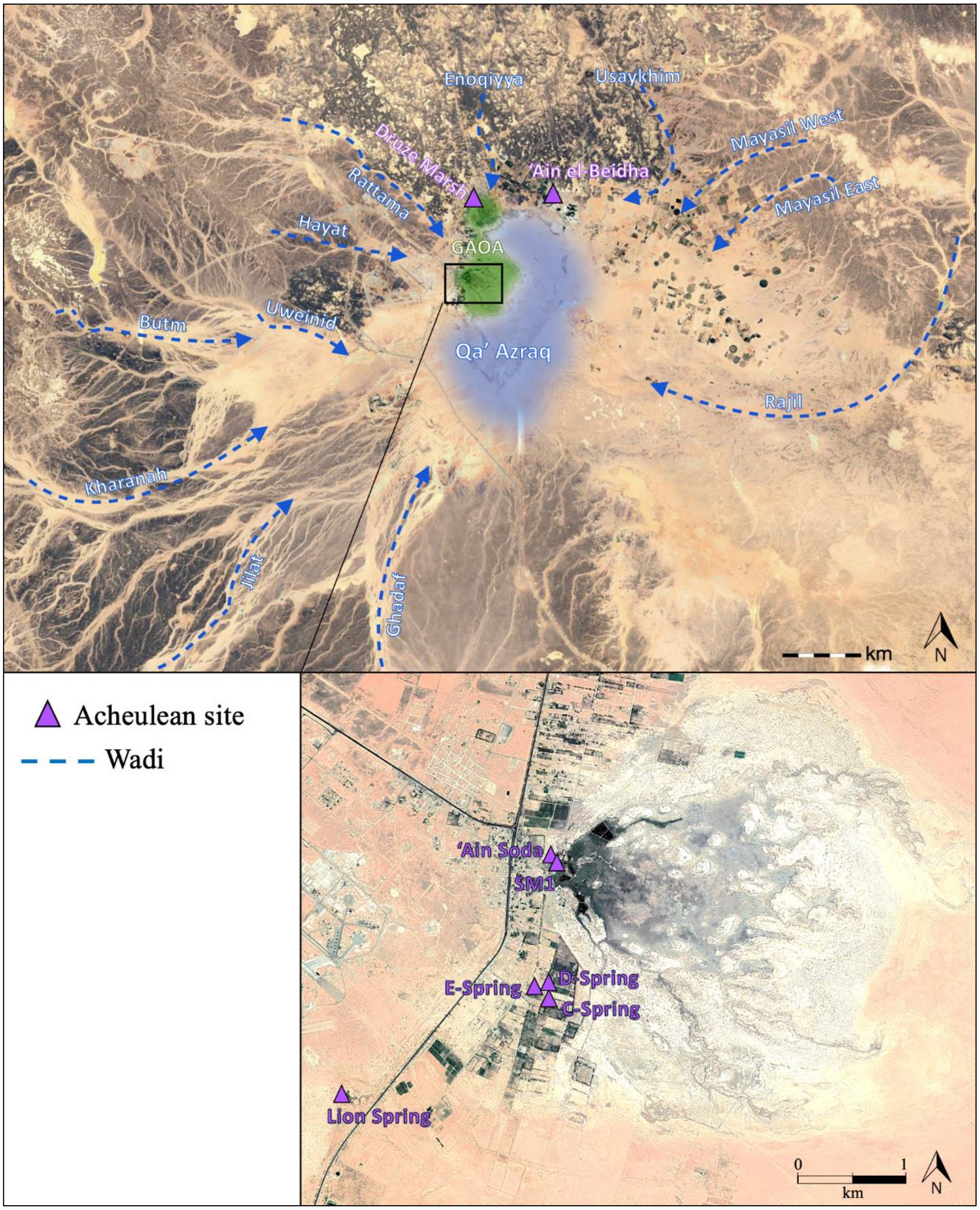

Figure 3: Radial network of wadis and key Acheulean sites within the central Azraq Basin. Qa' Azraq is depicted as flooded.

On the northwestern edge of Qa' Azraq is the Greater Azraq Oasis Area (GAOA), a single geographic unit that encompasses the historic Druze Marsh and the recently rehabilitated Shishan Marsh (Figure 1) (Ames and Cordova 2015; Cordova et al. 2013). Its freshwater is maintained by springs fed by an aquifer system contained in the bedrock, which is among the most important sources of surface and ground water for modern populations in Jordan (Abed 2018; el-Naqa 2010; el-Naqa et al. 2007). In the wet season, the overflow of Qa‘ Azraq can spill into the GAOA, changing the salinity of the latter. In the dry season, the effect is reversed as the water of the *qa‘* recedes and evaporates, rendering the water of the GAOA fresher. Therefore, the extent of the wetlands is subject not only to the conditions of the long-term regional climate, but also those of the seasons. Unfortunately, the practice of pumping water from the aquifer that began in the early 1980s led to a substantial drop in the water table and the rapid draining of the two marshes to the point where they were completely dry in the early 1990s (al-Kharabsheh 2000; Cordova et al. 2013). A restoration effort led by the Royal Society for the Conservation of Nature has rehabilitated a small portion (~10%) of the Shishan Marsh (Fariz and Hatough-Bouran 1998; France 2010). A similar effort has not been applied to the Druze Marsh.

3.2. Lower Palaeolithic occupation in the Azraq Basin

The Lower Palaeolithic is well attested within the Azraq Basin (Figure 3; Table **1** 1). In 1956, an irrigation project on the margin of the wetlands inadvertently discovered a dense collection of lithics at Lion Spring (‘Ain el-Assad). An assemblage containing hundreds of handaxes and cleavers was retrieved from the briefly exposed strata and associated back-dirt piles (Copeland 1989b; 1989c; Harding 1967; Kirkbride 1989). Approximately 2.5 km northeast of Lion Spring, another site, C-Spring, was also identified through the same project. Formal excavations in 1985 revealed a Lower Palaeolithic deposit containing faunal remains and a “river of flint” (Garrard et al. 1987; 1988; Hunt and Garrard 1989). This lithic assemblage comprised over 4000 artefacts, most of which were handaxes, unutilised flakes, cores, and debitage (Copeland 1989a). Many cores had either been aborted and discarded or worked down to a disc, possibly to form bifaces. This observation, combined with the high proportion of preparation and finishing flakes, led to the interpretation of the site as a potential knapping locale (Copeland 1991; Hunt and Garrard 1989). The assemblages from Lion Spring and C-Spring contain a distinct suite of artefacts, including medium-small handaxes, high quantities of cleavers, some Quina scrapers, and Levallois-like flakes, but very few blades. This industry was designated the “Late Acheulean of Azraq” (LAA) facies, since the assemblages contain elements of the Acheulean industry and indicate an incorporation of the Levallois technique (Copeland 1988, 1989a).

Table 1: List of important Lower Palaeolithic sites and surveyed wadis in the central Azraq Basin.

Sector/site		Type of recovery	Key references
‘Ain el-Beidha (White Spring)	137	Survey	Copeland (1989d)
	201A	Survey	Copeland (1989d)
	209	Survey	Copeland (1989d)
‘Ain Soda		Excavation	Dirks (1998); Lister et al. (2013); Rollefson et al. (2006); Rollefson et al. (1997a); Rollefson et al. (1997b)
C-Spring		Excavation and salvage	Clutton-Brock (1989); Copeland (1989a, 1991); Garrard et al. (1987; 1988); Hunt and Garrard (1989)
Druze Marsh	DM2B DM3 DM8 DM11	Excavation	Ames and Cordova (2015); Ames et al. (2014); Cordova et al. (2013)
D-Spring		Salvage	Copeland (1989e)
E-Spring		Salvage	Copeland (1989e)
Lion Spring (‘Ain el-Assad)		Excavation	Copeland (1989b, 1989c); Harding (1967); Rollefson (1980)

Sector/site		Type of recovery	Key references
Shishan Marsh	SM1	Excavation	Ames et al. (2022); Beller (2023); Beller et al. (2020); Boyd et al. (2022); Nowell et al. (2016); Pokines et al. (2019)
Wadi Butm		Survey	Copeland and Hours (1989b)
Wadi Enoqiyya		Survey	Hours (1989)
Wadi Kharanah		Survey	Copeland and Hours (1989b)
Wadi Rajil		Survey	Copeland (1989d)
Wadi Rattama		Survey	Copeland and Hours (1989b)
Wadi Uweinid		Survey	Garrard et al. (1977); Rollefson (1984)

Surveys along the several wadi channels provided additional evidence of Lower Palaeolithic occupation. In 1981, a brief reconnaissance within Wadi Uweinid, a small tributary of Wadi Butm, recovered a scatter of large bifaces, blades, and flakes (Rollefson 1984). These were collectively described as typical of the Middle Acheulean (Rollefson 1984), but exhibit consistencies with Late Acheulean assemblages found later in the region. Between 1982-1986, an extensive project conducted by the Centre National de la Recherche Scientifique from the Université Lumière in Lyon surveyed the Butm, Enoqiyya, Kharanah, Rattama, and Rajil channels (Figure 3) (Copeland and Hours 1989b). All except Wadi Enoqiyya yielded Lower Palaeolithic artefacts characterised by large-medium handaxes, few cleavers, thick blades, and "proto-Levallois cores" (Copeland and Hours 1989b). These assemblages were termed the "Desert Wadi Acheulean" (DWA) facies, as their typological and technological characteristics indicated they were distinct from the LAA (Copeland 1988; 1998; Copeland and Hours 1989b). In contrast, the Lower Palaeolithic artefacts discovered along Wadi Enoqiyya were more consistent with the LAA (Hours 1989).

The complete drying of the Shishan and Druze marshes permitted access to deeply stratified deposits that correspond to the Middle and Late Pleistocene. Excavations conducted at ‘Ain Soda within the Shishan Marsh during the late 1990s found faunal remains associated with an assortment of lithic artefacts, including flake tools, handaxes, and cleavers (Rollefson et al. 2006; Rollefson et al. 1997a; Rollefson et al. 1997b). These assemblages are described as part of the "Late and Final Acheulean" (Rollefson 1997a), exhibiting consistencies with the LAA facies and demonstrating a Lower Palaeolithic presence within the GAOA.

Several soundings in the Druze Marsh also identified several Palaeolithic layers. The exposed stratigraphy offered a detailed record of the nature of changing hydrology and environment and its relationship to hominin occupation (Ames and Cordova 2015; Ames et al. 2014; Cordova et al. 2013). For example, excavations within Druze Marsh recovered Acheulean handaxes and a cleaver associated with a deep marsh transitioning to dryer conditions in layer 1b-c. While no absolute dates have been obtained, occupation in Unit 1b-c is thought to be contemporaneous (estimated >250 ka) with other Late Acheulean sites around and within the GAOA (Ames and Cordova 2015; Ames et al. 2014).

3.3. Shishan Marsh 1

The archaeological site of Shishan Marsh 1 (hereafter SM1) is situated near ‘Ain Soda (Figure 3). The recent excavation uncovered an area of approximately 21 m^2, but the site is much larger and continues further into the unexcavated profiles.

Altogether, ten sedimentary units were identified (Ames et al. 2022; Nowell et al. 2016). Layers 1 and 2 are mixed Holocene deposits near the surface and contain limited cultural material, including Lower Palaeolithic lithics, historical ceramics, and modern trash. Layers 3-7a, 9, and 10 were archaeologically sterile. Layers 7b-c and 8 yielded abundant Palaeolithic cultural materials and a small faunal assemblage indicative of hominin activity. The results of optically stimulated luminescence dating places the time of burial at 266 ± 40 ka (layer 8) and 125 ± 12 ka (layer 7b) (Ames et al. 2022; Nowell et al. 2016). These are considered to be minimum dates and further geochronological evaluation will offer more clarity.

Each lithic artefact >2.5 cm in maximum dimension was piece-plotted using a total station. Orientation was also recorded on specimens that exhibited an elongated axis, typically where the length was 1.5 times greater than the width. Each spit was sieved through 2 mm screens to collect debitage. In addition, every NE quadrant was wet sieved to facilitate the recovery of any small debitage and other flaking debris.

The small faunal assemblage is dominated by mammalian megafauna from the Palearctic and Afrotropic biogeographic ecological zones, including *Gazella* sp., *Bos primigenius*, *Camelus* sp., *Stephanorhinus hemitoechus*, and various equids (Pokines et al. 2019). Their remains mainly comprise teeth and limb bones. Overall, the combination of faunal remains and stone tools suggests SM1 is most consistent with a butchering site (Nowell et al. 2016; Pokines et al. 2019).

4. BIFACES FROM SHISHAN MARSH 1

4.1. Biface typology

Approximately 2000 identifiable tools and flakes were recovered from layers 8 and 7b-c, of which a large portion (n=1296), including all the bifaces, has been analysed (Table 2). Evaluation of the lithic assemblage draws on established morphological (Debénath and Dibble 1993) and technological criteria (Callahan, 2013 (1981)), and indicates consistencies with the LAA facies (Nowell et al. 2016).

To date, 61 cores have been identified among the assemblage. The majority are multidirectional (n=30), while others of note are bidirectional (n=7) and Levallois (n=4). The small tools are largely represented by various utilised flakes (n=845), scrapers (n=104), blades (n=61), and borers (n=36). There are two main differences in the composition of lithics between the two layers. First, layer 7 is dominated by both modified and unmodified Levallois flakes and very few biface thinning flakes, while layer 8 contains more biface reduction flakes (Pokines et al. 2019 vol. *91*(2): 772).

A total of 84 bifaces, handaxes (n=79) and cleavers (n=5), were identified in the assemblage (Figure 4; Table 2, Table 3; Appendix 1). Their manufacture was completed with the use of a soft hammerstone (e.g., dolostone, limestone) or billet (e.g., antler, bone).

Layer 8 contains four cleavers and 38 handaxes. Three cleavers and 19 handaxes are ovate in their morphology. Other handaxes include discoid (n=3), cordiform (n=2), and early-stage or preform reduction (n=4). Three handaxes and a cleaver were made on large flakes. Another cleaver and 15 handaxes were made from tabular material. The previous state of the other 22 bifaces could not be determined.

Layer 7 contains one cleaver and 41 handaxes. The majority of handaxes are ovate (n=22), while several others are discoid (n=4), cordiform (n=3), or preform (n=4). Two handaxes and a cleaver were made from large flakes, while three handaxes were made from clasts. Tabular material accounted for the previous state of 18 handaxes, while those of the remaining 18 handaxes were unknown.

Figure 4: Selected lithics from SM1: #2941 ovate handaxe, #4488 ovate handaxe, #4033 ovate handaxe, and #1767 amygdaloid handaxe. Photographs taken by JAB (Beller 2020: Appendix 2).

Table 2: Typology of current analysed lithics from Shishan Marsh 1. Table reproduced from (Beller 2020: 81; Murray 2017).

Type	Count	Type	Count
Backed knife, natural	1	Flake, early core reduction	224
Biface (handaxe)	79	Flake, late biface thinning	37
Biface (cleaver)	5	Flake, late core reduction	136
Blade	22	Flake, Levallois	82
Blade, Levallois	39	Flake, tranchet	7
Borer	36	Notch	10
Burin	11	Point	3
Burin spall	11	Point, Levallois	31
Chopper	1	Scraper, bifacial	1
Core	61	Scraper, convergent	15
Core tool	15	Scraper, déjeté	3
Denticulate	16	Scraper, double	21
Flake	281	Scraper, end	27
Flake, bipolar	1	Scraper, single	37
Flake, early biface thinning	77	Tested material	6
Total		1296	

Table 3: Previous state of the bifaces of from Shishan Marsh 1. Table modified from Beller (2020: 98-99 and Appendix 1).

	Type		Clast	Large flake	Tabular Material	Unknown	Total
Layer 8	Cleaver	Ovate		1	1	1	3
		Unknown			1		1
	Handaxe	Amygdaloid			1		1
		Cordiform				2	2
		Discoid		1	1	1	3
		Early Stage			3		3
		Fragment			1	2	3
		Ovate		2	7	9	18
		Preform			1		1
		Unknown				7	7
	Layer total			4	16	22	42
Layer 7	Cleaver	Unknown		1			1
	Handaxe	Amygdaloid			2		2
		Cordiform			1	2	3
		Discoid			1	3	4
		Fragment	1	1		1	3
		Ovate	2	1	10	9	22
		Preform			4		4
		Triangular				1	1
		Unknown				1	2
	Layer total		3	3	18	18	42
Site total			3	7	34	36	80

4.2. Use wear analysis

A use-wear analysis of 54 handaxes, 31 from layer 8 and 23 from layer 7, was conducted to identify the nature of their function (Murray 2017). This analysis used low-powered microscopy to assess the distribution of edge damage (Odell 1981; Tringham et al. 1974). The edge damage distribution method is an assemblage-scale approach to use-wear that determines function based on the frequency and pattern of use-wear along the edges of stone tools (Bird et al. 2007; Schoville 2010; Schoville et al. 2016).

The main types of edge damage found on the SM1 handaxes are micro-flaking and rounding (Figure 5). Microflakes are small flakes detached along the edge of a stone tool, whereas rounding is the dulling of a sharp edge. Transverse actions, such as scraping or planing, cause a higher degree of rounding on edges facing the surface, whereas longitudinal actions, such as sawing and cutting, typically cause bifacial rounding (Odell 1981). These are consistent with edge damage found on other artefact types, such as naturally backed flakes, Levallois blades/points, and other utilised flakes (Nowell et al. 2016). The average frequency of edge damage is highest at the distal end and lowest at the proximal end (Figure 6). This pattern demonstrates handaxes were utilised to a greater extent at the distal end and further suggests that this portion is an important aspect of handaxe morphology.

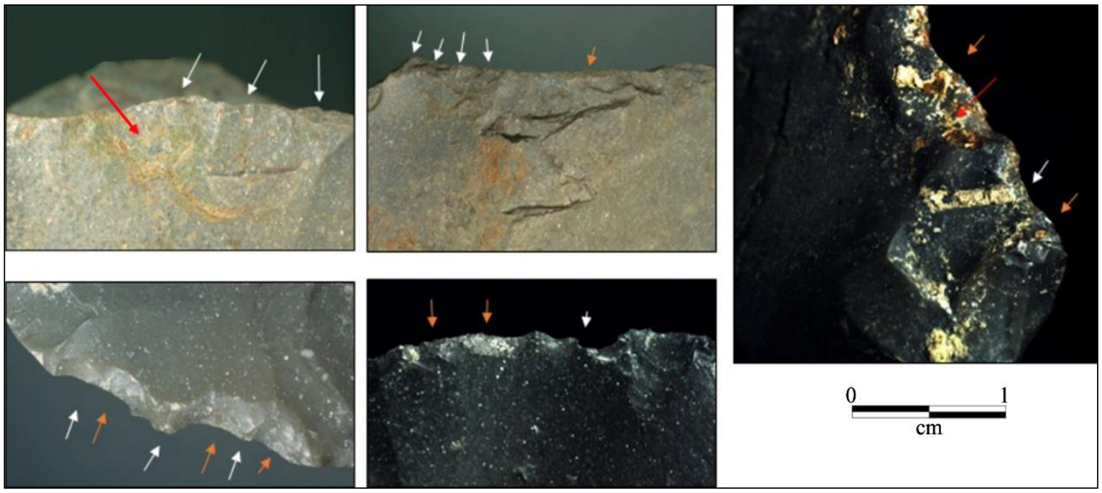

Figure 5: Edge damage on bifaces. Composite image from Murray (2017: 81-81). Examples of use-wear on the archaeological handaxes. White arrows indicate microflaking and orange arrows indicate rounding. Red arrows indicate observable residue. Photographs taken between 25-50x by JKM.

The mixture of bifacial and unifacial rounding and micro-flaking indicated that the tools were used for multiple activities. Collectively, the intensity of the edge damage seen on most of the artefacts suggests that these tools were used for extended periods of time (Vaughn, 1985) and/or on medium-hard materials (e.g. wood, bone) (Grace 1989). The distribution of edge damage that differs from random occurrence, combined with the overall low frequency of post-depositional scarring, suggests that most of the use-wear is anthropogenic in origin. In addition to the use-wear, many handaxes exhibit greenish-orange, translucent residue along utilised areas that have not been formally identified (Murray 2017).

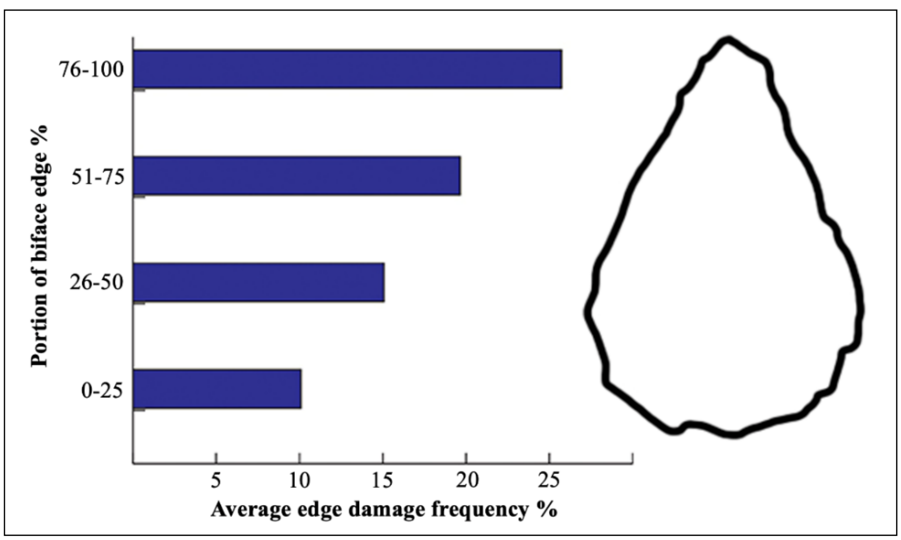

Figure 6: Bar graph showing the average frequency of edge damage by the portion of the edge across all analysed handaxes. 0-25% represents the base of the handaxes and 76-100% representing the distal end. The outline of the handaxe to the right of the graph demonstrates how the y-axis correlates to the section of the edges.

4.3. Provenance analysis

A provenance analysis based on geochemical profiles produced through laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) was conducted to identify the potential raw material sources from which the bifaces originated (Beller 2023; Beller et al. 2020). The Azraq Basin offers primary and secondary sources of chert, as the three sedimentary formations contain chert beds and nodules, while the various wadi channels that flow into Qa' Azraq constitute secondary sources (Figure 2, Figure 3). However, since the wadis deposit clasts into the *qa'* and wetlands that are significantly smaller than the necessary blank size for the manufacture of bifaces, it is posited that raw materials were obtained elsewhere on the landscape. The analysis involved a sample of bifaces (n=36) and two bidirectional cores, as well as 50 'sources' at 19 sampling localities from within the central Azraq Basin. It was discovered that the lithics were most geochemically consistent with sources belonging to the URC formation located to the west and northeast of Qa' Azraq. These are geographically separated by the overlying intrusion of the Jebel al-Druze basalt plateau. Several artefacts were linked to on-site exposures of the URC formation. However, it is not known whether these were accessible for exploitation or weathering for clasts at the time of occupation. No lithics could be suitably connected to the secondary sources of the south or east.

Provenance could not be suitably conducted through petrographic or macroscopic attributes due to the heavy varnish exhibited on the surface of the artefacts and the minimal destruction of material that was permitted. The varnish appears as a thin dark grey coating (1-5 mm in thickness) in stark contrast to the interior and tends to round sharper edges. One artefact (4488) fractured upon discovery during excavation illustrates the disconnect between the fresh and protected interior and varnished exterior (Figure 4). It is not known whether this varnish is related to sunlight exposure (e.g., desert varnish) or fluvial action. It should be noted that this varnish is different from the glaze (smooth silica coating) identified by Shackley (1989) at spring sites of the GAOA.

Clasts found in the wadi channels and strewn across the desert landscape exhibit additional forms of exterior modification. These manifest as combinations of the classic desert varnish, some crazing, and patinas (Crabtree and Butler 1964; Walwer 1993). The desert varnish clouds the translucency, although it is occasionally interrupted by an opaque white patina. A common observation is that their exteriors are a coarser texture (aside from the varnish), often with chatter marks related to physical damage during fluvial transport. The samples from all sources were purposely fractured open in order to more effectively reveal their interior attributes, as these are fresh and unaffected by weathering. This contrast exemplifies how the exterior is often not representative of the actual raw material, as the interior is subject to limited physical and geochemical alteration. Provenance associations between sources and artefacts based on the individual attributes of the material were not possible, as a complete fracturing of the pristine bifaces was not always possible.

5. DISCUSSION

5.1. Foraging ranges

The provenance results provide evidence for the unidirectional movement of raw material (blanks, cores, and/or tools) over varying distances (Figure 7). These distances can be described by traditional foraging ranges: on-site, local (western area), and regional (northeastern area) (Binford 1978, 1982; Ekshtain et al. 2017; Kandel et al. 2016).

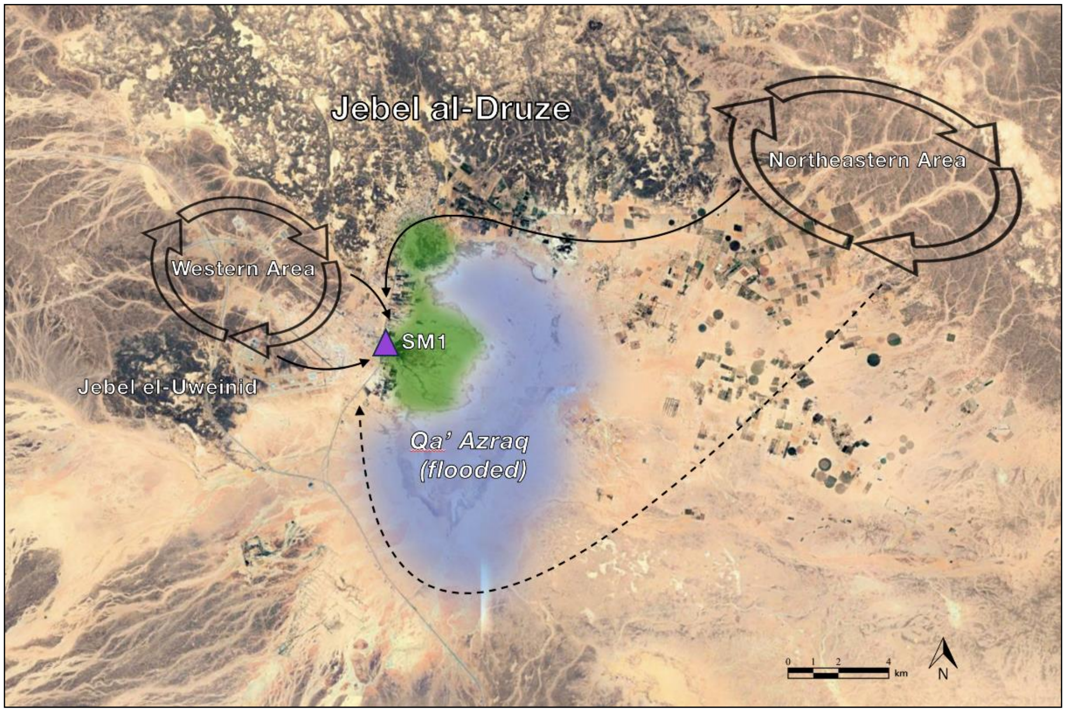

Figure 7: Procurement areas within the Azraq Basin. At the centre is SM1 (on-site catchment) and Qa' Azraq, depicted during the wet season. Figure created from Google Earth®.

Settlement around the Shishan Marsh may have brought the hominins into contact with disembedded tabular clasts from beds within 'Ain Soda. It is not yet clear if these were available given their depth. While there were some exposed portions of the beds today, it is more probable that some disembedded clasts were scattered within the vicinity of the site. If accessible, the quick on-the-spot collection of clasts would be convenient and opportunistic. It does not appear that hominins were dependent on these sources and were instead outfitted with a mobile toolkit. A near complete reliance upon on-site raw material would be demonstrated by an overwhelming frequency (e.g., 90%) of artefacts linked to these sources, but this is not the case.

The high availability and quality of material in the western catchment area provides ample opportunity for exploitation by hominins. This high proportion of bifaces made from tabular material suggests procurement closer to the source. From the locations along wadis Hayat and Rattama where beds are exposed and suitable tabular clasts and rolled cobbles are available, a trek to SM1 is under 7 km, a distance that can be traversed in a single day. It is gravelly and dusty underfoot, but with a gentle elevation change (~50 m over 10 km) and few topographic obstacles. The trek could follow the wadis, particularly the larger Wadi Rattama, which moves downstream southeast and reaches Qa' Azraq between the Druze and Shishan marshes. It is possible that bifaces could be manufactured at the location of raw material collection.

The northeastern catchment area provides similar qualities (medium-high) and distributions of raw material, but at a greater distance (15-21.5 km) from Shishan Marsh. Unfortunately, the exact location/s of raw material procurement and possible biface manufacture in this area is/are unknown. Multiple escarpments of the URC formation are exposed, but access to the beds can be difficult due to their isolation and the undulating landscape that surrounds them. Here, an approach from below is safest, though it initially requires navigating along wadi channels. The subsequent weathering and erosion of chert beds in this area results in the release of clasts into the Usaykhim and al-Masayil channels (and more distant Rajil). The numerous clasts in each wadi are brought downstream toward Qaʿ Azraq, although only finer sediments reach the *qaʿ* in the present geomorphic context. At the average walking pace of an adult (5 km/hour), a trek to SM1 can also be accomplished in a single day. However, this estimate excludes any search for and acquisition of non-lithic resources (e.g., vegetation, prey), as well as the collection of clasts or even the exploitation of beds, not to mention the time allotted for tool manufacture. A direct route to SM1 would pass over some undulating terrain until the boundary of Qaʿ Azraq is reached. Seasonal fluctuations could keep the *qaʿ* wet or make it too muddy to cross (Figure 7). During dry seasons, it is a straight trek across the gravely-sandy surface, although such a path (i.e. shortest route) or around it to the west offers no additional chert clasts. Regardless of the conditions, it may have been more advantageous to follow Wadi Usaykhim, as it cuts along the eastern edge of the igneous plateau. Although this route would include several extra kilometres, it would lead hominins closer to the Druze Marsh, rather than bypassing it. Its wetlands, when active, would have presented another resource-rich locale to which hominins could deviate and exploit (Ames and Cordova 2015; Ames et al. 2014).

5.2. Hominin movement across the landscape

A consideration of the wider lithic landscape provides insight into how hominins may have navigated within the Azraq Basin. Even if the disembedded clasts not been available in the Shishan Marsh, a portion of procurement occurred outside the wetlands and at various spots on the landscape. The extensive use-wear on the bifaces may also support the idea that groups were travelling further for material and using these tools before eventually discarding them in Shishan Marsh. Therefore, learning and communicating about their landscape was essential.

The availability of chert is largely affected by the intrusion of the Jebel al-Druze basalt plateau into the northwestern Azraq Basin. It operates as a lithological cap, overlain by layers of aeolian sediment and among which there is little (or no) access to chert. These igneous flows further create a geographic divide between the western and northeastern catchment areas. It is possible that hominins may have had little reason to venture over it and preferred to forage among the lower elevation and vegetation of the sedimentary landscapes. In fact, very little Palaeolithic material has been discovered among the plateau and along Wadi Enoqqiya (Betts 1988).

The utilisation of natural features of the regional landscape was likely conducive to the survival of hominin groups. For instance, following the wadi channels may have been useful in guiding hominins towards or from the GAOA. Indeed, material collected by previous surveys indicate Lower Palaeolithic occupation along or nearby the major wadi channels (Copeland 1988; Copeland and Hours 1989b). Passing over the gently descending landscape of the various catchment areas until the green oasis or low-lying *qaʿ* appear on the horizon would reinforce the direction of travel toward a collection of resources. Even casual exploration throughout a region has benefits beyond the procurement of lithics, as it permits the development and maintenance of familiarity with the landscape (Whallon, 2006). It allows for monitoring herds, surveying for other hominin groups, and evaluating the status of other water resources (e.g., Druze Marsh, various wadis). Any established or immediate knowledge can inform impactful decisions for the future of the group. For instance, the high hill upon which Qasr Usaykhim sits offers the viewer an extended 360° view of the regional landscape for tens of kilometers (Figure 8). Hominins using this regional vantage point can spot animals or other hominin groups moving throughout the region. Similar use of a lookout is suggested at Ar-Rasfa, Jordan, a Middle Palaeolithic site located along an escarpment overlooking ancient Lake Lisan (the modern Dead Sea) (Ahmad and Shea 2009; Shea 1998; Shea and Crawford 2003). Additionally, Jebel el-Uweinid, an extensive isolated igneous bluff to the southwest of the GAOA (now quarried with modern machinery), presents an elevated obstacle on the landscape. This dark protrusion may have been used to signal that available chert was to its immediate north in the western catchment area, as there is no suitable raw material available to its immediate south or east (Garrard et al. 1977).

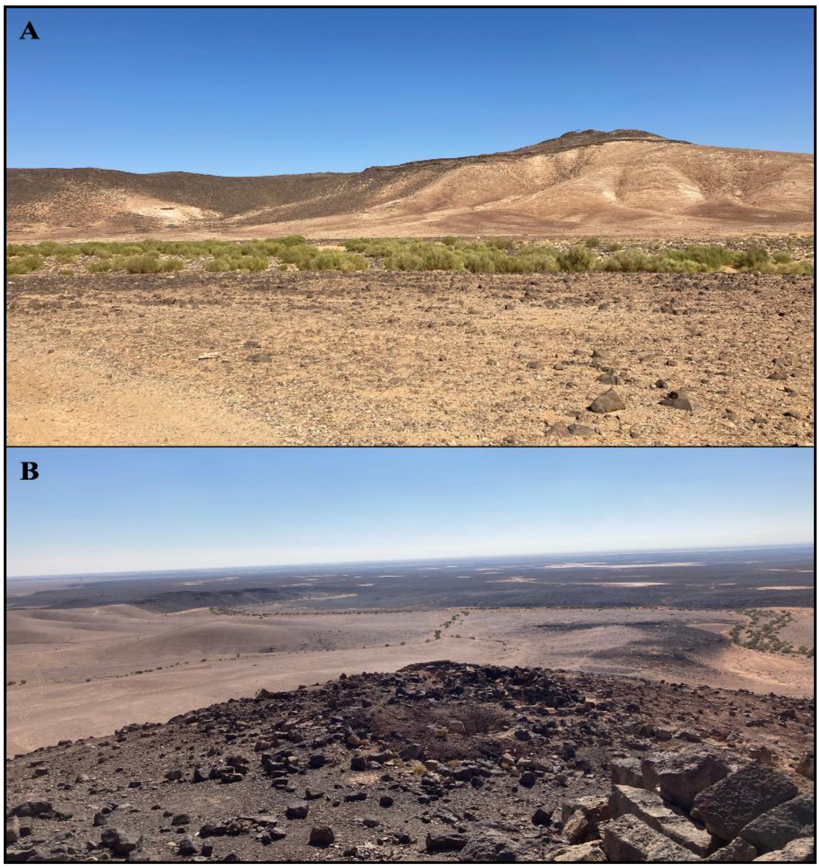

Figure 8: A) View looking up at Qasr Usaykhim, a Roman fortress, from Wadi Usaykhim. B) View looking south from Qasr Usaykhim; the GAOA can be seen just before the horizon. Photographs taken by JAB.

Foraging was certainly far reaching into the landscape that surrounded the GAOA, as hominins could predictably find chert sources in the western and northeastern catchment areas. Any resolution of seasonal movement is complicated by the absence of home-bases or residence sites, if any were used at all. It is not known from where hominins set out to procure their stone tools. The procurement areas (west and northeast) align with the areas that receive greater precipitation in the region. Hominins may have chosen to dwell among the various wadi channels during the wet season, as the *qa‘* flooded. During the dry season, as the water in the *qa‘* evaporated, they likely contracted toward or made frequent visits to the stable GAOA. It cannot (yet) be established if SM1 is indeed a dry season occupation, utilised when water levels were lower and any spillover from the *qa‘* had receded. The location of contemporaneous sites to SM1, such as Lion Spring and C-Spring (Clutton-Brock 1989; Copeland 1991; Rollefson 1980), on the boundaries of the GAOA further indicate repeated hominin activity around this localised pocket of resources.

5.3. Provisioning of the wetlands

Foragers of the central Azraq Basin were presented with a landscape of variable raw material distribution, leaving them with many decisions of which sources to exploit, where to manufacture tools, and whether to transport blanks or finished tools. A consideration of the data lends spotlights an intertwined provisioning pattern.

Conducting manufacture at the source allows foragers to carry lighter loads of finished implements (gear) to utilise for tasks encountered along their route or at their destination (Beck et al. 2002). Tools, cores, or blanks of raw material were transported over significant distances, although it is likely that most were transported as finished tools. Individuals could provision themselves with specific toolkits, namely handaxes and cleavers, to use on demand.

The types of tools present and the protein residue discovered upon them securely demonstrate their utility for butchering, although not necessarily who (hominins or non-human predators) killed the animals. The assortment of specialised tools (e.g., knives, scrapers) and flakes constitute a proficient toolkit for carcass processing and hide and meat removal. Handaxes and cleavers can also perform these tasks, as well as bone breaking for marrow extraction.

Most bifaces exhibit medium-high degrees of wear but are still in good condition. This is partly due to the high-quality material from which they are manufactured. No significant patterns can be established between procurement area and degree of wear, as even those from afar received use. Many bifaces were often discarded before exhaustion, but the continual "discard" of relatively good condition tools at SM1 and sites within its vicinity, such as ‘Ain Soda (Rollefson et al. 1997b), allowed a high concentration of different tools to accumulate at the wetland margins. The action of discard was not entirely a permanent rejection of the tool for further use, but rather a caching of it among others in that specific location. Consequently, hominins may have intentionally accumulated various large tools and cores at the margins of the wetlands for later anticipated needs, consistent with provisioning a place (Kuhn 1992; 1995; 2004).

6. CONCLUSION

The rich record of Lower Palaeolithic occupation within the central Azraq Basin is primarily evidenced by lithics (e.g., Copeland 1988; 1991; Copeland and Hours 1989a; Garrard et al. 1977). Previous studies focused on the typology of these assemblages and broadly assumed the lithic artefacts originated from clasts collected from wadi channels or were moved downstream into the GAOA and thus were within the immediate vicinity of each site. The paucity of raw material within the vicinity of SM1 and limited waste from biface reduction in the lithic assemblage prompted investigations into the nature of lithic procurement and provisioning.

This report combines studies on the typology, provenance, and use-wear related to the bifaces of the SM1 assemblage. The results of the collective analyses indicate the following scenario: hominins outfitted themselves with finished tools (bifaces) near exposed beds or along wadi channels, bringing the bifaces with them to SM1; the bifaces were used on the way or at SM1 where they were finally discarded with much utility remaining; the accumulation provisioned the site as a place with abundant prepared tools and cores that could continue to be used.

During the late Middle Pleistocene (MIS 8-7), hominins likely contracted toward the GAOA and Qaʿ Azraq, as the distribution of freshwater was gradually reduced within the central Azraq Basin (Copeland 1988). In particular, the GAOA provided a permanent concentration of vital resources, namely water and dense vegetation, both of which attracted herds. The similarities in provenance results between layers 8 and 7 suggest that the gradually increasing arid conditions in the region had little effect on procurement patterns. Hominins continued to explore the regional landscape, foraging in distant areas to the northeast of the GAOA, and moving the material and tools to a destination (SM1) beyond a typical local foraging range.

Although this study provides insight into the nature of lithic procurement and provisioning at an important site in the central Azraq Basin, there is a future need to investigate similar behaviours from neighbouring and contemporary sites to SM1. Larger lithics, specifically bifaces and cores, occur in substantial quantities at previously excavated sites, namely Lion Spring and C-Spring (Table 1) (Copeland 1989a; 1989b; 1989c; 1991). For example, it may be that hominins around the Druze Marsh (north GAOA) exploited different sources and exhibit different procurement and provisioning strategies than those of the Shishan Marsh (south GAOA). Their incorporation into a broader investigation will assist in establishing connections among Acheulean sites in the region and cast light on mobility patterns within this region.

ACKNOWLEDGEMENTS

The authors extend their gratitude to the Department of Antiquities of Jordan and, in particular, Aktham Oweidi, Ahmad Lash, and Ashraf Kraysha. We thank Dr. Barbara Porter and Dr. Pearce Paul Creasman, and the staff at the American Center of Research (Amman) for their accommodation and the generosity of the Harrell Family for a student fellowship. We would also like to thank the Azraq Wetland Reserve of the Royal Society for the Conservation of Nature for permission to conduct research, as well as the AMAPP crew, including Dr. April Nowell, Dr. Christopher Ames, Dr. James Pokines, Dr. Carlos Cordova, Stuart Lipkin, Jade de la Paz, and Alexandra Maller. This research was funded by the Social Sciences and Humanities Research Council of Canada through an Insight Grant (#435-2012-0625) awarded to Dr. April Nowell and a doctoral fellowship award (#752-2016-1355) to Jeremy A. Beller. We also thank the two reviewers for their constructive comments.

Declaration of interest

The authors declare that they have no competing interests.

توفيرُ الصُّوان واقتناؤه في موقع مستنقع أزرق الشيشان 1 حوض الأزرق الأردن خلال العصر الحجري الأدنى

جيريمي أ. بيلر [1]، جون ك. موراي [2]، عامر س. السليمان [3]

ملخص

إنَّ لمعالم سطح الأرض وتوافر المصادر وجودتها وكذلك قُرب التكشفات الصخرية وَبُعدِها دورًا مؤثِّرًا في خُطط الباحثين ومشاريعهم في ثقافات ما قبل التاريخ وعصوره، لكنَّ طبيعة توزيع المصادر الأوليَّة تختلفُ من منطقة لأخرى، وهذا يُعيق تصوُّرَ المصادر الأوليَّة وتتبُّعها على نحوٍ واضح وسليم في بعض المناطق ذات الرسوبيات المتأخِّرة. تتناول هذه الورقةُ العصرَ الحجريَّ القديمَ الأسفلَ في مستنقع أزرق الشيشان 1، كما تركِّزُ على الأدوات الحجريَّة ومصادرها في منطقة الدراسة، وهي تجيزُ العديدَ من الدراسات السابقة وتلخِّصُها لفهم طرائق مجتمعات ذلك العصر واستراتيجياته في التزوُّد بالمصادر الأوليَّة لصناعة الأدوات الصُّوانيَّة حول واحة الأزرق في العصر البلايستوسين الأوسط، وتتضمَّنُ هذه المساهمةُ أيضًا نتائجَ التحاليل التي جرت على عينات من المصادر والتكشُّفات الصخريَّة، وكذلك عينات أخرى لِكِسَرٍ من الأدوات الحجريَّة من منطقة الدراسة، التي أشارت إلى استخدامهم الصُّخور الخام من مصادرَ محليَّةٍ وأخرى بعيدة، كما حاولت الدراسةُ إزالةَ الغُموض عن بعض ملابسات تصنيع الأدوات الحجريَّة من مصادرَ ذاتِ جودة أقل جرى طرحُها والتخلُّصُ منها بعد ذلك، وتشيرُ الدراسةُ إلى أنَّ مجتمعات تلك الحِقبة انتقلوا إلى الأراضي الرَّطبة من أماكنَ بعيدةٍ جالبينَ مَعَهُم أدواتِهم الحجريَّةَ، التي استخدموها وألقوها في منطقة الدراسة، من مناطقَ مختلفةٍ.

الكلمات الدالة: العصر الحجري القديم السُّفلي، الأشولي، المشرقي، الملجأ، التنقُّل، الأدوات الحجريَّة.

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تاريخ استلام البحث 2023/6/5، وتاريخ قبوله للنشر 2024/1/23.

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Appendix 1

Characteristics of the bifaces of from Shishan Marsh 1. Table modified from Beller (2020) and Murray (2017).