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Celebrating 66 Years of Acheulean Exploration and Discovery in the Central Al Azraq Basin, Jordan

Abstract

The Al Azraq Basin is an important physiographic feature and hydrological catchment in the eastern desert of Jordan. At its heart today are the Al Azraq wetlands, an ecologically fragile oasis characterised by the spring-fed historic Druze Marsh and rehabilitated Shishan Marsh. The potential for Acheulean investigation in this region was realised by chance in 1956 when stone artefacts were uncovered during an irrigation project. Now, 66 years on, our understanding of Acheulean occupation in the region has been furthered by many notable campaigns, involving archaeologists from a number of countries, including Diana Kirkbride, Lorraine Copeland, Andrew Garrard, Francis Hours, Gary Rollefson, and April Nowell. Their projects have surveyed, documented, and excavated multiple Acheulean sites, including butchering and knapping locales. The collective efforts of these researchers from 1956 to 2022 are highlighted and synthesised to provide an expedient understanding of the nature of Acheulean occupation within the central Al Azraq Basin. Gradually, hominins moved from the distant reaches of the wadi sectors and the margins of a palaeolake (or collection of small lakes) toward the spring-fed marshy ponds concentrated in the centre of the basin.

Introduction

The Al Azraq Basin is a distinct hydrological catchment area situated predominantly across the Central Plateau and Northern Basalt Plateau of northeast Jordan, but encompasses a very small portion of northwest Saudi Arabia and extends northward into southern Syria (FIG. 1). It is a large (~13,000 km^2) endorheic basin, a closed body of water with no outflow. In the distant past, the unique geohydrological conditions of

Table 1. List of Acheulean sites of the Azraq Basin.

Sector/Site		Type of Recovery	Key References
ʻAyn Al Bayḏā (White Spring)	137	Survey	Copeland 1989d
	201A	Survey	Copeland 1989d
	209	Survey	Copeland 1989d
ʻAyn Sawdā and ʻAyn Qasiyyah		Survey and excavation	Dirks 1998; Lister *et al.* 2013; Rollefson, Quintero, *et al.* 1997; Rollefson, Schnurrenberger, *et al.* 1997; Rollefson, Quintero, and Wilke 2006
Buṯum		Survey	Copeland and Hours 1989b; Garrard, Stanley Price, and Copeland 1977
C-Spring		Excavation	Clutton-Brock 1989; Copeland 1989a, 1989e, 1991; Garrard *et al.* 1987, 1988; Hunt and Garrard 1989
Druze Marsh	2, 3, 8, 11	Excavation	Ames and Cordova 2015; Ames *et al.* 2014; Cordova *et al.* 2013
D-Spring		Excavation	Copeland 1989e
An Nuqʻiyyah		Survey	Hours 1989
E-Spring		Excavation	Copeland 1989e
Janab- Al KHarrānah - Mushāsh		Survey	Copeland and Hours 1989b; Garrard, Stanley Price, and Copeland 1977
Lion Spring (ʻAyn Al Asad)		Excavation	Copeland 1989b, 1989c; Harding 1967; Rollefson 1980
Rājil	231	Survey	Copeland 1989d
	251	Survey	Copeland 1989d
Ratamah		Survey	Copeland and Hours 1989b
Shishan Marsh	1, possibly 13	Excavation	Ames *et al.* 2022; Beller, Ames, and Nowell 2020; Nowell *et al.* 2014; Nowell *et al.* 2016; Pokines *et al.* 2019
ʻUwaynid		Survey	Byrd and Garrard 2013; Garrard, Stanley Price, and Copeland 1977; Rollefson 1984

the Al Azraq Basin allowed it to play an important role in Acheulean occupation.

For over half a century the Al Azraq Basin has been a remote archaeological hotspot, attracting scholars specialising in various periods, from the Lower Palaeolithic to Neolithic to Roman to Islamic. The initial discovery of Acheulean material in 1956 was unexpected and, by 2022, it had led to 66 years of intermittent archaeological exploration and discovery. These efforts have included salvage recoveries, extensive surveys, and excavations, all of which have produced critical information on the nature of occupation during the late Lower Palaeolithic (*ca.* 450–200 ka BP) (TABLE 1). The most significant culmination of early research on the Acheulean is *The Hammer on the Rock: Studies in the Early Palaeolithic of Al Azraq, Jordan,* edited by Lorraine Copeland and Francis Hours (1989a). Archaeological investigation is far from complete, however. A summary of recent archaeological inquiry by an international team was presented at the 15th International Conference on History and Archaeology of Jordan (ICHAJ 15) at Yarmouk University, Jordan, in July 2022. As a

conference volume takes shape, it provides an opportunity to acknowledge *the giants on whose shoulders we stand* (to paraphrase Sir Isaac Newton).

This report, while not exhaustive, presents a diachronic overview of archaeological research on the Acheulean of the central Al Azraq Basin, showcasing contributions by leading archaeologists from 1956 to 2022. It closes with a discussion of Acheulean occupation, wherein two broad phases are thought to occur. This interpretation is enriched by reconstructions of the region's dynamic hydrology, which reveal a gradual reduction of water availability from a palaeolake (or palaeolakes) to spring-fed marshy ponds concentrated in the basin's centre. This environmental change likely prompted hominins to adapt by relocating closer toward the perennial and stable desert refugium for resource security.

The Al Azraq Basin

The geology of the Al Azraq Basin is a patchy mosaic of igneous and sedimentary rocks, which are typically covered by alluvium and topsoil (Abed 2018; Bender 1974). In various places, the underlying sedimentary formations of the Belqa Group, namely the Muwaqqar Chalk-Marl, Umm Rijām Chert-Limestone, and Wadi Shallala Chalk are exposed. These sedimentary deposits provide bedded and nodular chert as raw material for stone tool manufacture throughout the region (Ames *et al.* 2014; Beller, Ames, and Nowell 2020; Copeland 1988, 1991; Rollefson 1980; Rollefson, Schnurrenberger, *et al.* 1997; Sánchez de la Torre *et al.* 2019). In the northwestern portion of the Al Azraq Basin, the formations are overlain by a large exposure (~11,400 km^2, Harrat Al Jabbān) of the Harrat Ash Shām basalt plateau of Oligocene-Pleistocene age (Al-Malabeh 1994; Cordova 2007; Ilani *et al.* 2001).

The average temperatures in July and January are 26.6ºC and 11.6ºC, respectively (El-Naqa 2010), although high temperatures in the summer can often exceed 45ºC. The current climate is arid with an average annual precipitation of 87 mm and under 50 mm at its centre (El-Naqa 2010). Precipitation by low-pressure systems over the Mediterranean Sea rarely fully penetrate over the central highlands along the Dead Sea Transform, leaving the rain shadow deserts of the eastern Levant without significant rainfall (Cooke, Warren, and Goudie 1993; Frumkin, Bar-Yosef, and Schwarcz 2011; Jennings *et al.* 2015). At the centre of the Al Azraq Basin is Qā' Al Azraq, a salty mudflat (*qa'* in Arabic), roughly 75 km^2 in size that is a dry, yet seasonally flooded, flat surface and constitutes the lowest elevation in the basin (Abed 2018; Ames and Cordova 2015). Qā' Al Azraq provides a large catchment for input from several large seasonal streams—known locally as *wadis*—namely the Buṯum, An Nuq'iyyah, Hayat, Al Masāyil, Ratamah, Rājil, and Usaykhim sectors (FIG. 2). Any precipitation that reaches the Al Azraq Basin is typically confined to the northern and western portions, giving the wadi sectors in these areas an extended duration of seasonal flow (Abed 2018; Enzel *et al.* 2008).

At the eastern edge of Qā' Al Azraq lies the Greater Al Azraq Oasis Area (GAOA), a single geographic unit with freshwater marshes maintained by springs fed by an aquifer system contained in the Tertiary limestones and basalt (Dottridge 1998; El-Naqa 2010). The GAOA comprises the historic Druze Marsh and the recently rehabilitated Shishan Marsh (see FIG. 1). 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). The Druze Marsh has not recovered, but 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). The aquifer system of the Al Azraq Basin 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). A visit to the modern Al Azraq Wetland Reserve reveals that it operates as a small desert oasis for migratory birds and a watering hole for various wild animals, some which have been recently reintroduced (FIG. 1).

Initial Clues of Prehistoric Occupation

Archaeological research in the central Al Azraq Basin has been conducted intermittently, with the first secure discovery of Lower Palaeolithic material occurring in 1956. Architectural ruins from historic periods, namely Roman and Islamic, were exposed on the modern landscape and attested to occupation over the last two millennia. However, the potential for prehistoric archaeology was initially realised in the 1920s when pilots of the Royal Air Force of the British Army flew over the region and later documented on the ground what they had observed from the air. Group-Captain Lionel W. B. Rees and Flight-Lieutenant P. Maitland independently took photographs and made sketches of the regional physiogeography, inscriptions, and numerous stone-built structures (Maitland 1927; Rees 1927, 1929). These latter features consist of stacked and arranged boulders, particularly those of basalt, and include kites, cairns, and camps. They were described by the local Bedouin as "the works of the old men" (Maitland 1927: 197), as their age was thought to be quite ancient. Pedestrian reconnaissance among the features noted that "[f]lints of various ages are found near them, but no connexion with the walls can be affirmed" (Rees 1929: 398). The "works" have since been dated to as far back as the Chalcolithic (4500–3500 BC) and possibly Neolithic (10,000–4500 BC) (Betts and Burke 2015; Kennedy 2011; Kennedy and Bewly 2004), both periods of dynamic cultural development in the region. Nevertheless, in the 1920s it was apparent that human (and possibly hominin) occupation within the Al Azraq Basin greatly pre-dated that of the Roman Empire.

Discovery of the Spring Sites

The territorial reorganisation of the Near East during the aftermath of the First World War, the calamity of the Second World War, and the subsequent 1948 Arab-Israeli War caused the archaeological potential of Jordan and the Al Azraq Basin to be temporarily obscured. In 1956, it was reignited by chance during the construction of an irrigation system in Al Azraq by the U.S. Aid Point IV Princess Alia Project conducted by Baker and Harza Engineering Company (1958). Foreman R. Pannell noticed a regular occurrence of lithic artefacts in the dredging buckets. These were primarily retrieved from the spring sites of 'Ain el-Assad, more commonly known by its English translation, "Lion Spring" (FIG. 2).

Pannell informed G. Harding, then director of the Department of Antiquities of Jordan, and an immediate visit to the site left him stunned by the volume

of bifaces. Harding (1958: 9) describes seeing "six or seven hundred axes" and "several hundred" other lithic artefacts (Harding 1967; Rollefson 1980: 2). Shortly after, D. Kirkbride, a researcher with the Department of Antiquities of Jordan, visited the irrigation project to collect more exhumed material and document the associated geomorphic contexts (Copeland 1989b; Kirkbride 1989). Clusters of lithic artefacts and fauna remains appeared in grey clay (level 4) and coarse sand layers (level 5) approximately 180–240 cm below the surface (Kirkbride 1989).

Additional trenches contributed to a large canal system, namely at C-Spring (hereafter C-Spring-BH, for Baker and Harza), D-Spring, and E-Spring, where a further 160 lithic artefacts were collected from the surface and backdirt piles (FIG. 2). The materials were later analysed by Copeland (1991, 1989e), but biased in favour of "good" pieces. These included bifaces, cores, and scrapers, most of which were consistent with the Acheulean technocomplex. In 1958, F. Zeuner also visited the sites and intended to contribute to their interpretation as Part II of *Stone Age Exploration in Jordan* (see Zeuner, Kirkbride, and Park 1957). Unfortunately, he passed away before fully publishing on them, although a commemorative report was later produced as Zeuner (1989).

A short hiatus of Acheulean exploration in the Al Azraq Basin was assumed, partially due to the emerging geopolitical circumstances leading up to the 1967 War ("Six Day War") between Israel and neighbouring Arab states and the de-escalation that followed. The lithic materials (>1,200) recovered by both Harding and Kirkbride at 'Ayn Al Asad remained largely unanalysed until an examination by Copeland in 1983–1985. These were diagnostic of the Acheulean as well (Copeland 1989b, c). Two short visits to the site by G. Rollefson (1980) in 1979 enabled the collection of over 500 lithic artefacts, including 62 bifaces, from the backdirt piles. The following two years, 1980–1981, Rollefson conducted two seasons of formal excavation at Lion Spring. The team was ultimately unsuccessful at relocating the Acheulean layers, but discovered additional bifaces and Levallois material in reworked backdirt (Rollefson 1982, 1983).

During the 1970–80s, a team led by A. Garrard (later director of the Council for British Research in the Levant, 1983–1989) undertook the Al Azraq Basin Project, which sought to establish the long-term nature of environment, settlement, and subsistence during the late Pleistocene and early Holocene (Garrard and Byrd 2013; Garrard, Stanley Price, and Copeland 1977; Garrard *et al.* 1987; Price and Garrard 1975). The project comprised surveys and probes along several wadi sectors, namely Jīlāt, Usaykhim (Aseikhim), and Uweinid ('Uwaynid), over four seasons (FIG. 2) (1975, 1982, 1984, 1985), as well as a small-scale excavation of C-Spring in 1985. Although the aim was to discover and document Upper Palaeolithic and Epipalaeolithic sites (Garrard and Byrd 2013), evidence of Lower Palaeolithic occupation was rediscovered at C-Spring. A 3 x 1.5 m sounding (hereafter C-Spring-AG) was opened, separated from the original C-Spring-BH trenches by 30 m (FIG. 2) (Copeland 1989a; Garrard *et al.* 1987; Hunt and Garrard 1989). At a depth of approximately 3 m, layers of blue-grey silt (levels P and Q) with sparse Middle Palaeolithic and Lower Palaeolithic artefacts overlay further silt layers (levels R and S), which contained a trove of >4,000 artefacts (Copeland 1989a; Hunt and Garrard 1989). The abundance

and density of artefacts across such a small area led to the site's description as a "river of flint" (Copeland 1991: 3). The lithics were analysed by Copeland (1989a) and consisted of handaxes, unutilised flakes, cores, and debitage that were consistent with the Acheulean. Special note was made of the good condition and lack of use of many artefacts, which are described as "mint-fresh" and "razor-sharp" (Copeland 1991: 3–4). 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 knapping floor (Copeland 1991).

The techno-typological consistencies among the collective BH+AG assemblages from C-Spring and 'Ayn Al Asad led to their demarcation as a distinct facies, known as the Late Acheulean of Al Azraq (LAA) facies (FIG. 3) (Copeland 1991; Copeland and Hours 1988). The assemblages from nearby D-Spring and E-Spring contained similar attributes but were too small to generate any specific inferences regarding the nature of the sites. Broadly, the LAA is characterised by medium-small handaxes, cleavers, Quina scrapers, Levallois-like flakes, and very few blades. This collective toolkit exhibits a progression toward a greater incorporation of the Levallois technique. The absolute dating of the LAA assemblages was not established, but a travertine layer above the Acheulean-bearing deposits at C-Spring was thought to be stratigraphically consistent with a similar travertine layer found below the Neolithic layers at the nearby site of Al Azraq 31 in the Shishan Marsh (FIG. 2). At Al Azraq 31, the travertine layer yielded an age of 220±30 ka BP through uranium-series dating (Macumber 2001), providing a minimum age for the LAA.

Surveys along *Wadi* Sectors

The discovery of spring sites beside the margins of the GAOA inspired an exploration of other areas within the central Al Azraq Basin. In 1981, a brief reconnaissance of Wādī 'Uwaynid, a small tributary of Wādī Buṯum, by Rollefson found a surface scatter of artefacts, including 28 bifaces and associated cores and flakes (Rollefson 1984).

Between 1982 and 1986, an extensive survey project was conducted by the Centre national de la recherche scientifique (hereafter CNRS) at the Université Lumière in France with support from Garrard (Copeland 1988; Copeland and Hours 1989a). The surveys involved the collection of lithics of all periods and a periodic assessment of the associated geomorphology.

The surveys focused on several important wadi sectors within the Al Azraq Basin: Buṯum, Al KHarrānah, and Ratamah (FIG. 2). Al KHarrānah survey included the associated channels of Janab and Mashash. Although some values are slightly inconsistent among the reported texts and tables, lithics assigned to the Lower Palaeolithic dominated the assemblages, with a combined count of 167 bifaces collected from all three sectors (Copeland and Hours 1989b).

To the east, where Wādī Rājil enters Qā' Al Azraq, two surface sites (231, 251) yielded lithics that are likely from the Lower Palaeolithic. Site 231 contained a partial biface, and site 251 was characterised by rolled flakes, a blade, and a battered biface or core (Copeland 1989d). Farther south, the Qā' Jashshā area was also surveyed, but no Lower Palaeolithic materials were discovered (Copeland 1989d).

It was observed that the techno-typological attributes of the assemblages of the aforementioned wadis were dis-

tinct from those of the LAA, leading to their categorisation as the Desert Wadi Acheulean (DWA) facies. These are characterised by large-medium handaxes, few cleavers, thick blades, and proto-Levallois cores (FIG. 4). Some artefact clusters were found eroding from poorly consolidated conglomerates, while others were surface scatter. Most likely these initially originated from upstream in the valleys prior to increased fluvial activity (Copeland 1988). The few lithics from Wādī Rājil, the only Lower Palaeolithic sites on the east side of the *qa'*, also exhibit consistencies with the DWA, such as large partial bifaces and a heavy blade with a cortex butt (Copeland 1989d). The lithic material found by Rollefson (1984) in Wadi Uweinid was described as reminiscent of the Middle Acheulean but is thought to be consistent with the DWA, as this facies had not been identified at the time of initial publication.

Additional surveys and geomorphological investigations east of the drainage of Wādī An Nuqʿiyyah and on the northern fringe of Qāʿ Al Azraq recovered Lower Palaeolithic material from several sites within the area of ʿAyn Al Baydā (White Spring) (FIG. 2). The relatively few Lower Palaeolithic lithics (n=30) discovered along Wādī An Nuqʿiyyah were most consistent with the LAA (Hours 1989). The ʿAyn Al Baydā sites (137, 201A, and 209) were initially noted by Kirkbride (1989) in 1956 but more thoroughly explored by the CNRS team. They are situated roughly within a 1.5km stretch and contained lithic evidence of Lower Palaeolithic, Middle Palaeolithic, and "post-Middle" Palaeolithic occupation (Copeland 1989d). The diagnostic tools from the three ʿAyn Al Baydā sites were considered too few to establish secure consistencies with either the DWA or LAA (Copeland 1989d).

Excavations within the Former Wetlands

The over-pumping of Al Azraq aquifer during the 1980–90s and the subsequent drop of the water table led to the complete drying of the Shishan and Druze marshes. These unfortunate circumstances permitted access to previously submersed deposits. Palaeolithic materials were initially identified in 1996 by a palaeoenvironmental team working for the Madaba Plains Project. During the extraction of sediment cores in the ʿAyn Soda (Sawdā) section of the Shishan Marsh, they noticed surface scatters and the protrusion of *in situ* bifaces in exposed profiles from bulldozer activity. The team contacted Rollefson and a larger crew quickly began a systematic recovery of exposed material from ʿAyn Sawdā and nearby ʿAyn Qasiyyah (FIG. 2). Lower Palaeolithic artefacts (>400) were almost exclusively recovered from ʿAin Soda, as only one biface was found at ʿAyn Qasiyyah (Rollefson, Quintero, *et al.* 1997). Initial documentation of the stratigraphy in ʿAin Soda was performed in 1996 with a more comprehensive study in 2007 (Cordova *et al.* 2008; Rollefson, Quintero, *et al.* 1997). Formal excavations in ʿAin Sawdā led by Rollefson were conducted in 1997 and, while the results have yet to be fully published, preliminary results suggest consistencies with the 1996 season and material from the spring sites to the south (Rollefson, Quintero, *et al.* 1997; Rollefson, Schnurrenberger, *et al.* 1997). Rollefson and colleagues also undertook a survey within the confines of the Shishan Marsh and identified additional sites around ʿAyn Sawdā (Rollefson, Quintero, and Wilke 2001).

The success of Rollefson's excavations highlighted the potential of the (former) wetlands area to host undisturbed archaeological sites. In 2008–2011, the

Druze Marsh Archaeological and Paleoecological Project (DMAPP) led by A. Nowell placed several large soundings within the northern Druze Marsh (FIG. 2). Several of these produced a small collection of Lower Palaeolithic artefacts, namely Acheulean handaxes and cleavers, associated with a deep marsh transitioning to dryer conditions (Ames and Cordova 2015; Ames *et al.* 2014; Cordova *et al.* 2013).

A subsequent investigation in 2013–2015, the Al Azraq Marshes Archaeological and Paleoecological Project (AMAPP), also led by Nowell, was undertaken in the Shishan Marsh. These excavations focused on the site of Shishan Marsh 1 (SM1) and several associated soundings (SM2-14) within its vicinity (see FIG. 2). Altogether, 10 sedimentary units were identified, with layers 7b–c and 8 containing abundant Lower Palaeolithic remains, roughly a metre below the surface (Ames *et al.* 2022; Nowell *et al.* 2014). Optically stimulated luminescence dating places the occupation within 266 ± 40 ka BP (layer 8) to 125 ± 12 ka BP (layer 7b) and 119 ± 40 ka BP (layer 7a) (Ames *et al.* 2022; Nowell *et al.* 2016). It should be noted that these are the only absolute dates from any Acheulean layers in the region. A novel study by Nowell *et al.* (2016) analysed protein residue on a sample of stone tools from SM1. These proteins, leftover from the blood of animals, were compared to protein signatures from modern zoo animals. The results indicated the presence of various taxa within the wetlands, including many large herbivores (*e.g.,* bovine, camel, elephant, horse, rhinoceros) and waterfowl (family Anatidae), a group that is not physically represented in the faunal assemblages.

The material from ʿAin Soda is described as part of the "Late and Final Acheulean" (Rollefson, Schnurrenberger, *et al.* 1997), as are the assemblages from DM8 (Ames *et al.* 2014) and SM1 (Nowell *et al.* 2016). It was observed that cleavers occur in significantly higher (10–15x) frequencies at ʿAin Soda, C-Spring, and Lion Spring than other sites within the Levant (Gilead 1973; Rollefson 1984; Rollefson, Schnurrenberger, *et al.* 1997). The tools exhibit deliberately dulled lateral edges, at least one tranchet scar across the distal end, and often a bifacially worked base. These modifications created at least two functions on one tool: chopping/hacking (base) and slicing (distal). These techno-typological characteristics led to this distinct tradition being termed the "Al Azraq Acheulean cleaver" (Rollefson, Schnurrenberger, *et al.* 1997: 56).

Palaeoenvironment of the Central Al Azraq Basin

Several of the aforementioned archaeological projects have contributed significant hydrological and geomorphic data. When these are combined with data obtained through dedicated geographical projects, they provide a greater resolution of the palaeoenvironmental conditions during Acheulean occupation in the central Al Azraq Basin. Broadly speaking, these suggest a relatively wet period during Marine Isotope Stage (MIS) 10–9, followed by a drying trend during MIS 8–7 within the region. These conditions exhibit a localised trend distinct from neighbouring regions.

The wetter conditions in the Al Azraq Basin are attested by several lines of evidence. Geological soundings at two localities, one at Al ʿUmarī and the other approximately 10km northeast of Al Azraq, discovered similar *Cardium* fossil horizons. These remains are taken as evidence of extensive water

coverage. Uranium-series dating placed age estimates for this layer at 346–316 ka BP (Abed *et al.* 2008). Some support is found in the stratigraphy at the spring and wetland sites that correspond to this time frame. For example, in the Shishan Marsh, layers 10–9 at SM1 comprise clay-rich sediments, indicative of lacustrine conditions. These are overlain by layer 8, which dates to 266±40 ka BP (Nowell *et al.* 2016). Nearby, a large exposure of the stratigraphy in ʻAin Soda (AS-1) sounding contains a layer of compact green clay, suggesting a deep lake environment (Cordova *et al.* 2008). Similar lacustrine deposits have been noted in >50 m sediment cores extracted from the centre of the *qa'*, which predate a saturated infrared stimulated luminescence age of ~250 ka BP (Ahmad and Davies 2021; Davies 2000). In the Druze Marsh, layer 1b contains clayey silt, which suggests an open water environment (Ames and Cordova 2015), although no radiometric dates are available. Together, the sediments found at sites and localities dispersed across the GAOA and beyond point to the existence of an extensive palaeolake (a diameter of >50 km) or a patchwork of smaller lakes during MIS 10–9 (FIG. 5).

The gradual drying trend during MIS 8–6 is also evident at the spring and wetland sites. At SM1, layers 8–7 (after 266 ± 40 ka BP) comprise a series of alluvial sediment influx with gradual decreasing energy. This is interpreted as a transitional environment within the wetlands from a lake to marshy ponds at the edge of a fan delta (Ames *et al.* 2022; Nowell *et al.* 2016). In Druze Marsh, layer 1c (above 1b) exhibits consistencies with aeolian accumulation, possibly a lunette, indicating a transition toward a shoreline environment (Ames and Cordova 2015; Ames *et al.* 2014). The dense occupation of the spring sites in the heart of the basin suggests that the expansive lake had sufficiently receded. Meanwhile, the occurrence of artefact clusters in clay-silt layers indicates that marshy ponds, likely fed by the aquifer system, were periodically present.

Acheulean Occupation in the Central Al Azraq Basin

The review of previous archaeological and palaeoecological investigation in the Al Azraq Basin reveals unique circumstances for occupation by Lower Palaeolithic hominins and offers the following summarised scenario, first proposed by Copeland (with contributions by Hours) during the 1980s.

Increased precipitation in the Al Azraq Basin during MIS 10–9 replenished the aquifer and allowed water to accumulate in the heart of the basin. Throughout MIS 9, the regional environment of the Al Azraq Basin included a savannah landscape with large palaeolake(s) at its centre. A high lake stand gradually developed, as evident from the sedimentological records at several localities throughout the basin, as well as the absence of DWA material at the centre. The documented extent of the lake(s) stretched (at least) from northeast of the GAOA to southeast at Umari (FIG. 5), covering the (future) wetlands and larger Qāʻ Al Azraq (Abed *et al.* 2008; Ames and Cordova 2015). Hominin occupation corresponding to this regional setting is found at higher elevations in the region, such as along the upstream reaches of the various wadi sectors, which are mainly concentrated in the western portion of the basin. This occupation is demonstrated by the distribution of DWA facies, which are also estimated to be >300 ka BP. The banks of the channels probably offered an attractive habitat for hominin groups that surrounded the palaeolake margins,

as did the wider grassland savannas and steppes of the Central Plateau (al-Nahar and Clark 2009).

Decreased precipitation in the Al Azraq Basin during MIS 8–6 contributed to a long-term drying trend within the region (Ames and Cordova 2015; Ames *et al.* 2014; Ames *et al.* 2022). The palaeolake margins receded into Qāʿ Al Azraq and the spring-fed wetland complex of the GAOA emerged as a series of marshy ponds. Water availability in the region was generally reduced and concentrated in the GAOA and nearby *qa'*, although the latter source was subject to seasonal evaporation. However, since the GAOA is fed by an aquifer via springs and not by direct precipitation, it likely remained a perennial water source. This concentrated pocket of resources amidst a largely open and savanna-type landscape enabled it to operate as a stable desert refugium (Ames and Cordova 2015; Ames *et al.* 2022; Cordova *et al.* 2013; Nowell *et al.* 2016). Hominins responded to the gradual reduction of water availability by contracting toward the GAOA, most likely on a seasonal basis, ensuring access to a diverse range of fauna and flora. Their presence around the GAOA is indicated by the distribution of the LAA facies among the spring and wetland sites, and downstream Wādī An Nuqʿiyyah.

Conclusion

The Al Azraq Basin is a large, hydrologically distinct geographic feature in the eastern desert of Jordan. At its centre is the low-lying Qāʿ Al Azraq, a catchment for various wadi sectors that floods on seasonal basis. Adjacent to Qāʿ Al Azraq is the GAOA, a collection of springs that contribute to a perennial water supply.

Archaeological exploration and discovery over the last 66 years have cast considerable light on the nature of Acheulean occupation in the central Al Azraq Basin. Since their first discovery by chance in 1956, Acheulean materials have cropped up all around Al Azraq, from distant wadis to the heart of the wetlands. Even today, a trek around the modern town of Al Azraq will likely bring one in contact with an Acheulean surface find. The recovery and analysis of Acheulean material, from both surface and buried sites, as well as the subsequent interpretation has been performed by leading archaeologists, including Kirkbride, Copeland, Hours, Garrard, Rollefson, and Nowell, who deserve recognition for their efforts. Collectively, they have demonstrated that the central Al Azraq Basin is a crucial locality for understanding hominin subsistence and technology in the eastern Levant during the late Lower Palaeolithic.

Additionally, Acheulean research has also highlighted the importance of geohydrological conditions in the Al Azraq Basin. These were pivotal to the survival of hominins and other animals, as well as the various vegetation, both in the past and present. Today, the GAOA remains an isolated and fragile ecosystem within eastern Jordan, threatened by over-pumping, urban development, and anthropogenic desertification. The surrounding landscape is dry and barren with a general lack of vegetation due to tree-cutting, brush removal, and over-grazing by livestock herds. Unfortunately, the name "Al Azraq," meaning blue in Arabic, hardly seems fitting. Never-the-less, as it did in antiquity, the GAOA provides resources for human populations and, with responsible management, can continue to do so in the future.

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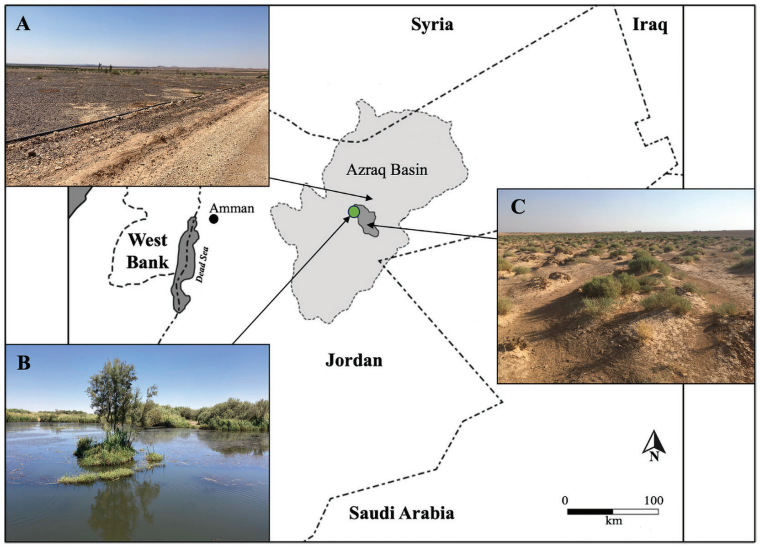
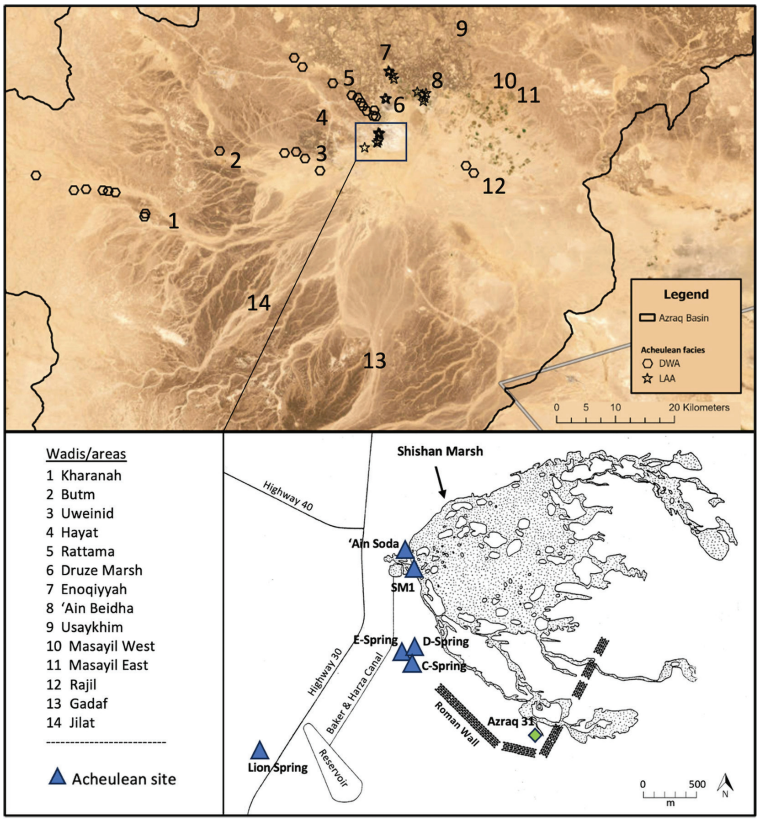
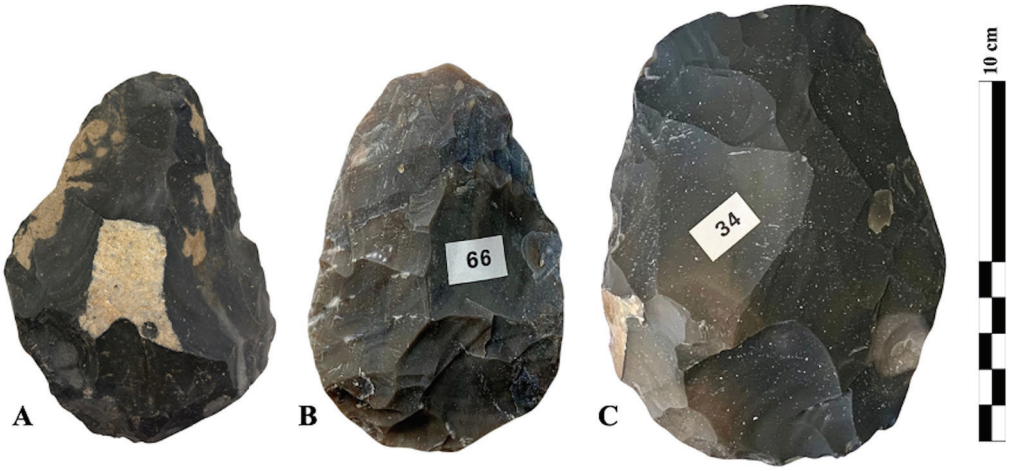


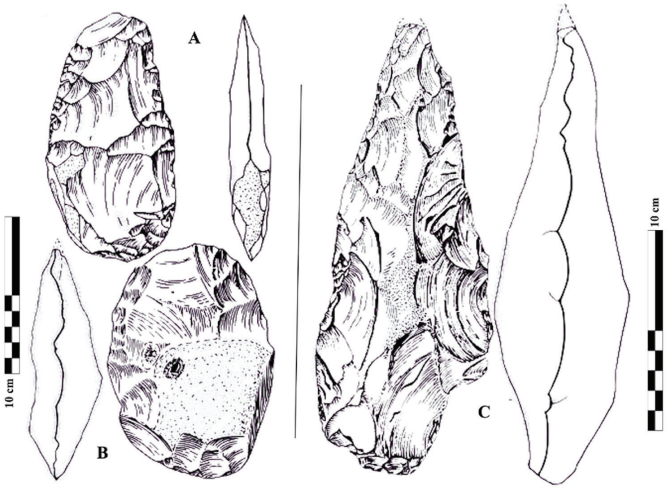
1. Location of the Azraq Basin, Jordan. Insets: A) surrounding barren desert landscape; B) restored wetlands of the modern Azraq Wetland Reserve; C) the mudflat known as Qāʿ Al Azraq (photographs and figure by J. Beller; base map digitally redrawn and modified after Ames et al. 2014: 61).



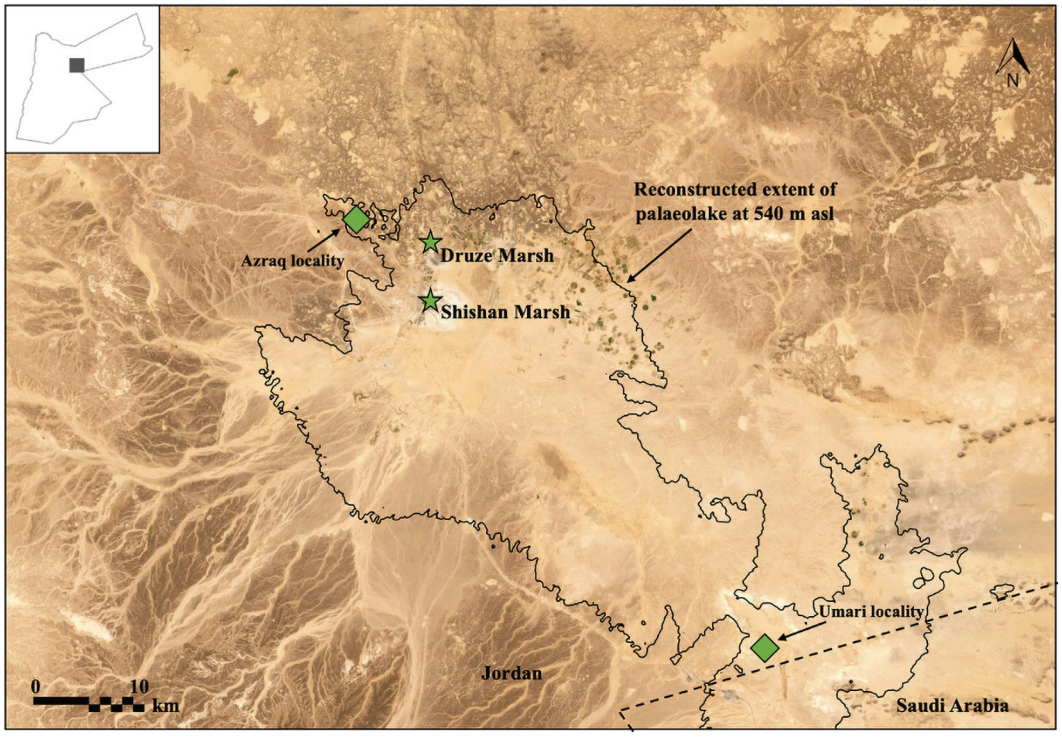
2. Location of major wadi sectors and key Acheulean sites in the central Azraq Basin. Site coordinates taken from references in TABLE 1 (composite figure created by S. Richardson and J. Beller with ArcGIS).



3. Sample artefacts of the LAA facies. A) handaxe from Lion Spring (#135); B) handaxe from C-Spring (#66); C) cleaver from C-Spring (#34) (photographs by A. Bell, used with permission).



4. Sample artefacts of the DWA facies. Only drawings exist, as there are no suitable photographs to reproduce, and it is unknown where (and if) the assemblages are stored. A) elongated ovate biface (137) from Wadi Butm; B) rolled ovate or discoid biface (247A) from Wadi Butm; C) large lanceolate biface from Wadi Rattama (artefacts digitally redrawn by J. Beller from Copeland and Hours 1989b).



5. Reconstructed extent of the MIS 10–9 palaeolake at 540 m elevation contour within the central Azraq Basin (figure created by S. Richardson and J. Beller with ArcGIS and based on the GPS coordinates and suggestions in Abed et al. 2008).

Bibliography

Abed, Abdulkader M. 2018. Geological Evolution of the Azraq Basin, Eastern Jordan: An Overview. *Jordan Journal of Natural History* 5: 6–52.

Abed, A.M.; Yasin, S.; Sadaqa, R. and Al-Hawari, Z. 2008. The Paleoclimate of the Eastern Desert of Jordan during Marine Isotope Stage 9. *Quaternary Research* 69:458–468.

Ahmad, K. and Davies, C.P. 2021. "Stable Isotopic and Geochemical nalysis of Lacustrine Carbonates from the Al-Azraq Basin, Jordan: Implications for Paleoenvironment and Paleohydrology. *Arabian Journal of Geosciences* 14 (470). doi: https://doi.org/10.1007/s12517-021-06650-1

Al-Kharabsheh, A. 2000. Groundwater Modelling and Long-term Management of the Azraq Basin as an Example of Arid Area Conditions (Jordan). *Journal of Arid Environments* 44:143–153.

Al-Malabeh, A. 1994. Geochemistry of Two Volcanic Cones from the Intra-continental Plateau Basalt of Harra el-Jabban, NE-Jordan. *Geochemical Journal* 28:517–540.

al-Nahar, M. and Clark, G.A. 2009. The Lower Paleolithic in Jordan. *Jordan Journal for History and Archaeology* 3(2):173–215.

Ames, C.J.H. and Cordova, C.E. 2015. Middle and Late Pleistocene Landscape Evolution at the Druze Marsh Site in Northeast Jordan: Implications for Population Continuity and Hominin Dispersal. *Geoarchaeology* 30:307–329.

Ames, C.J.H.; Cordova, C.E.; Boyd, K.; Schmidt; C.; Degering, D.; Kalbe, J.; Jones, B.G.; Dosseto, A.; Pokines, J.T.; al-Souliman, A.S.A.; Beller, J.A. and Nowell, A. 2022. Middle to Late Quaternary Palaeolandscapes of the Central Azraq Basin, Jordan: Deciphering Discontinuous Records of Human-Environment Dynamics at the Arid Margin of the Levant. *Quaternary International* 635:31–52.

Ames, C.J.H., Nowell, A.; Cordova, C.E.; Pokines, J.T. and Bisson, M.S. 2014. Paleoenvironmental Change and Settlement Dynamics in the Druze Marsh: Results of Recent Excavation at an Open-Air Paleolithic Site. *Quaternary International* 331: 60–73.

Baker, M.Jr.Inc. and Harza Engineering Company. 1958. *Princess Alia Project: Definite Plan Report.* Amman: Natural Resource Authority.

Beller, J.A.; Ames, C.J.H. and Nowell, A. 2020. Exploring Mid-Late Pleistocene Lithic Procurement Strategies at Shishan Marsh 1: Preliminary Geochemical Characterization of Chert Sources around the Greater Azraq Oasis Area, Jordan. *JAS Reports* 29 (102091). https://doi.org/10.1016/j.jasrep.2019.102091

Bender, F. 1974. *Geology of Jordan.* Translated by M. K. Khdeir. Edited by D. H. Parker and U. Wilkening. *Contributions to the Regional Geology of the Earth.* Berlin: Gebruder Borntraeger.

Betts, A.V.G. and Burke, D. 2015. Desert Kites in Jordan—A New Appraisal. *Arabian Archaeology and Epigraphy* 26:74–94.

Byrd, B. and Garrard, A.N. 2013. The Late Palaeolithic—Chipped Stone Assemblages. Pp. 137–394 in A.N. Garrard and B. Byrd (eds.), *Late Palaeolithic and Neolithic Communities of the Jordanian Steppe: The Azraq Basin Project*. Oxford: Oxbow Books.

Clutton-Brock, J. 1989. A Re-consideration of the Fossil Fauna from C-Spring, Azraq. Pp. 391–397 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

Cooke, R.U., Warren, A. and Goudie, A. 1993. *Desert Geomorphology.* London: University College London Press.

Copeland, L. 1988. Environment, Chronology and Lower-Middle Paleolithic Occupations of the Azraq Basin, Jordan. *Paléorient* 14:66–75.

— 1989a. Analysis of the Paleolithic Artifacts from the Sounding of A. Garrard at C-Spring, Azraq; 1985 Season. Pp. 325–390 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

— 1989b. The Artifacts from the Sounding of D. Kirkbride at Lion Spring, Azraq in 1956. Pp. 171–212 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

— 1989c. The Harding Collection of Acheulean Artifacts from Lion Spring, Azraq: A Quantitative and Descriptive Analysis. Pp. 213–258 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

— 1989d. Surface Finds at the Northern and South-Eastern Sites. Pp. 451–468 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

— 1989e. Surface Finds from 'Site C' and Other Sheshan Spring Sites. Pp. 305–318 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

— The Late Acheulean Knapping-Floor at C-Spring, Azraq Oasis, Jordan. *Levant* 23:1–6.

Copeland, Lorraine, and Francis Hours. 1988. The Paleolithic in North-Central Jordan: An Overview of Survey Results from the Upper Zarqa and Azraq. Pp. 287–309 in A.N. Garrard and H.G.K. Gebel (eds.), *The Prehistory of Jordan: The State of Research in 1986*. Oxford: British Archaeological Reports.

— 1989a. *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan. British Archaeological Reports* 540. Oxford: British Archaeological Reports.

— 1989b. The Lower and Middle Paleolithic of the Desert Wadis in the Azraq Basin: Survey Results, 1982–1986. Pp. 65–152 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

Cordova, C.E. 2007. *Millennial Landscape Change in Jordan: Geoarchaeology and Cultural Ecology.* Tucson: University of Arizona Press.

Cordova, C.E.; Nowell, A.; Bisson, M.S.; Ames, C.J.H.; Pokines, J.T.; Chang, M. and al-Nahar, M. 2013. Interglacial and Glacial Desert Refugia and the Middle Paleolithic of the Azraq Oasis, Jordan. *Quaternary International* 300:94–110.

Cordova, C.E.; Rollefson, G.O.; Kalchgruber, R.; Wilke, P.J. and Quintero,

L.A. 2008. Natural and Cultural Stratigraphy of 'Ayn as-Sawda, Azraq Wetland Reserve: 2007 Excavation Report and Discussion of Finds. *ADAJ* 52:417–425.

Davies, Caroline P. 2000. Reconstruction of Paleoenvironments from Lacustrine Deposits of the Jordan Plateau. Ph.D. diss., Arizona State University.

Dirks, Wendy. 1998. Preliminary Account of Pleistocene Mammals from 'Ain Soda, Azraq Basin, Jordan. *Journal of Vertebrate Paleontology* 18:38A–39A.

Dottridge, J. 1998. Water Resources Quality, Sustainability and Development. Pp. 67–80 in R.W. Dutton; J.I. Clarke and A.M. Battikhi (eds.), *Arid Land Resources and Their Management: Jordan's Desert Margin*. London: Kegan Paul International.

El-Naqa, Ali. 2010. *Study of Salt Water Intrusion in the Upper Aquifer in Azraq Basin, Jordan: Final Report.* Amman: International Union for the Conservation of Nature.

El-Naqa, Ali, Mohammad Al-Momani, Suzan Kilani, and Nezar Hammouri. 2007. Groundwater Deterioration of Shallow Groundwater Aquifers Due to Overexploitation in Northeast Jordan. *CLEAN—Soil, Air, Water* 35:156–166.

Enzel, Yehouda, Rivka Amit, Uri Dayan, Onn Crouvi, Ron Kahana, Baruch Ziv, and David Sharon. 2008. The Climatic and Physiographic Controls of the Eastern Mediterranean over the Late Pleistocene Climates in the Southern Levant and Its Neighboring Deserts. *Global and Planetary Change* 60:165–192.

Fariz, G.H. and A. Hatough-Bouran. 1998. Population Dynamics in Arid Regions: The Experience of the Azraq Oasis Conservation Project. Pp. 75–86 in A. de Sherbinin and V. Dompka (eds.), *Water and Population Dynamics: Case Studies and Policy Implications*. Washington, D.C.: American Association for the Advancement of Science.

France, R. 2010. Rehabilitation of a Historic Wetland: Jordan's Azraq Oasis. In *Restorative Redevelopment of Devastated Ecocultural Landscapes*, by R. France, 85–115. Boca Raton, Fla.: CRC Press.

Frumkin, Amos, Ofer Bar-Yosef, and Henry P. Schwarcz. 2011. Possible Paleohydrologic and Paleoclimatic Effects on Hominin Migration and Occupation of the Levantine Middle Paleolithic. *Journal of Human Evolution* 60:437–451.

Garrard, Andrew N., Alison Betts, Brian Byrd, and Christopher O. Hunt. 1987. Prehistoric Environments and Settlements in the Azraq Basin: An Interim Report on the 1985 Excavation Season. *Levant* 19:5–26.

— 1988. "Summary of Palaeoenvironmentaland Prehistoric Investigations in the Azraq Basin. Pp. 311–337 in Andrew N. Garrard and H.G. Gebel (eds.), *The Prehistory of Jordan: The State of Research in 1986*. Oxford: British Archaeological Reports.

Garrard, Andrew N., and Brian F. Byrd, eds. 2013. *Beyond the Fertile Crescent: Late Palaeolithic and Neolithic Communities of the Jordanian Steppe. Levant Supplementary Series* 13. Oxford: Oxbow.

Garrard, Andrew N., N.P. Stanley Price, and Lorraine Copeland. 1977. A Survey of Prehistoric Sites in the Azraq Basin, Eastern Jordan. *Paléorient* 3:109–126.

Gilead, D. 1973. Cleavers in Early Paleolithic Industries in Israel. *Paléorient* 1:73–86.

Harding, Gerald L. 1958. Recent Discoveries in Jordan. *PEQ* 90:7–18.

— 1967. *The Antiquities of Jordan.* Amman: Jordan Distribution Agency.

Hours, F. 1989. The Paleolithic Industries of Wadi Enoqiyya, Azraq. Pp. 403–450 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

Hunt, C.O. and Garrard, A.N. 1989. The 1985 Excavation at C-Spring. Pp. 319–324 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

Ilani, S., Harlavan, Y.; Tarawneh, K.; Rabba, I.; Weinberger, R.; Ibrahim, K.; Peltz, S. and Steinitz, G. 2001. New K-Ar Ages of Basalts from the Harrat Ash Shaam Volcanic Field in Jordan: Implications for the Span and Duration of the Upper Mantle Upwelling beneath the Western Arabian Plate. *Geology* 29:171–174.

Jennings, R.P.; Singarayer, J.; Stone, E.J.; Krebs-Kanzow, U.; Khon, V.; Nisancioglu, K.H.; Pfeiffer, M.; Zhang, X.; Parker, A.G.; Parton, A.; Groucutt, H.S.; White, T.S.; Drake, N.A. and Petraglia, M.D. 2015. The Greening of Arabia: Multiple Opportunities for Human Occupation of the Arabian Peninsula during the Late Pleistocene Inferred from an Ensemble of Climate Model Simulations. *Quaternary International* 382:181–199.

Kennedy, D.L. 2011. The 'Works of the Old Men' in Arabia: Remote Sensing in Interior Arabia. *JAS* 38:3185–3203.

Kennedy, D.L. and R. Bewly. 2004. *Ancient Jordan from the Air.* London: Council for British Research in the Levant.

Kirkbride, D. 1989. A Description of Stone Age Sites at Azraq, Jordan. Pp. 153–170 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq, Jordan*. Oxford: British Archaeological Reports.

Lister, A.M.; Dirks, W.; Assaf, A.; Chazan, M.; Goldberg, P.; Applbaum, Y.H.; Greenbaum, N. and Horwitz, L.K. 2013. New Fossil Remains of *Elephas* from the Southern Levant: Implications for the Evolutionary History of the Asian Elephant. *Palaeogeography, Palaeoclimatology, Palaeoecology* 386:119–130.

Macumber, P.G. 2001. Evolving Landscape and Environment in Jordan. Pp. 1–30 in B. MacDonald; R. Adams and P. Bienkowski (eds.), *The Archaeology of Jordan*. Sheffield: Sheffield Academic Press.

Maitland, P. 1927. The 'Works of the Old Men' in Arabia. *Antiquity* 1:196–203.

Nowell, A.; Cordova, C.E.; Ames, C.J.H. and Pokines, J.T. 2014. *Azraq Marshes Archaeological and Paleoecological Project (AMAPP): Report of the May 22–June 15, 2014 Season at Shishan Marsh (SM1)*. Report submitted to the Department of Antiquities of Jordan. Amman.

Nowell, A.; Walker, C.; Cordova, C.E.; Ames, C.J.H.; Pokines, J.T.; Stueber, D.O.; DeWitt, R. and al-Souliman, A.S.A. 2016. Middle Pleistocene Subsistence in the Azraq Oasis, Jordan: Protein Residue and Other Proxies. *JAS* 73:36–44.

Pokines, J.T.; Lister, A.M.; Ames, C.J.H.; Nowell, A. and Cordova, C.E. 2019. Faunal Remains from Recent Excavations at Shishan Marsh 1 (SM1), a Late Lower Paleolithic Open-air site in the Azraq Basin, Jordan. *Quaternary Research* 91(2):768–791.

Price, N.P.S. and Garrard, A.N. 1975. A Survey of Prehistoric Sites in the Azraq Basin, Eastern Jordan. *Paléorient* 3:109–126.

Rees, L.W.B. 1927. Ancient Reservoirs near Kasr Azrak. *Antiquity* 1:89–92.

— 1929. The Transjordan Desert. *Antiquity* 3(12):389–407.

Rollefson, G.O. 1980. Late Acheulian Artifacts from 'Ain el-Assad ('Lion's Spring'), near Azraq, Eastern Jordan. *BASOR* 240:1–20.

— 1982. Preliminary Report on the Excavations of 'Ain el-Assad, 1980. *ADAJ* 26:5–35.

— 1983. Two Seasons of Excavations at 'Ain el-Assad near Azraq, Eastern Jordan, 1980–1981. *BASOR* 252:25–34.

— 1984. A Middle Acheulian Surface Site from Wadi Uweinid, Eastern Jordan. *Paléorient* 10(1):127–133.

Rollefson, G.O.; Quintero, L.A. and Wilke, P.J. 2001. Azraq Wetlands Survey 2000, Preliminary Report. *ADAJ* 45:71–80.

— 2006. Late Acheulian Variability in the Southern Levant: A Contrast of the Western and Eastern Margins of the Levantine Corridor. *NEA* 69(2):61–72.

Rollefson, G.O., Quintero, L.A.; Wilke, P.J.; Schnurrenberger, D.; Low, R. and Watson, R.P. 1997. 1997 Excavations at 'Ain Soda in Azraq, Eastern Jordan. *Occident and Orient* 2(2):16–17.

Rollefson, G.O.; Schnurrenberger, D.; Quintero, L.A.; Watson, R.P. and Low, R. 1997. 'Ain Soda and 'Ain Qasiya: New Late Pleistocene and Early Holocene Sites in the Azraq Shishan Area, Eastern Jordan. Pp. 45–58 in H.G.K. Gebel, Z. Kafafi and G.O. Rollefson (eds.), *The Prehistory of Jordan, II: Perspectives from 1997*. Berlin: Ex Oriente.

Sánchez de la Torre, M.; Gratuze, B.; Mangado, X. and Delage, C. 2019. The Lithic Landscape around Kharaneh IV (Azraq Basin, Jordan): Petrographical and Geochemical Characterization of Geological Cherts. *JAS Reports* 26 (101857):1–10.

Zeuner, F.E. 1989. Stone Age Exploration in Jordan: The Azraq Area with Special Reference to C-Spring. Pp. 301–304 in L. Copeland and F. Hours (eds.), *The Hammer on the Rock: Studies in the Early Palaeolithic of Azraq Jordan*. Oxford: British Archaeological Reports.

Zeuner, F.E.; Kirkbride, D. and Park, B.C. 1957. Stone Age Exploration in Jordan, I. *PEQ*:17–54.