A large handaxe from Wadi Dabsa and early hominin adaptations within the Arabian Peninsula

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The role played by the Arabian Peninsula in hominin dispersals out of Africa has long been debated. The DISPERSE Project has focused on south-western Arabia as a possible centre of hominin settlement and a primary stepping-stone for such dispersals. This work has led to the recent discovery, at Wadi Dabsa, of an exceptional assemblage of over 1000 lithic artefacts, including the first known giant handaxe from the Arabian Peninsula. The site and its associated artefacts provide important new evidence for hominin dispersals out of Africa, and give further insight into the giant handaxe phenomenon present within the Acheulean stone tool industry.

Keywords: Saudi Arabia, Palaeolithic, Acheulean, human evolution, handaxes, hominin dispersal

Introduction

Acheulean bifacial tools are considered to be one of the greatest enigmas of the African Early Stone Age and European Lower Palaeolithic (Wymer 1982: 102). They appear in

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the archaeological record from 1.76 million years ago and persist for over one million years, representing an extensive period of technological stasis associated with a variety of hominin species, landscapes and environments (Asfaw *et al.* 1992; Quade *et al.* 2004; Lepre *et al.* 2011). Wrapped within this technological enigma are overly large handaxes, whose excesses in both size and weight have confounded archaeologists as to the exact purpose behind their production (Wynn 1995). Here we present the recently discovered Palaeolithic site of Wadi Dabsa, Saudi Arabia, and the recovery of a large Acheulean handaxe. The rich lithic assemblage from Wadi Dabsa not only yields evidence of how hominin populations may have adapted to varied landscapes and conditions during their dispersals out of Africa, but also provides insight into how such large bifacial tools may have been used.

There is clear evidence that the Arabian Peninsula was host to Acheulean hominins throughout the Early to Middle Pleistocene (*c.* 2 Mya–200 kya), and that these hominins occupied landscapes and environments close to water and raw material sources in the interior and coastal regions of the Peninsula (Petraglia 2003; Field & Lahr 2005; Bailey *et al.* 2007, 2015; Petraglia & Rose 2009; Petraglia *et al.* 2009; Groucutt & Petraglia 2012). It is not clear whether a land bridge would have existed across the southern end of the Red Sea at periods of low sea level during the Pliocene or Early Pleistocene. The long-term rotation of the Arabian Plate away from Africa might imply progressive widening of the sea channel and therefore the possible existence of a land bridge at some earlier time. Accommodation of plate motions by crustal deformation, however, mainly occurs in the Afar depression and along the Arabian escarpment, rather than in the area of the Red Sea Channel; there are too many uncertainties concerning the topographic impact of tectonic and volcanic activity at this early period to be certain. Nonetheless, by the Middle Pleistocene, and certainly from approximately half a million years ago, analysis of isotopic composition in deep sea cores and from tectonic modelling of palaeocoastlines shows that a narrow and shallow sea connection to the Indian Ocean persisted for long periods during lower sea levels in the Hanish Sill region. This would have afforded the possibility of sea crossings of no more than 4km. A very extensive area of potentially attractive coastal lowland would also have been exposed on both sides of this channel (Siddall *et al.* 2003; Bailey 2009; Lambeck *et al.* 2011; Rohling *et al.* 2013; Bailey *et al.* 2015).

The significance of Arabia in the dispersal and evolution of hominins out of Africa is, however, much debated, due to the lack of chronological certainty for many of its prehistoric sites; and although the use of the 'Southern Dispersal Route' (involving a crossing of the southern Red Sea and the southern Arabian Peninsula) during the Pleistocene is plausible, the lack of significant genetic input from within modern populations in Arabia suggests that these migrations involved small populations (Cabrera *et al.* 2009). Regardless of their size, these groups would have migrated into, and along, what are now the Red Sea and Gulf of Aden coastlines. These regions, in particular those along the southern Red Sea coast with their added increment of territory available at lower sea levels, would have presented hominins with a productive landscape of fauna, water and raw material sources comparable to those already experienced in the Horn of Africa. They would also have acted as refugia during periods of hyperaridity, when the Arabian interior would have become uninhabitable (Petraglia & Rose 2009; Winder *et al.* 2015).

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The DISPERSE Project and Wadi Dabsa

The DISPERSE Project is concerned with the impact of sea-level change and active tectonics on the early landscapes of human evolution and hominin dispersal within Africa and beyond (Bailey *et al.* 2012, 2015; Devès *et al.* 2014; Inglis *et al.* 2014a & b; Kübler *et al.* 2016). Work has concentrated in particular on the southern Red Sea and the south-western Arabian escarpment; on reconstruction of prehistoric landscapes on land and underwater; and on survey and investigation of Palaeolithic sites and later coastal middens in their landscape setting. This regional focus is informed by the hypothesis that south-western Arabia was an early centre of hominin settlement and a primary stepping-stone for range expansion out of Africa. This hypothesis is based on the presence of similar tectonic and volcanic landscapes that were advantageous in the earliest centres of human evolution in the East African Rift, proximity and accessibility to the Rift across a narrow sea-crossing for long periods of the Pleistocene and on relatively beneficial climatic conditions and ecological diversity (King & Bailey 2006; Bailey *et al.* 2007, 2012, 2015; Reynolds *et al.* 2011; Winder *et al.* 2013, 2015).

The Harrat Al Birk is an extensive series of basaltic flows that extend along the present-day coastline for approximately 100km, and stretch inland for around 30km, where they meet the basement rocks of the foothills of the Western Arabian Escarpment (Dabbagh *et al.* 1984; Prinz 1984). Wadi Dabsa, at present a seasonally flowing watercourse running for approximately 7km to the sea, drains the western edge of the Harrat (Figures 1 & 2). In its upper reaches, the wadi flows through a small basin within the basalt, the base of which has been almost completely covered by tufa deposition, around 1km^2 in total. The tufa was deposited during a past period of consistent flow of carbonate-rich water, possibly fed by a number of small tributaries draining the surrounding slopes, and forming a series of dams and pools (Inglis *et al.* 2015). The tufa formation suggests perennial water flow, and, given the limited catchment of the basin, may be linked to past spring activity, rather than runoff. Regardless of the source, the presence of large volumes of water would have made the locality particularly attractive to hominins in the past—something that is evidenced by the extraordinary accumulation of archaeological material recovered during survey of the area.

Survey of the basin resulted in the surface collection of artefacts along a number of transects across the tufa and surrounding basalt. Intensive survey using 5 × 5m grid squares was also carried out at site L0106, where a dense lithic scatter was discovered extending over about 100m^2 of the tufa surface, near to an area where the basalt outcrops through the tufa. Over 900 artefacts were collected from the survey area across a 40 × 50m area, which represents approximately a quarter of the total extent of this scatter. In total, 1002 lithic artefacts were recovered from within the Wadi Dabsa basin, including the surrounding basalt outcrops and the tufa. These display predominantly Early Stone Age/Lower Palaeolithic and Middle Stone Age/Middle Palaeolithic affinities, although several Later Stone Age artefacts produced exclusively from quartz were also found along the southern edge. The assemblage primarily consists of flake debitage, but also includes a large number of cores and several retouched tools (Table 1). Wadi Dabsa is the most artefact-rich location found thus far. Here we provide an initial analysis of the Acheulean material and its importance for elucidating early hominin landscape use within the Arabian Peninsula.

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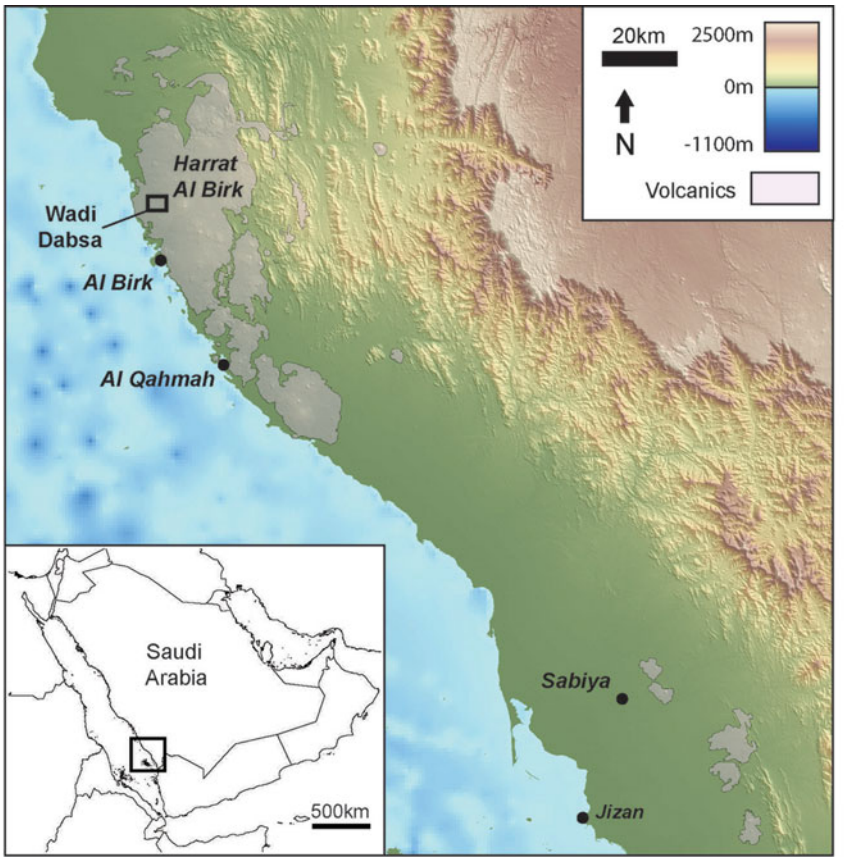

Figure 1. Location of Wadi Dabsa on the south-western coastline of the Arabian Peninsula.

The Acheulean assemblage of Wadi Dabsa

A number of cores and retouched tools within the assemblage are typical of the Acheulean, including discoidal and simple flake cores with episodes of parallel working, as well as bifaces and large cutting tools. Nineteen of the artefacts can be classified as handaxes, cleavers or fragments thereof. Most of these tools were produced on large flakes, sourced either by deliberate flaking from large cores, or by selection of local, naturally produced exfoliation flakes. This method of production shares close similarities to other Acheulean sites within the Arabian Peninsula (Petraglia *et al.* 2009; Shipton *et al.* 2014), although the majority of the tools illustrate an intense focus on reduction of the tip, rather than the butt. High-quality basalts—almost certainly sourced from the surrounding lava fields—appear to be the predominant raw material of choice, with andesite used in much lower quantities. The local basalt from the lava fields, however, appears to vary in its porosity and density, with finer-grained materials to the north, and poorer-quality material along the southern edge (Inglis *et al.* 2015). The predominance of higher-quality raw materials within the assemblage, therefore, appears to indicate that the hominins present at the site carefully selected the better materials available.

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Table 1. Distribution of artefact types within the Wadi Dabsa assemblage.

Type		Number found
Flakes/debitage	flakes	475
	prepared core flakes	96
	blades	17
	used flakes	28
	splintered pieces/wedges	3
	shatter	89
Cores	cores	140
	core fragments	6
Bifacial tools	handaxes	11
	cleavers	4
	pics	4
	broken handaxes	4
Retouched tools	backed knife	1
	burins	2
	denticulate	4
	notch	9
	large cutting tools	16
	piercers/borers	13
	points	8
	scrapers	47
Other	clasts	23
	hammerstones	2
Total		**1002**

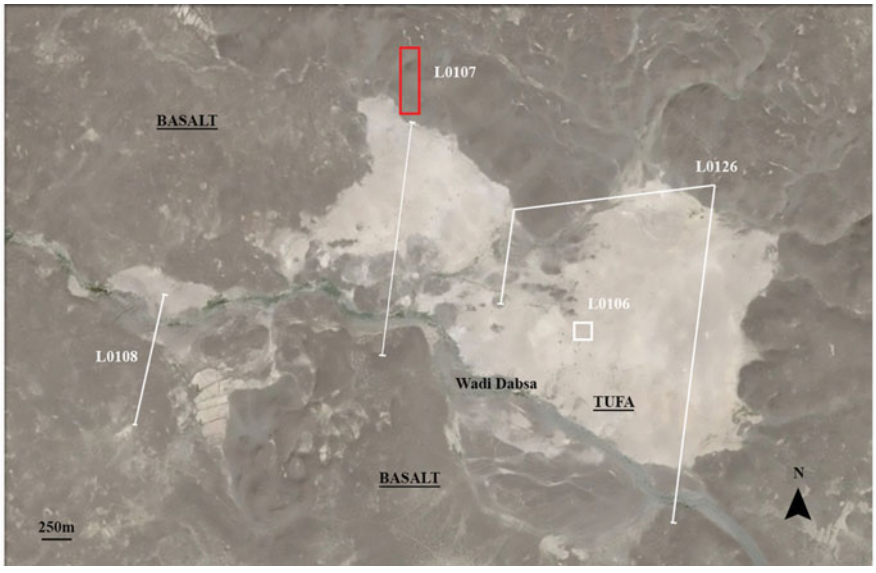

Figure 2. Wadi Dabsa and associated geology and archaeological transects. L0107 (red highlight) indicates the location where the large handaxe was found.

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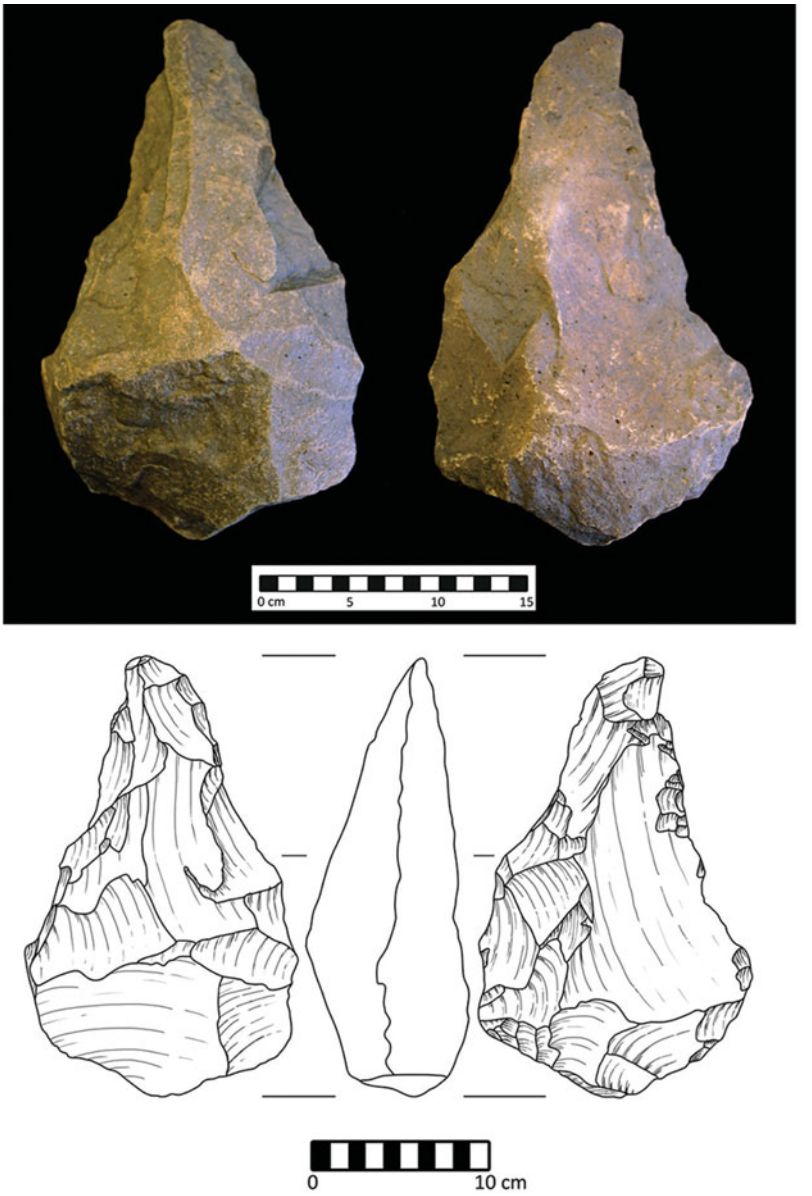

Figure 3. Top) photograph of the large handaxe from Wadi Dabsa; bottom) illustration of the handaxe, including profile view. Photograph by A. Shuttleworth; illustration by F. Foulds.

Within the assemblage, however, a single large bifacially worked tool stands out as anomalous (Figure 3). This was recovered during surface collection along a 250m transect at L0107, stretching from the north-western edge of the tufa to the top of a basalt jebel that overlooks the basin and wadi. It is 265mm long, weighs 3598g and was produced from either a very large basalt flake or, more probably, a natural exfoliation flake. On the basis of its size, it was originally interpreted as a large, abandoned roughout or core. Its appearance

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Table 2. A comparison of the large handaxe with other known handaxes of length greater than 240mm. Data based on Leakey and Roe (1994) and Gowlett (2013).

Locality	Length (mm)	Breadth (mm)	Thickness (mm)
Kilombe	248	120	53
Kilombe	258	151	56
Kilombe	243	111	55
Sidi Abderrahman Cunette	250	162	47
Sidi Abderrahman Cunette	241	107	73
Kalambo Falls	291	138	65
Cornelia-Uitzoek	240	124	73
Cornelia-Uitzoek	243	114	77
Holsdam	245	107	65
Peninj	265	119	81
Olduvai Gorge FLK	289	132	72
Olduvai Gorge FLK	268	124	83
Olduvai Gorge FLK	249	116	72
Olduvai Gorge FLK	277	129	69
Olduvai Gorge FLK	270	117	67
Wadi Dabsa	**265**	**160**	**85**

shares affinities with Victoria West cores and with examples of cores developed on bifacial tools, albeit of a much larger size (DeBono & Goren-Inbar 2001; Sharon & Beaumont 2006; Sharon 2007, 2009). Limited preparation of the ventral surface and a lack of any additional examples from the site, however, preclude this interpretation. Furthermore, the large scar on the ventral surface appears to be a natural exfoliation surface, rather than an intentional removal. Evidence of bifacial retouch on the upper two-thirds using a heavy, hard hammer, and extensive working of the tip, probably using a smaller hard hammer, indicate the imposition of a working edge. This suggests that the artefact should be considered a finished tool, as opposed to an abandoned roughout, especially given that the pattern of reduction is closely comparable to similar examples of tip preparation seen on other bifaces recovered from the site.

Metrical analysis of large cutting tools (e.g. Sharon 2007) indicates that the large biface from Wadi Dabsa is well above average in terms of its size, even if it is not the largest currently known. A number of bifaces measuring at least 250mm have been found in both Europe and Africa, most notably those from Cuxton, Olorgesailie, Olduvai Gorge (site FLK), Isimila and the Furze Platt giant, all of which provide examples surpassing 300mm (Issac 1977: 134; MacRae 1987; Roe 1994: 207; Wenban-Smith 2004; Cole *et al.* 2016). A comparison of the Wadi Dabsa handaxe with several of these known large handaxes (Table 2) demonstrates that this new example fits well within the range of these previously collected artefacts, although it is generally broader and thicker than most. While the size of the large handaxe from Wadi Dabsa is comparable to others, it is rare that such tools approach weights of 3000g or more, with only a few known examples from Africa (Kelley 1959; Sharon 2007; Petraglia & Shipton 2008). The excessive weight of the example from

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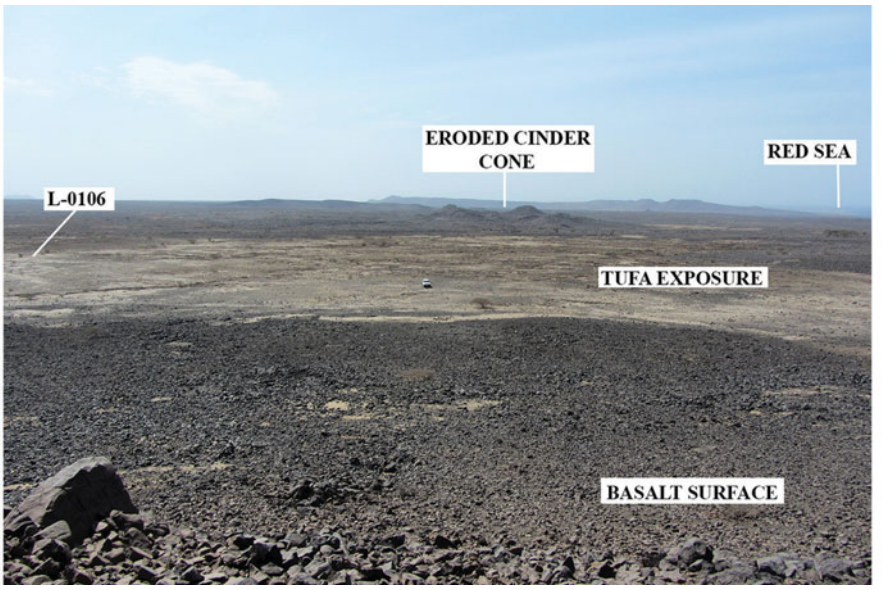

Figure 4. View from the top of a basalt jebel at the northern extent of L0107, looking south over the basalt surface and tufa exposure. Adapted from Inglis et al. *(2015). Photograph by R. Inglis.*

Wadi Dabsa would certainly have made it difficult to wield in the hand, begging the question of how and for what purpose this tool may have been used.

Discussion

In the context of the wider Acheulean occupation of the Arabian Peninsula, Wadi Dabsa is comparable to sites such as Wadi Fatima and Dawādmi to the north, and those recently discovered in the Nefud Desert (Petraglia *et al.* 2009; Shipton *et al.* 2014; Jennings *et al.* 2015). It can also be added to the wider evidence for the Acheulean occupation of the Red Sea region produced by the DISPERSE Project and previous studies (Zarins *et al.* 1980, 1981; Inglis *et al.* 2013, 2014a & b, 2015). The location of Wadi Dabsa at the confluence of several tributaries and the potential presence of a larger body of water conform to the expectation that Acheulean sites are associated with water sources (Potts *et al.* 1999; Shipton 2011). This is unsurprising, given that hominin ranges would have been constrained by access to fresh water (Hardaker 2011). The surrounding basalt jebels would have provided expansive views of the surrounding landscape extending as far as the Red Sea coastline (Figure 4), which are equivalent to viewsheds reported for Wadi Fatima and Dawādmi (Petraglia *et al.* 2009).

The presence of large cutting tools (such as handaxes) produced on large flakes also conforms to descriptions of other Acheulean assemblages within Arabia. Although these cutting tools were produced using the abundant local raw materials, Wadi Dabsa displays clear evidence for the preferential selection of good-quality stone—specifically basalt clasts sourced to the north of the basin, which display a more cohesive cryptocrystalline structure compared to that available along the southern edge. This provides some evidence that

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Table 3. A comparison of the mean length, thickness and weight of the Wadi Dabsa handaxes, with examples from Europe, Africa, India and the Arabian Peninsula. (* Figures in brackets provide the average and standard deviations for the Wadi Dabsa assemblage following removal of the large handaxe.) Data based on Petraglia *et al.* (2009) and Shipton *et al.* (2014).

Locality	Mean length *n*	Mean length (mm)	Mean thickness *n*	Mean thickness (mm)	Mean thickness SD	Mean weight *n*	Mean weight (g)	Mean weight SD
Africa								
Olduvai Gorge Bed II	21	195.39	17	66.92	19.2	17	1406.81	784.12
Kariandusi	58	157.94	35	43.6	14.74	35	571.02	369.8
Olorgesailie DE89A	63	180.76	60	46.23	10.43	60	877.82	381.8
Olorgesailie H9AM	13	199.77	10	36.2	7.53	10	770	426.54
Olorgesailie I3	62	97.95	57	33.54	9.28	57	225.12	197.48
Olorgesailie FB	16	98.81	15	34.6	8.44	15	180.87	116.11
Olorgesailie DE89C	69	158.7						
Europe								
High Lodge	68	116.51	63	35.15	14.01	63	259.89	208.83
Arabia								
Dawādmi 206–76	49	162.87	27	52.04	22.02			
Wadi Fatima	35	141.86	15	49.67	9.8			
Arzraq Lion Spring			42	43.97	9.68	42	216.43	86.11
Wadi Dabsa*	**11**	**140.27 (127.8)**	**11**	**60.54 (58.1)**	**15.83 (14.33)**	**11**	**1105.72 (856.5)**	**993.39 (580.77)**
India								
Hunsgi V	151	143.51	45	48.44	9.99	45	669	349.6
Hunsgi II	34	162.9	18	52.22	10.6	18	1041.94	551.14
Gulbal II	17	147.14	12	47.5	9.65	12	902.5	385.84
Mudnur VIII	9	227.78	9	61.11	9.28	9	1302.22	204.56
Yediyapur I	21	123.13	10	36	5.16	10	443	230.3
Yediyapur IV	20	132.94	11	42.73	11.04	11	626.82	415
Yediyapur VI	66	127.86	21	42.86	13.09	21	591.19	563.49
Fatehpur V	31	126.82	11	40.91	11.36	11	455.45	246.74
Teggihalli II	31	121.54						
Anagwadi	25	137.24	15	45.73	6.04			
Godavari	10	114						

the local hominins had a clear appreciation of the variability in the conchoidal fracture properties of the lithic materials available to them. The presence of a Large Flake Acheulean at Wadi Dabsa, which is close to other Near and Middle Eastern sites that have been linked to similar knapping strategies seen at, for example, Gesher Benot Ya'aqov, suggests that these represent a new wave of Acheulean-using hominins dispersing from Africa (Martínez-Navaro & Rabinovich 2011). If this is the case, then Wadi Dabsa could expand this hypothesis to include the Arabian Peninsula.

The size and weight of the Wadi Dabsa handaxes fall within the range of variation generally recorded for the Acheulean (Table 3). In terms of shape, however, the handaxes found at Wadi Dabsa, including the large handaxe described above, show clear and repeated focus on reduction and finishing of the tip, leaving the butt minimally worked. This

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suggests an active selection of a particular handaxe form. Variability in biface shape has long been a central topic within Lower Palaeolithic research. It has been suggested that variation in the shape of bifaces can often be explained by the need to establish and preserve a sharp cutting edge (Lycett 2008). A suite of factors, however, continues to be acknowledged as influencing handaxe shape, including raw material selection, social pressures and the individual (e.g. Ashton & McNabb 1994; Callow 1994; Gamble 1997; White 1998; Kohn & Mithen 1999; Spikins 2012; Foulds 2014). Among the bifaces from Wadi Dabsa, as well as the lithic artefacts from other sites examined as part of the DISPERSE Project, an emphasis on the creation of a good working edge is notable. It remains to be seen whether this was due to functional requirements, raw material affordance or the cultural transmission of specific methods of lithic manufacture in general.

The large handaxe presented here currently represents a unique find within the Arabian Peninsula, and is the largest handaxe from this region currently known to the authors. It falls within the range of variation seen amongst other examples of overly large tools, despite its excessive weight. The occurrence of only a single large biface at Wadi Dabsa, however, is more in keeping with the context in which such bifaces have been discovered in Europe, where they are generally found as single occurrences. That large handaxes are generally found in isolation, however, may present a false indication of their individuality. It is clear from African sites, where such large tools are found in assemblages (e.g. at Olduvai and Isimila—Roe 1994; Cole *et al.* 2016), that multiple, similar examples can occur. This may also be the case at Cuxton, where at least four handaxes over 200mm in length were recovered by Tester (Shaw & White 2003; Cole 2011), complementing the two large bifaces found during excavation by Wenban-Smith (2004).

The key question regarding the large handaxe is why it was produced. Several functional explanations have been posited on the phenomenon of large bifaces, including their role as digging tools, as expressions of knapping skill and as artefacts incorporated into some form of social display (Wymer 1968: 225, 1982: 103; Kohn & Mithen 1999). None of these theories has been convincingly proven. The large handaxe from Wadi Dabsa does not appear to represent the work of a highly skilled knapper wishing to demonstrate the extent of their abilities, whereas those used to support this hypothesis tend to be exquisitely worked (Wenban-Smith 2004). Prime examples are the biface from Furze Platt and the ficron and cleaver from Cuxton, which exhibit careful and controlled knapping to create a relatively well-thinned and symmetrical edge.

The excessive size and weight of the Wadi Dabsa biface leads us to believe that it was too large and unwieldy to be used in the hand—an observation that has been made of similar large tools (Wymer 1968, 1982; Roe 1981). Furthermore, it is unlikely that the maker intended to carry it from site to site. This suggests that either its use as a hand-held butchery tool, as is often proposed for handaxes, was unlikely, or alternatively, that our impressions of size and weight are significantly different to those of the hominins who made them (Wenban-Smith 2004). Conversely, it might be a large, bifacial core. As discussed above, however, the lack of additional examples and limited preparation appear to preclude this hypothesis. Despite the lack of extensive reduction used to form its overall shape, it seems reasonable to suggest that this large handaxe was made for a clear utilitarian purpose. This is supported by the fact that it conforms closely to other handaxes within

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the assemblage, most notably in the increased reduction intensity around the tip to create a cutting edge. It may perhaps have been employed as a static tool, with hominins resting the handaxe on the ground, secured between an individual's legs, and resources brought down on the tip for processing. In this way it could have been used to process faunal remains to access meat and marrow. Sites such as Isimila, Elandsfontein and Doornlaagte have provided examples of similar tools that were found on their edges when excavated, as if pressed into the ground (Wymer 1982: 103). While this is certainly plausible for the Wadi Dabsa handaxe, its recovery as part of an unstratified surface collection find from within the basalt fields means that this possibility cannot be substantiated. Microwear analysis of the tip will be required to determine whether it was used for a specific material or in a particular fashion.

Conclusion

Wadi Dabsa presents a highly concentrated area of Acheulean activity within the Arabian Peninsula. It provided a wide range of resources, including raw materials for tool production and a fresh water source that would have attracted animals suitable for hunting. These resources were essential for hominin dispersal from the Red Sea shoreline and deeper into the Arabian Peninsula. The site is made more extraordinary by the large quantity of artefacts recovered, suggesting either the repeated or intensive use of this locality. The large handaxe adds to the complexity and difficulty of interpreting this newly discovered site, as well as representing a significant addition to the known catalogue of these enigmatic bifacial tools. While it is geographically unique, being the only example currently known from within the Arabian Peninsula, its unusually excessive weight highlights its unique nature in comparison to similar overly large tools. The use of such large bifaces is still a mystery, and it is hoped that the Wadi Dabsa specimen can contribute to this debate, as well as furthering discussion regarding their dispersal throughout the Acheulean world.

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