# The Recent Discovery of a Palaeolithic site at Wadi Dabsa, Saudi Arabia: Implications for Hominin Adaptations in the Arabian Peninsula.

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*Introduction*

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Acheulean bifacial tools are considered one of the greatest enigmas of the Early Stone Age (ESA) of Africa and the Lower Palaeolithic of Europe (Wymer 1982: 102). They appear in the archaeological record from 1.76 million years ago (Asfaw et al. 1992; Lepre et al. 2011; Quade et al. 2004) and persist for over one million years, presenting an extensive period of technological stasis associated with a variety of hominin species, landscapes, and environments. Wrapped within this technological enigma are those overly large handaxes, whose excesses in both size and weight have confounded archaeologists as to their exact nature and use (Wynn, 1995). Here we present the recently discovered Palaeolithic site of Wadi Dabsa, Saudi Arabia and the recovery of a large Acheulean handaxe from this location. 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 played host to Acheulean hominins throughout the Early to Middle Pleistocene (c. 2 Mya–200 kya) (Petraglia, 2003; Petraglia & Rose 2009 and references therein; Groucutt & Petraglia, 2012), and that these hominins occupied landscapes and environments close to water and raw material sources in the interior (Petraglia et al., 2009; Groucutt & Petraglia, 2012), and coastal regions of the Peninsula (Field & Lahr, 2005; Bailey et al. 2007, 2015). It is not clear whether a land bridge would have existed across the southern end of the Red Sea at low sea-level stands 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 possible closure by extrapolation to an early stage in this process.  However, accommodation of plate motions by crustal deformation mainly occurs in the Afar depression and along the Arabian escarpment rather than in the area of the Red Sea Channel, and there are too many uncertainties about the topographic impact of tectonic and volcanic activity at this early period to be certain. At any rate, by the Middle Pleistocene, and certainly from about half a million years ago, it is clear from the analysis of isotopic composition in deep sea cores and from tectonic modelling of palaeocoastlines that a narrow and shallow sea connection to the Indian Ocean would have 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 4 km, and a very extensive area of potentially attractive lowland coastal territory 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 though the use of the 'Southern Dispersal Route' during the Pleistocene is plausible, the lack of significant genetic input from this region within modern populations 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 made 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 hyper-aridity when the Arabian interior would have become uninhabitable (Petraglia & Rose, 2009 and references therein; Winder et al. 2015).

*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. 2014, Kübler et al., 2016). Work has concentrated in particular on the southern Red Sea and the South-west Arabian escarpment, on reconstruction of prehistoric landscapes on land and under water, 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-west Arabia was an early centre of hominin settlement and a primary stepping-stone for range expansion out of Africa due to the similar tectonic and volcanic processes that have been shown to be 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 relatively beneficial climatic conditions and ecological diversity (King & Bailey 2006; Bailey et al. 2007, 2011, 2015; Reynolds et al. 2011; Winder et al. 2013, 2015).

The Harrat Al Birk is an extensive series of basaltic flows associated with numerous cinder cones that extend along the present-day coastline for ~100km and stretch inland for ~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, drains the western edge of the *harrat*, running for ~7km to the sea (**FIGURE 1** and **FIGURE 2**). In its upper reaches, the wadi flows through a small basin within the basalt, the base of which has been covered by tufa deposition, around 2km$^2$ 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, 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. No matter the source, the presence of large volumes of water would have made the locality particularly attractive to hominins in the past, something that is attested to by the extraordinary accumulation of archaeological material recovered during survey of the area.

***Figure 1 and Figure 2 to be placed somewhere around here***

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 5x5m grid squares was also carried out at site L0106, where a dense lithic scatter was discovered extending over about 100 m$^2$ 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 40x50m area, representing approximately a quarter of the area of this scatter. In total, 1002 lithic artefacts were recovered from within the Wadi Dabsa basin area, including the surrounding basalt outcrops as well as 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 on 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 productive 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.

***Table 1 to be placed somewhere around here***

*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. 2010; Shipton et al. 2014), although the majority of the tools evidence 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 their 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 a careful selection for the better materials available on the part of the hominins present at the site.

***Figure 3 to be placed somewhere around here***

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 266mm long, weighs 3598g, and was produced from either a very large basalt flake or, more likely, a natural exfoliation flake. On the basis of its size, it was originally interpreted as a large, abandoned roughout or core. Its appearance shares affinities with Victoria West cores (Sharon 2007, 2009; Sharon and Beaumont 2006), as well as with examples of cores developed on bifacial tools (DeBono & Goren-Inbar 2001), albeit of a much larger size. However, limited preparation of the ventral surface and a lack of any additional examples from the site 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, as well as 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 as 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.

***Table 2 to be placed somewhere around here***

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 (Wenban-Smith 2004), Olorgesailie (Issac 1977, 134), Olduvai Gorge, site FLK (Roe 1994: 207), Isimila (Cole et al. 2016) and the Furze Platt giant (MacRae 1987), all of which provide examples surpassing 300mm. A comparison of the Wadi Dabsa handaxe with several of these known large handaxes is provided in **TABLE 2**, demonstrating that this new example fits well within the range of these previously collected artefacts, though it is generally broader and thicker than most. Whilst 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; Petraglia & Shipton 2009; Sharon 2007). The excessive weight of the example from Wadi Dabsa would certainly have made it difficult to wield in the hand, begging the question of how this tool may have been used and for what purpose.

*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 (Jennings et al. 2015; Petraglia et al. 2009), and those recently discovered in the Nefud Desert (Shipton et al. 2014). In addition, it can be added to the wider evidence for the Acheulean occupation of the Red Sea region produced by the DISPERSE project (Inglis et al. 2013, 2014, 2015) and previous studies (Zarins et al 1980, 1981). The location of Wadi Dabsa at the confluence of several tributaries and the potential presence of a larger body of water conforms 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).

***Figure 4 to be placed somewhere around here***

The presence of large cutting tools produced on large flakes, such as handaxes, also conforms to what has been described for other Acheulean assemblages within Arabia. These cutting tools were produced using the abundant local raw materials, although Wadi Dabsa displays clear evidence for the preferential selection of good quality raw materials, 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 for a clear appreciation for the conchoidal fracture properties of the lithic materials by local hominins living within the region. The presence of a Large Flake Acheulean at Wadi Dabsa close to other Near and Middle Eastern sites which 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 has the potential to expand this hypothesis to include the Arabian Peninsula.

***Table 3 to be placed somewhere around here***

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 in manufacture for a preferential reduction and finishing of the tip, leaving the butt minimally worked suggesting 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 that variation in the shape of bifaces can often be explained by the need to establish and preserve a sharp, cutting edge (Lycett 2008). However, a suite of factors 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). In the case of 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 pattern of reduction in handaxes is 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 that is 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. However, the fact that large handaxes are generally found in isolation may present a false indication of their individuality. It is clear from African sites, where such large tools are found in an assemblage context, e.g. Olduvai (Roe 1994) and Isimila (Cole et al. 2016), then multiple, similar examples can occur. This may also be the case at Cuxton, where at least four handaxes over 200 mm in length were recovered by Tester (Cole 2011; Shaw and White 2003), which compliment the two large bifaces found during excavation by Wenban-Smith (2004).

The key question regarding the large handaxe is why it was produced. Several hypotheses concerning the function of large bifaces have been put forward, including their use as digging tools (Wymer, 1983, 103), expressions of knapping skill (Wymer, 1968, 225), and as artefacts incorporated into some form of social display (Kohn & Mithen, 1999). None of these theories has been conclusively 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 by others (Wymer 1968, 1982; Roe 1981). By the same token, it is also unlikely that it was made with the intention of someone carrying it from site to site. This might suggest that either its use as a hand held butchery tool, as is often suggested for handaxes, was unlikely, or alternatively that our impressions of size and weight are significantly different to those of hominins who made them (Wenban-Smith 2004). There is the potential that it could be a large, bifacial core. However, as discussed above, the lack of additional examples and limited preparation appear to preclude this hypothesis. Moreover, given the lack of extensive reduction used in the creation of the large handaxe from Wadi Dabsa, as well as its dimensions and conformity in shape and working to other handaxes within the assemblage, most notably in the intense reduction of the tip to create a cutting edge, it seems reasonable to suggest that it was made for a clear utilitarian purpose. It might 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 so as 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 large handaxe from Wadi Dabsa, 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 presenting a new addition to the known catalogue of these enigmatic bifacial tools. It is geographically unique, being the only example currently known from within the Arabian Peninsula, while its unusually excessive weight highlights its importance in comparison to similar overly large tools. The use of such large bifaces is still a mystery that requires solving, and it is hoped that the addition of the Wadi Dabsa specimen can contribute to this debate, as well as further discussion regarding their dispersal throughout the Acheulean world.

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*Figure Captions*

Figure 1: Location of Wadi Dabsa on the southwest coastline of the Arabian Peninsula.

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

Figure 3: (top) Photograph of the large handaxe from Wadi Dabsa, (bottom) illustration of the handaxe, including profile view. Photograph taken by A. Shuttleworth. Illustration by F. Foulds.

Figure 4: View from the top of a basalt jebel at the northern extent of L-0107, looking south over the basalt surface and tufa exposure. Adapted from Inglis et al (2015). Photo by R. Inglis.

*Table Captions*

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

Table 2. A comparison of the large handaxe with other known handaxes of length greater than 240mm. Part of the data for this table is based on Gowlett (2013). Data for the Olduvai FLK handaxes is based on metrics recorded in Leakey and Roe (1994).

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 with the removal of the large handaxe). Data gathered from Shipton et al. (2014) and Petraglia et al. (2009).

*References*

ASFAW, B., BEYENE, Y., SUWA, G., WALTER, R.C., WHITE, T.D., WOLDEGABRIEL, G. & T. YEMANE 1992. The earliest Acheulian from Konso-Gardula. *Nature* 360: 732-735. DOI: http://dx.doi.org/10.1038/360732a0

BAILEY, G.N. 2009. The Red Sea, coastal landscapes and hominin dispersals. In: Petraglia, M.D. & J.I. Rose (eds) *The Evolution of Human Populations in Arabia*: 15-37. Dordrecht, Netherlands: Springer.

BAILEY, G.N., FLEMMING N., KING, G.C.P., LAMBECK, K., MOMBER, G., MORAN, L., AL-SHAREKH, A. & C. VITA-FINZI 2007. Coastlines, submerged landscapes and human evolution: the Red Sea Basin and the Farasan Islands. *Journal of Island and Coastal Archaeology* 2 (2): 127–60.

BAILEY, G.N., KING, G.C.P., DEVÈS, M., HAUSMANN, N., INGLIS, R., LAURIE, E., MEREDITH-WILLIAMS, M., MOMBER, G., WINDER, I., ALSHAREKH, A. & D. SAKELLARIOU 2012. DISPERSE: dynamic landscapes, coastal environments and human dispersals. *Antiquity* 86 (334). http://antiquity.ac.uk/projgall/bailey334/

BAILEY, G.N., DEVÈS, M.H., INGLIS, R.H., MEREDITH-WILLIAMS, M.G., MOMBER, G., SAKELLAROU, D., SINCLAIR, A.G.M., ROUSAKIS, G., AL GHAMDI, S. & A.M. ALSHAREKH 2015. Blue Arabia: Palaeolithic and underwater survey in SW Arabia and the role of coasts in Pleistocene dispersals. *Quaternary International* 382: 42-57.

CABRERA, V.M., ABU-AMERO, K.K., LARRUGA, J.M. & A.M. GONZÁLEZ 2009. The Arabian peninsula: Gate for human migrations out-of-Africa or cul-de-Sac? A mitochondrial DNA phylogeographic perspective. In: Petraglia, M.D & J.I. Rose (eds) *The Evolution of human populations in Arabia: paleoenvironments, prehistory and genetics*: 79-88. Dordrecht, Netherlands: Springer

CALLOW, P. 1994. The Olduvai bifaces: technology and raw materials. In M.D. Leakey & D.A. Roe (eds) *Oldovai Gorge, Volume 5: Excavations in Beds III, IV and the Masek Beds, 1968-1971*: 235-253. Cambridge: Cambridge University Press.

COLE, J. 2011. *Hominin cognitive and behavioural complexity in the Pleistocene: Assessment through identity, intentionality and visual display*. Unpublished PhD thesis, University of Southampton.

COLE, J., MCNABB, J., BUSHOZI, P., BATES, M., KWEKASON, A., NASH, D. & P. TOMS 2016. *Recent Investigations in the Stone Ages Site of Ismila, Tanzania*. Paper presented to the Unravelling the Palaeolithic conference, Southampton, 14-16th January 2016.

DEBONO, H. & N. GOREN-INBAR 2001. Note on a link between Acheulian handaxes and the Levallois method. *Proceedings of the Israel Prehistoric Society* 31: 9-23.

DEVÈS, M.H., STURDY, D.A., KING, G.C.P., GODET, N. & G.N. BAILEY 2014. Hominin reactions to herbivore distribution in the Lower Palaeolithic of the southern Levant. *Quaternary Science Reviews*. 96: 140–160. DOI: 10.1016/j.quascirev.2014.04.017

FIELD, J.S. & M.M. LAHR 2005. Assessment of the Southern Dispersal: GIS-Based Analyses of Potential Routes at Oxygen Isotopic Stage 4. *Journal of World Prehistory* 19 (1): 1- 45. DOI: 10.1007/s10963-005-9000-6

FOULDS, F.W.F. 2014. Invisible individuals, visible groups: on the evidence of individual and groups at the Lower Palaeolithic site of Caddington, Bedfordshire, UK. In F.W.F. Foulds, H.C. Drinkall, A.R. Perri, D.T.G. Clinnick & J.W.P. Walker (eds) *Wild Things: Recent advances in Palaeolithic and Mesolithic research*, pp. 12-40. Oxford: Oxbow Books.

GAMBLE, C. 1997. Handaxes and Palaeolithic individuals. In N. Ashton, F. Healey & P. Pettitt (eds) *Stone Age archaeology: essays in honour of John Wymer*, pp. 105-109. Oxford: Oxbow Books.

GOWLETT, J.A.J. 2013. Elongation as a factor in artefacts of humans and other animals: an Acheulean example in comparative context. *Philosophical transactions of the Royal Society B* 368: 20130114

GROUCUTT, H.S. & M.D. PETRAGLIA 2012. The prehistory of the Arabian Peninsula: Deserts, Dispersals, and Demography. *Evolutionary Anthropology* 21: 113-125.

HARDAKER, T.R. 2011. *New approaches to the study of surface Palaeolithic artefacts: a pilot project at Zebra River, Western Namibia*. British Archaeological Reports International Series 2270. Oxford: Archaeopress.

INGLIS, R.H., SINCLAIR, A.G.M., SHUTTLEWORTH, A. & A.M. ALSHAREKH 2013. Preliminary Report on 2013 Fieldwork in Southwest Saudi Arabia by the DISPERSE Project: (2) Jizan and Asir Provinces Feb–March. *Unpublished Report to the Saudi Commission for Tourism and Antiquities.* Available at <http://www.disperse-project.org/field-reports>

INGLIS, R.H., SINCLAIR, A.G.M., SHUTTLEWORTH, A., ALSHAREKH, A., AL GHAMDI, S., DEVÈS, M., MEREDTH-WILLIAMS, M.G., AND G.N. BAILEY 2014. Investigating the Palaeolithic Landscapes and Archaeology of the Jizan and Asir Regions, Southwest Saudi Arabia. *Proceedings of the Seminar for Arabian Studies* 44: 193-212.

INGLIS, R.H., FOULDS, F., SHUTTLEWORTH, A., ALSHAREKH, A., AL GHAMDI, S., SINCLAIR, A.G.M., & G.N. BAILEY 2015. The Palaeolithic occupation of the Harrat Al Birk: Preliminary report on 2015 fieldwork in Asir Province, southwest Saudi Arabia. *Unpublished Report to the Saudi Commission for Tourism and Antiquities.* Available at <http://www.disperse-project.org/field-reports>

ISAAC, G.L. 1977. *Olorgesailie: Archaeological Studies of a Middle Pleistocene Lake Basin in Kenya*. Chicago: University of Chicago Press.

Jennings, R.P., Shipton, C., Breeze, P., Cuthbertson, P., Antonio Bernal, M., Oshan Wedage, W.M.C., Drake, N.A., White, T.S., Grocutt, H.S.,Parton, A., Clark-Balzan, L., Stimpson, C., al Omari, A.-A., Alsharekh, A. & M.D. Petraglia 2015. Multi-scale Acheulean landscape survey in the Arabian Desert. *Quaternary International* 382: 58-81.

Kelley, H. 1959. Bifaces de tres grande taille. *Bulletin de la Société préhistorique française* 16: 739-772.

King, G.C.P. & G.N. Bailey 2006. Tectonics and human evolution. *Antiquity* 80: 265–86.

Kohn, M. & S. Mithen 1999. Handaxes: products of sexual selection? *Antiquity* 73: 518-526.

Kübler, S., Owenga, P., Rucina, S., Reynolds, S.J., Bailey, G.N. & G.C.P. King 2016. Edaphic and topographic constraints on exploitation of the Central Kenya Rift by large mammals and early hominins . *Open Quaternary* 2: 5, pp. 1–18. DOI: http://dx.doi.org/10.5334/oq.21

Lambeck, K., Purcell, A., Flemming, N.C., Vita-Finzi, C., Alsharekh, A.M. & G.N. Bailey 2011. Sea level and shoreline reconstructions for the Red Sea: isostatic and tectonic considerations and implications for hominin migration out of Africa. *Quaternary Science Reviews* 30 (25-26): 3542-3574.

Leakey M.D. & D.A. Roe 1994. *Oldovai Gorge, Volume 5: Excavations in Beds III, IV and the Masek Beds, 1968-1971*. Cambridge: Cambridge University Press.

Lepre, C.J., Roche, H., Kent, D.V., Hardman, S., Quinn, R.L., Brugal, J.-P., Lenoble, A. & C.S. Feibel 2011. An earlier origin of the Acheulien. *Nature* 477 (7362): 82-85. DOI: http://dx.doi.org/10.1038/nature10372

Lycett, S.J. 2008. Acheulean variation and selection: does handaxe symmetry fit neutral expectations? *Journal of Archaeological Science* 35:2640-2648.

MacRae, R.J. 1987. The great giant handaxe stakes. *Lithics* 8: 15-17.

Martínez-Navarro, B. and R. Rabinovich 2011. The fossil Bovidae (Artiodactyla, Mammalia) from Gesher Benot Ya 'aqov, Israel: Out of Africa during the Early–Middle Pleistocene transition. *Journal of Human Evolution* 60(4): 375–386.

Petraglia, M.D. 2003. The Lower Palaeolithic of the Arabian Peninsula: occupations, adaptations and dispersals. *Antiquity* 77: 671-684.

PETRAGLIA, M.D. & J.I. ROSE (eds) 2009. *The Evolution of human populations in Arabia: paleoenvironments, prehistory and genetics.* Dordrecht, Netherlands: Springer.

PETRAGLIA, M.D., DRAKE, N. & A.M. ALSHAREKH 2009. Acheulean landscapes and large cutting tool assemblages in the Arabian Peninsula. In: M.D. Petraglia & J.I. Rose (eds) *The Evolution of human populations in Arabia: paleoenvironments, prehistory and genetics.* Dordrecht, Netherlands: Springer.

POTTS, R., BEHRENSMEYER, A.K. AND P. DITCHFIELD 1999. Paleolandscape variation and Early Pleistocene hominid activities: members 1 and 7, Olorgesailie Formation, Kenya. *Journal of Human Evolution* 37(5): 747–788.

PRINZ, W. 1984. *Geological map of the Wadi Haliy quadrangle, Sheet 18E, Kingdom of Saudi Arabia.* Scale 1:250,000. Geoscience Map GM-74C. Kingdom of Saudi Arabia Ministry of Petroleum and Mineral Resources, Deputy Ministry for Mineral Resources, Jeddah.

QUADE, J., LEVIN, N., SEMAW, S., STOUT, D., RENNE, P., ROGERS, M.J. & S. SIMPSON 2004. Palaeoenvironments of the earliest stone tool-makers, Gone, Ethiopia. *Geological Society of America Bulletin* 116 (11-12): 1529-1544. DOI: http://dx/doi.org/10.1130/B25358.1

REYNOLDS, S.C., BAILEY, G.N. & G.C.P. KING 2011. Landscapes and their relation to hominin habitats: case studies from Australopithecus sites in eastern and southern Africa. *Journal of Human Evolution* 60 (3): 281-298.

ROE, D. 1981. *The Lower and Middle Palaeolithic Periods in Britain.* London: Routledge and Kegan Paul.

ROE, D. 1994. A metrical analysis of selected sets of handaxes and cleavers from Olduvai Gorge. In M.D. Leakey and D.A. Roe (eds) *Oldovai Gorge, Volume 5: Excavations in Beds III, IV and the Masek Beds, 1968-1971*, pp. 146-235. Cambridge: Cambridge University Press.

ROHLING, E.J., GRANT, K.M., ROBERTS, A.P. & J.-C. LARRASOAÑA 2013. Paleoclimate Variability in the Mediterranean and Red Sea Regions during the last 500,000 Years. *Current Anthropology* 54 (S8): 0000 - 0017

SHARON, G. 2007. *Acheulian large flake industries: technology, chronology, and significance*. British Archaeological Reports International Series S1701. Oxford: Archaeopress.

SHARON, G. 2009. Acheulian giant-core technology. *Current Anthropology* 50: 335-367.

SHARON, G. & P. BEAUMONT 2006. Victoria West – a highly standardised prepared core technology. In N. Goren-Inbar and G. Sharon (eds) *Axe Age: Acheulian tool making from quarry to discard*, pp. 181-199. London: Equinox.

SHAW, A.D. & M.J. WHITE 2003. Another look at the Cuxton handaxe assemblage. *Proceedings of the Prehistoric Society* 69: 305-314.

SHIPTON, C. 2011. Taphonomy and Behaviour at the Acheulean Site of Kariandusi, Kenya. *African Archaeological Review* 28(2): 141–155.

SHIPTON, S., PARTON, A., BREEZE, P., JENNINGS, R., GROUCUTT, H.S., WHITE, T.S., DRAKE, N., CRASSARD, R., ALSHAREK, A., & M.D. PETRAGLIA 2014. Large Flake Acheulean in the Nefud Desert of Northern Arabia. *PaleoAnthropology* 2014: 446-462.

SPIKINS, P. 2012. Goodwill hunting? Debates over the 'meaning' of handaxe form revisited. *World Archaeology* 44 (3): 378–392.

WENBAN-SMITH, F. 2004. Handaxe typology and Lower Palaeolithic cultural development: ficrons, cleavers and two giant handaxes from Cuxton. *Lithics* 25: 11-21.

WHITE, M.J. 1998. On the significance of Acheulian biface variability in southern Britain. *Proceedings of the Prehistoric Society* 64: 15-44.

WINDER, I., KING, G.C.P., DEVÈS, M. & G.N. BAILEY 2013. Complex topography and human evolution: the missing link. *Antiquity* 87: 333-349

WINDER, I., DEVÈS, M., KING, G.C.P., BAILEY, G.N., INGLIS, R.H. & M. MEREDITH-WILLIAMS 2015. Dynamic landscapes and complex topography as agents in human evolution: the dispersals of the genus *Homo*. *Journal of Human Evolution* 87: 48-65.

WYMER, J. 1968. *Lower Palaeolithic Archaeology in Britain, as represented by the Thames Valley.* London: John Barker Publishers Ltd.

WYMER, J. 1982. *The Palaeolithic Age*. London: Croom Helm Ltd.

WYNN, T. 1995. Handaxe enigmas. *World Archaeology* 27: 10-23

ZARINS, J., MURAD, A. & K. AL-YAISH 1981. The Second Preliminary Report on the Southwestern Province. *Atlal* 5: 9–42.

ZARINS, J., WHALEN N.M., IBRAHIM, I., MORAD A. & M. KHAN 1980 Comprehensive Archaeological Survey Program: preliminary report on the Central Southwestern Provinces survey. *Atlal* 4: 9–117.

| **Type** | | **Number found** |
|---|---|---|
| **Flakes/debitage** | | |
| | *Flakes* | 475 |
| | *Prepared core flakes* | 96 |
| | *Blades* | 17 |
| | *Utilised flakes* | 28 |
| | *Spintered 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 |
| | *Burin* | 2 |
| | *Denticulate* | 4 |
| | *Notch* | 9 |
| | *LCTs* | 16 |
| | *Piercer/borer* | 13 |
| | *Points* | 8 |
| | *Scraper* | 47 |
| **Other** | | |
| | *Clasts* | 23 |
| | *Hammerstones* | 2 |
| **Total** | | 1002 |

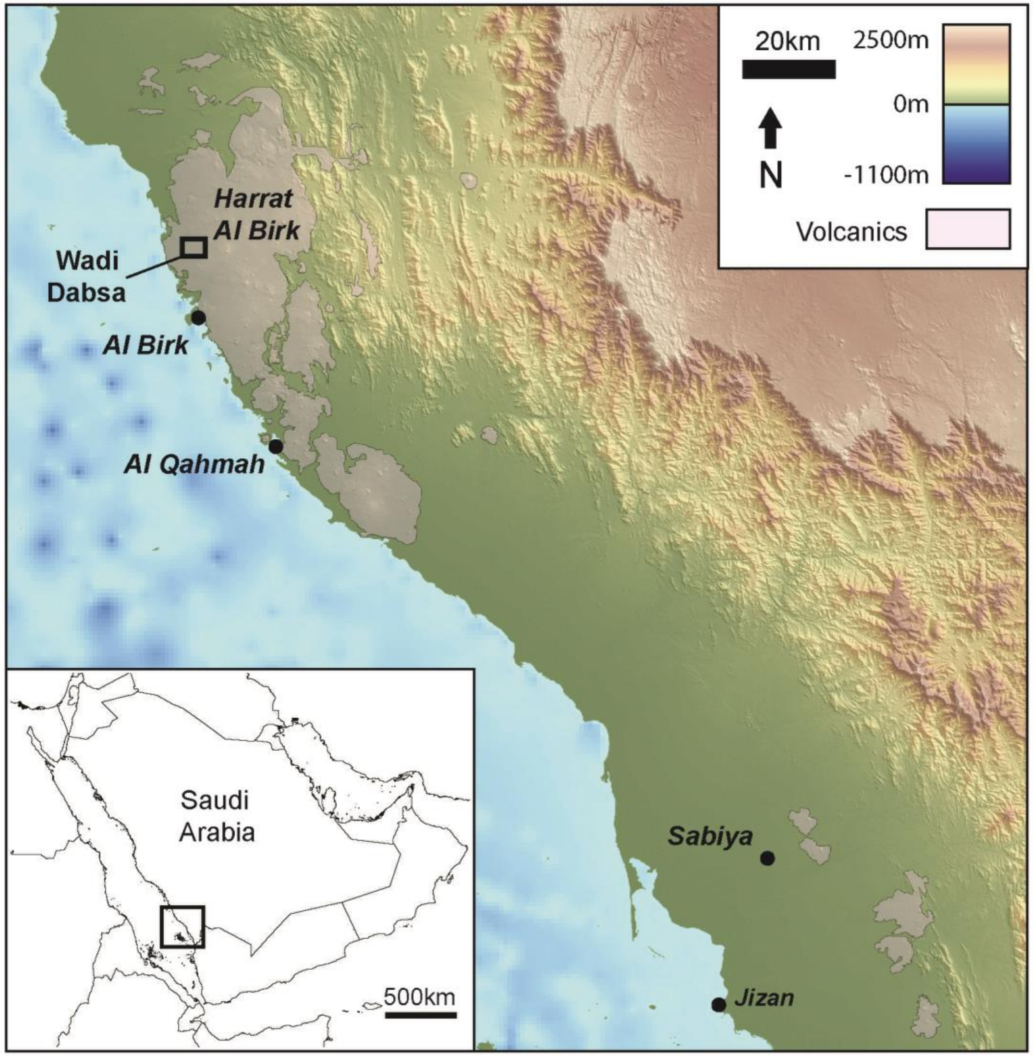
**TABLE 1**

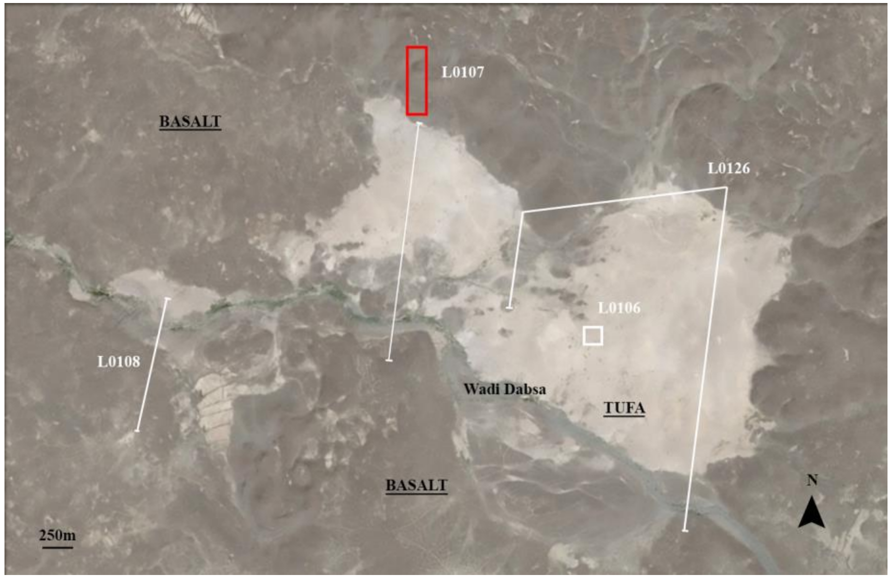
| Locality | Length (mm) | Breadth (mm) | Thickness (mm) |
|---|---|---|---|
| Kilombe | 248 | 120 | 53 |
| Kilombe | 258 | 151 | 56 |
| Kilombe | 243 | 111 | 55 |
| Sidi Abderrahman Cunette | 250 | 162 | 47 |
| Sidi Abderrahman Cunette | 241 | 107 | 73 |
| Kalambo Falls | 291 | 138 | 65 |
| Cornelia-Uitzoek | 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** |

**TABLE 2**

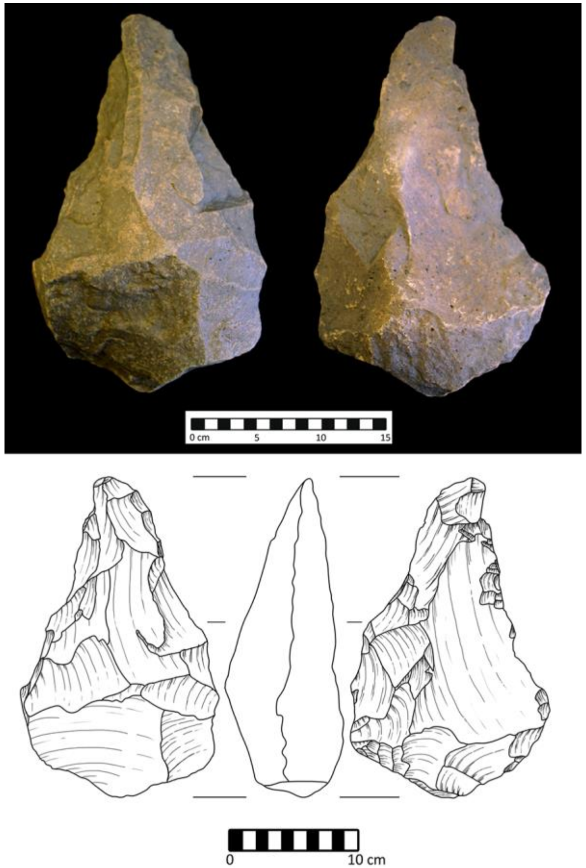
| **Locality** | ***n*** | **Mean Length (mm)** | ***n*** | **Mean Thickness (mm)** | **SD** | ***n*** | **Mean Weight (g)** | **SD** |
|---|---|---|---|---|---|---|---|---|
| *Africa* | | | | | | | | |
| Olduvai Gorge Bed II | 21 | 195.39 | 17 | 66.92 | 19.2 | 17 | 1406.81 | 784.12 |
| Kariandusi | 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 |
| Orlogesailie H9AM | 13 | 199.77 | 10 | 36.2 | 7.53 | 10 | 770 | 426.54 |
| Orlogesailie I3 | 62 | 97.95 | 57 | 33.54 | 9.28 | 57 | 225.12 | 197.48 |
| Orlogesailie FB | 16 | 98.81 | 15 | 34.6 | 8.44 | 15 | 180.87 | 116.11 |
| Orlogesailie 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 (127.80)** | **11** | **60.54 (58.10)** | **15.83 (14.33)** | **11** | **1105.72 (856.50)** | **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 | | | | | | |

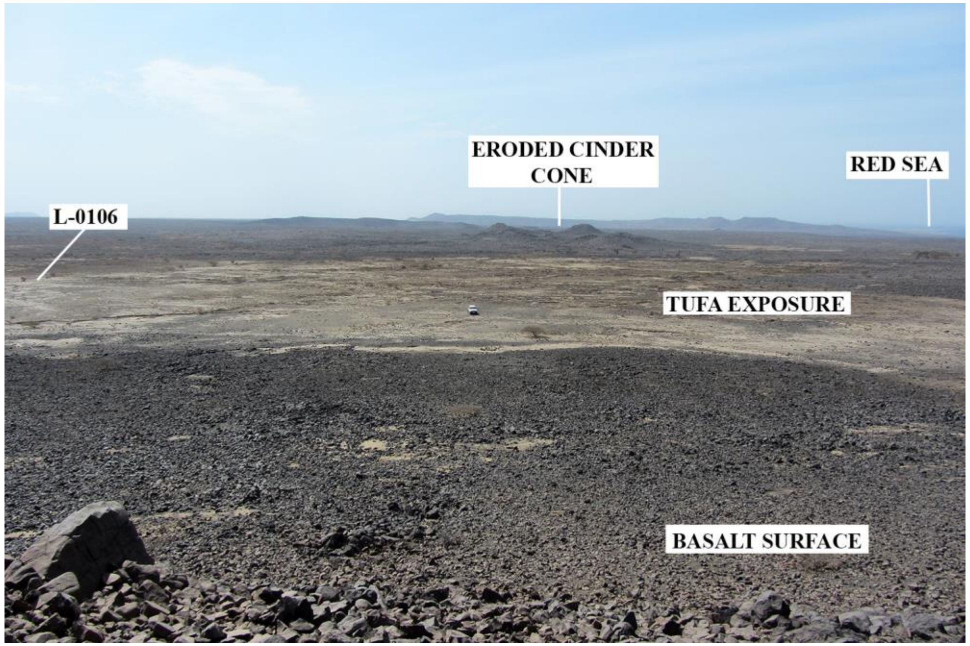
**TABLE 3**


20km
2500m
0m
-1100m
N
Volcanics
Harrat
Al Birk
Wadi
Dabsa
Al Birk
Al Qahmah
Sabiya
Jizan
Saudi
Arabia
500km



L0107
BASALT
L0126
L0106
L0108
Wadi Dabsa
TUFA
BASALT
N
250m


0 cm
5
10
15
0
10 cm


ERODED CINDER CONE
RED SEA
L-0106
TUFA EXPOSURE
BASALT SURFACE