Kariandusi –
An Acheulean site in the Kenya Rift Valley

Kariandusi was one of the first early archaeological sites known in East Africa, discovered by Louis Leakey's second expedition of 1928-29 (Leakey 1931, 1936). The sites lie on the eastern side of the Gregory Rift Valley, about 120 km NNW of Nairobi, and about 2 km to the east side of Lake Elmenteita. The Acheulean localities face across the lake and the rift valley floor. The Nakuru-Elmenteita basin is flanked by Menengai volcano on the north, and by the volcanic pile of Mount Eburru on the south, visible from Kariandusi. The western wall of the rift, the Mau escarpment, can also be seen some 35 km away. In the present day the basin contains the small lakes of Elmenteita, close to the sites, and out of sight beyond Lion Hill, Lake Nakuru. Geologists have been fascinated with the history of the lakes since their first investigations a century ago. According to McCall (1966), the diatomites at Kariandusi were first reported by Hobley in 1909; the sediments were later described by Gregory (1921). The diatomite, with its strikingly white deposits more than 30 metres deep, is an indicator of large and deep lakes in the past.

Much geological evidence confirms that at times in the past this basin has been occupied by large lakes, sometimes reaching levels hundreds of metres higher than the present Lakes Nakuru and Elmenteita (McCall et al. 1967; Washbourn-Kamau 1971). Lying at a height of about 1880 m (nearly 6200 ft) the Kariandusi sites would have been near the side of one of these former lakes. Impressive scarps of the Rift wall rise less than one kilometre behind the sites, continuing as the Bahati Escarpment to the north, and the Gilgil Escarpment further south, and reaching to 2250 m (7400 ft) less than 3 km from the sites.

Close to the sites, the scarps of the Rift Valley wall are dissected by the valley of the Kariandusi River, which has a relatively short course, fed partly by waters from hot springs only 2 km from the sites. The river runs down to Lake Elmenteita, passing through a deep gorge, where it has cut through an accumulation of sediments. The diatomite quarry cuts through older versions of the gorge which have been filled by sediments. The deposits containing the Acheulean handaxes are best exposed in a side gorge on the left bank of the Kariandusi River, which reaches within about 150 m of the old Nairobi-Nakuru main road. Under present conditions, water flows in this side gorge only rarely.

Archaeological interest concentrates on the levels overlying the main and upper diatomite. These are locally variable. In his section, Solomon (in Leakey 1931) distinguished a band of tuffaceous gravel, immediately overlying the (upper) diatomite, and overlying units of fine stratified tuffs with a little intercalated sandy material. This distinction is readily observable in the exposures, and artefacts have been found both from the tuffaceous gravels and from the finer tuffs.

The absolute dating of Kariandusi was largely speculative until Evernden and Curtis (1965) made the first application of the Potassium-Argon technique to the Pleistocene, dating volcanic tuffs at Kariandusi, and producing a result of about a million years for the archaeological sites. Apart from a clearly erroneous date of 3.1 million years, their dates ranged as follows:

KA 1064 tuff (rounded pumice fragments in tuff) with axe	1.1
KA 965 possibly reworked tuff under hand-axe	0.93
KA 1035 pumice fragments from diatomite 50 feet below site level	0.95

This age was regarded as much too old at the time, but has proved to be correct, as was confirmed by Durkee and Brown (2014), who found traces of the same volcanic eruptions on the sites of Olorgesailie and Isinya, with a date of about 977,000.

From around 12,000 – 9,000 years ago, a large high lake, up to 180 metres above present day levels, existed in the Elmenteita-Nakuru basin (Washbourn-Kamau 1971). McCall et al. (1967) suggested that the large lake recorded by the Kariandusi diatomites may have had a similar form. More recent research on palaeoclimates indicates that large stable lakes were an important feature of the rift valley about one million years ago (Maslin et al. 2014; Trauth et al. 2005).

The early history

Kariandusi is possibly the first early stone age Acheulean site to have been found in situ in Kenya. The diatomite deposits at Kariandusi were already known in the early years of the 20th century, but the archaeological sites were discovered only when Louis Leakey explored this part of the Rift Valley in his Second Expedition in 1928-29. Leakey records that the site was discovered by team-members Dr. J. Solomon and Miss E. Kitson (Leakey 1936). Investigations were carried out at the site, and a series of hand-axes was described in *The Stone Age Cultures of Kenya Colony* (Leakey 1931). There is little other mention of the site in that book, apart from a geological discussion by Solomon (in Leakey 1931, p.256) who includes a section showing Middle and Upper Pleistocene sediments, and containing Acheulean and 'Aurignacian and Mousterian' artefacts respectively.

Further brief comments appeared in Leakey (1936), including the declaration that, 'We now have a collection of over two thousand specimens excavated from an area barely 10 feet square ....' These probably came from an area at the front of the Upper Site, where there is now an open area. Leakey then believed that 'the Kariandusi River site was a

factory site of the time of the fourth stage of the Acheulean' (Leakey 1934), but by the time of the 1953 reprint of the book he indicated that he no longer adhered to the stage system.

The site area has received special attention not only because of its archaeology, but also because of the commercial significance of the diatomite deposits. Although various specialist reports of these deposits have been made (Pulfrey 1944; Barnard 1950), the best general treatments of the geology of the site area are those provided in McCall (1966) and in McCall et al.(1967). Interpretation of the sites depends partly on evaluation of the relationship of the Kariandusi sediments to the history of the Rift Valley itself. The sediments are lacustrine, and well stratified, consisting largely of diatomites and tuffs. Although Leakey believed that the sediments were themselves strongly faulted, Shackleton was of the opinion that the Kariandusi sediments were deposited on a horst-and-graben surface, originating in the last major faulting of this part of the Rift Valley (Shackleton 1955, 1978).

At Kariandusi, trachytes underlie the sedimentary sequence, named by McCall (1966) as the Gilgil trachyte. According to McCall et al. (1967), this has been affected by major faults, while 'the Kariandusi sediments are affected only by minor renewals of movement on the older lines.' The crucial point, remarked both by Shackleton and McCall, is that such faults could not have caused any appreciable remoulding of the Rift Valley. Both authors express the belief that it was already roughed out in its present form at the time of the Kariandusi deposition. This view is supported by later work (e.g. Williams 1978; Nyamweru 1980), and is an important factor in considering the palaeogeography of the sites (Figs 2b,3).

The Kariandusi sediments have an appreciable dip to the west, which has been interpreted as suggesting that slight down-warping of the Rift Valley floor continued after their deposition (McCall et al. 1967). J. Solomon gave the first geological discussion (in Leakey 1931, p.256), and included a section drawing showing the Pleistocene sediments. He labelled them as containing Acheulean and 'Aurignacian and Mousterian' artefacts respectively. These would now be labelled as Middle Stone and Later Stone Age, but they are not prominently represented on the site.

Later developments and the first pamphlet guide...

Shortly after the Second World War, new excavations were carried out at the Kariandusi Acheulean site in preparation for the First Pan-African Congress of Prehistory, held at Nairobi in 1947. The delegates made an excursion visit to the sites, so they are mentioned in the pre-publication papers and guide of the tours issued to delegates. They did not

feature significantly in the Proceedings of the Congress (published by Louis Leakey and Sonia Cole in 1952). Attention had passed to Olorgesailie and Olduvai. But in an act of great foresight and importance the excavations of 1946-7 were preserved as a museum exhibit, and make up some of the remains that can be seen today. The first visitors' guide to Kariandusi was prepared by Dr Merrick Posnansky in the 1950s. He was first warden of the Olorgesailie site, and talked of his early work during the EAQUA conference in Kenya in 2013.

The Upper Site

The Main or Upper Site is the area investigated in detail by Louis Leakey in 1929-1931 and in 1946/47 (Gowlett 1980; Leakey and Cole 1952; Shipton 2011). It is in this area that stone tools were first observed. The site lies on the right side of the side gorge, in which there are good exposures of the upper diatomite and of the overlying pumice gravels. Stone tools were visible in this section. Artefacts from the earlier excavations were lifted at the time; those which are left *in situ* are within the 1946-47 excavations. These excavations, an extension of the area previously investigated, cut right across the top of a spur which juts out into the side gorge.

Since the long section of the excavations is very well preserved, it was possible to draw and level it long after the original excavation. The section has a long main face, with short faces angled back at each end. It can be seen that the artefact horizon occurs in the upper pumice beds, about 3 m above the top of the upper diatomite, and that in long section it runs approximately parallel with the upper surface of the diatomite, so conforming with the general dip of the sediments. The angled face of the section at the western end shows the artefact horizon dropping away more steeply, towards the deeper part of the channel structure at the edge of which it lies. This part of the section provides a better cross-section of the sedimentary structure.

Marius Walter and Martin Trauth (2013) examined the orientation of the 1946-47 Upper Site artefacts and found that unlike a similar density accumulation of Acheulean artefacts from the Olorgesailie localities H/6A and Mid, those from Kariandusi had been aligned by fluvial action. Likewise, Ceri Shipton (2011) observed coarse sediment adhering to artefacts from the 1931 excavation and a high degree of rounding suggesting the artefacts had been subject to fluvial post-discard processes. However, the 1929 excavation in a different part of the Upper Site produced fresher artefacts with finer sediment adhering, suggesting they were in a more primary setting.

Some fossil bones were preserved on the surface of the Upper Site, where they are marked by white arrows. They are chiefly dense and heavy parts of the skeleton, which

survived the abrasion of being carried in a stream. This pattern provides taphonomic information suggesting a depositional environment of sufficient water energy that only select dense faunal elements were deposited at this point (cf. the bar deposit at Gesher Benot Ya'aqov: Goren-Inbar et al. 1992). Labels on site and the original site guide indicate that the chief faunal remain was horse teeth, attributed to *Equus oldowayensis*. Churcher (1981) recorded the presence of this early zebra at nine other sites in East Africa during the Lower and Middle Pleistocene.

The Kariandusi artefacts are derived, but they are still archaeological material in an ancient sedimentary environment, and as such can be compared with other occurrences although they represent the endpoint of a taphonomic process. Examination of the 1946-47 finds shows that the distribution of artefacts and manuports is very dense. The large numbers of stone blocks or manuports often occur in groups, and amongst them are some pumice blocks. No petrographic analysis of the stone blocks has been carried out, but in the present day there is an outcrop of the Gilgil trachyte on the nearby rise, 80 m from the site. This probably stood out above the sediments in the past, and is very likely to have been the principal source of lava raw material. Large numbers of obsidian artefacts occur on the excavated horizon, including about 100 bifaces. There are also smaller obsidian artefacts, such as scrapers. Some artefacts of lava also occur, notably spheroids, and a few bifaces, some of which are heavily abraded. In contrast, most of the obsidian bifaces are in fresh condition. Their raw material comes from a number of sources, some in the direction of Eburu mountain (Merrick et al. 1994).

The presence of stone blocks of local material, coupled with artefacts chiefly of an exotic material, is parallelled elsewhere in the Acheulean, for instance at Olorgesailie and Latamne (Isaac 1977; Clark 1968).

The Lower Site

In 1974 new finds of handaxes were made in an area on the opposite side of the side gorge from the original Leakey site, further downslope towards the diatomite quarry and the Kariandusi River. They were discovered during the stripping of overburden for an extension of the diatomite quarry, and fortunately were reported to the museums by the manager of the quarry, Mr R. Terry. By that time a drainage ditch made to protect the quarry face from runoff had revealed the presence of large numbers of bifaces just beneath the surface. Excavations were made to investigate this occurrence (Gowlett 1979, 1980), and it was preserved in an additional museum display. The finds from Trench

B include hundreds of handaxes found in a jumble at the edge of a channel which had filled with gravel (Gowlett and Crompton 1994). The site is likely to be of approximately the same age as the other occurrences, but there is very little obsidian among the tools: they are made almost entirely from local trachyte lava, with a few of other volcanic materials such as rhyolite. As well as the handaxes there are numbers of large stone flakes which resulted from the manufacturing process.

Within the area of the lower sites, investigations were made in two other places. Trenches A and C were both excavated into the top of the pumice series at locations near the side gorge where the upper pumice beds have a total thickness of c. 7 metres.
Trench A was cut to a depth of 60 cm through hard compacted fine-grained pumice tuffs, the fine laminae in which suggest deposition in standing water. An artefact horizon was reached at the base of this, at a level of about 5m above the top of the upper diatomite, but the material appeared to be abraded or rolled. At one side the trench had cut the backfill of an older trench, indicating that Louis Leakey's investigations extended to this area. Trench C was dug into the face of the side gorge through the same deposits (Fig. 9), and now houses the top of a stairway for access to and from the gorge. The trench reached the same horizon as in Trench A: an obsidian hand-axe and two large obsidian scrapers were found in situ, among cobbles of lava, and with a large pumice boulder or bomb. These finds came from a horizon underlying fine-grained blue-grey pumice tuffs which were sampled for palaeomagnetic determinations, and gave indications of reversed magnetisation on analysis by P. Dagley. This measurement helps to confirm that the Kariandusi artefacts belong in sediments aged over 0.790 Ma, the age of the Brunhes-Matuyama boundary.

Studies of the handaxes

Kariandusi is famed for its obsidian handaxes, and is one of the earliest sites, alongside Melka Konture in Ethiopia, where they occur in large numbers. Lava bifaces are however also numerous on the sites. Although all the occurrences are to some degree taphonomically disturbed, this has not stopped the Kariandusi bifaces from being subject of several interesting studies over the years.

First, Maxine Kleindienst (1961, 1962) did ground-breaking work on inter-site comparisons in the 1960s, devising a typology based on a set of heavy-duty and light-duty artefacts. Kariandusi stood out notably for its flake-and-handaxe composition, conspicuously scarce in the heavy-duty forms found on most other Acheulean sites. Interestingly, in her subsequent study of Kariandusi artefacts in Cambridge, Laurel Phillipson (1997) found mentions by Louis Leakey of numbers of rough stone balls (probably spheroids), but these

were not in the collections. They have not been observed in the Nairobi collections, nor in the more recently studied Lower Site.

Tom Wynn and Forrest Tierson (1990) compared the form of handaxes across continents, using a new polar coordinates system for their measurements. They included more than 80 Kariandusi bifaces, and were able to discriminate obsidian from lava with 75% success. The difference in form was elucidated further in an allometry study by Gowlett and Crompton (1994): it could be accounted for largely by the size difference between obsidian and lava bifaces. Although there is some overlap, obsidian was preferred for smaller handaxes about 6-13 cm long, with a strong preference for lava from about 14-24 cm long. The shape differences across the two sets of bifaces match in allometry signature (Gowlett 2011), with similar results found on other sites such as Kilombe, Kapthurin, and Kalambo Falls. This finding accords with the doubts of Wynn and Tierson that the makers would select specific raw materials for specific shapes. Nevertheless, it seems that some shapes occurring in obsidian are rare or absent in lava. Classic cleavers are far more common among the lava bifaces, reaching around 16 per cent in numbers.

Phillipson (1997) studied around 250 handaxes of ‘andesite/basalt’ which Louis Leakey had sent to the Cambridge Museum of Archaeology and Anthropology. She was interested in the position of secondary working, and the comfort of hand holds, reducing subjectivity by studying measured edge-angles. She noted the ‘asymmetric diamond’ of handaxes in mid cross-section, describing it as showing an ‘off-centre bulge’ on each face. This was taken as possible evidence for handedness, with 45 of 54 specimens studied determined as right handed in use, 6 left-handed, and 3 indeterminate. The approach was admitted to be somewhat subjective, but it gives a similar outcome to Toth’s (1987) work on flakes at East Turkana.

In another detailed study, Ceri Shipton (2013) compared 58 Kariandusi bifaces from the 1929-1931 excavations with those from a range of sites in the Hunsgi-Baichbal valley in India, using 3D geometric morphometrics. This study found that limestone bifaces from the sites of Isampur Quarry and Hunsgi V were more similar in size and shape to Kariandusi than they were to other limestone assemblages in the same valley, suggesting geography and material were not the primary determinants of hand-axe form. In his 2011 paper Shipton proposed assessing the extent to which bifaces were resharpened by estimating the retouch scar density on their ventral surfaces. In a follow-up study, biface scar density was measured more accurately and showed to be a useful index of reduction intensity, with those Kariandusi bifaces made on materials from more distal sources (obsidian and rhyolite) having higher scar densities than those made from the local trachyte (Shipton and Clarkson 2015). This study was one of the first systematically to

make 3D scans of Acheulean artefacts. Shipton (2018) then used 3D scans to compare 78 Kariandusi bifaces to those from other Acheulean sites in east Africa. He found that those from Kariandusi were thinner, more symmetrical, and had straighter edges than those from the older sites of Olduvai Gorge Bed II and Olorgesailie CL1-1. . [More on contribution of Kariandusi to recent studies?]

No fossil hominin remans have been found at Kariandusi, but the likelihood is that the makers of the many handaxes and other stone tools were *Homo erectus*. Part of a cranium from Olorgesailie, to the south is the nearest evidence of this species (Potts et al. 2004), while human mandibles from Kapthurin to the north are of a similar age. *Homo erectus* is also well known from Olduvai Gorge, and from Lake Turkana.

Diatomite, Kariandusi and the museums

The Kariandusi sites are positioned in a rapidly changing world. Development is rapid in the area. The diatomite industry has seen a phase of expansion in recent years. A new headquarters and large processing sheds are now visible from the museum site. Diatomite has been mined at Kariandusi since a survey mapped the deposits in 1950. Made up from the skeletons of billions of algae or phytoplankton, it is about 85% pure silica. Diatomite is used as a filter aid, as a cleaning agent, for example for stainless steel, and as an insecticide. It is odourless, non-toxic and soft to the touch. But for insects the sharp edges of the fossil siliceous microskeletons are lethal. This expansion has changed the character of the museum setting, so that there is no longer the idyllic view across Lake Elmenteita described by Cole (1954).

The guides' hut is one of the oldest buildings on the site and has its own heritage value. In 2003 the National Museums built a new display building at Kariandusi. It has space for exhibiting tools and casts of fossil hominins, and also contains diorama paintings made by a Kenyan artist. Another site building is a large wooden hut which was transported from Gilgil in 1974. It is typical of a design once used for temporary government buildings or barracks and still has a useful life for housing displays. The Kariandusi Museum is much-visited by school parties, as well as by tourists. Two hours drive north of Nairobi, it remains close to the A104 Nairobi-Nakuru road, and is fully accessible to coaches. School visits are made from all directions, but with good parking and picnicking facilities, there is always ample space.

Outreach education for schools is an important activity of the National Museums of Kenya. Plans are afoot to expand and to update the exhibits at Kariandusi so that students can get a fuller impression of life in the Rift Valley in the times earlier hominin ancestors. The

sites are close to the World Heritage locations of Lakes Elmenteita, Nakuru and Bogoria and their National Parks and thus have a part to play in future development of tourism.

In summary, Kariandusi has an enduring importance as one of the sites that paved the way to the study of human evolution in East Africa, and a historical importance as one of the first sites investigated by Louis Leakey. Although its localities have all been subject to post-depositional disturbance, they have retained real archaeological value, as is demonstrated by the series of studies that have been carried out on the handaxes in particular. They provide useful collections of million-year-old artefacts. As they are preserved as an open air museum in a key location, under the tutelage of National Museums of Kenya, they have a continuing and growing role in education and tourism.

References

Barnard, G.C. (1950). Diatomite and its production in Kenya Colony. *Mining Magazine* 32: 271-274.

Churcher, C.S. (1981). Zebras (Genus Equus) from nine Quaternary sites in Kenya, East Africa. *Canadian Journal of Earth Sciences*, 18(2),330-341, doi 10.1139/e81-025

Clark, J.D. (1968). Further excavations (1965) at the Middle Acheulian occupation site at Latamne, northern Syria; general results, definitions and interpretations. *Quaternaria*, 10, 1-71.

Cole, S. 1954. *The prehistory of East Africa*. Harmondsworth, Penguin. Revised edition 1963, New York, Macmillan.

Durkee, H., & Brown, F.H. (2014). Correlation of volcanic ash layers between the Early Pleistocene Acheulean sites of Isinya, Kariandusi, and Olorgesailie, Kenya . *Journal of Archaeological Science*, 49, 510-517.

Evernden, J.F. & Curtis, G.H. (1965). Potassium-argon dating of late Cenozoic rocks in East Africa and Italy. *Current Anthropology*, 6, 343-385.

Goren-Inbar, N., Belitzky, S., Goren, Y., Rabinovich, R. and Saragusti, I. (1992). Gesher Benot Ya-aqov - the 'Bar': an Acheulian assemblage. *Geoarchaeology* 7,1:27-40.

Gowlett, J.A.J. (1980). Acheulean sites in the Central Rift Valley, Kenya. In Leakey, R.E. & Ogot, B.A. (Eds.), *Proceedings of the 8th Panafrican Congress of Prehistory and Quaternary Studies, Nairobi,1977* (pp. 213-217). Nairobi: TILLMIAP.

Gowlett, J.A.J. (2011). The vital sense of proportion. *Paleoanthropology* 2011, 174-187.

Gowlett, JAJ, & Crompton, RH. (1994). Kariandusi: Acheulean morphology and the question of allometry. African Archaeological Review 12, 3-42.

Gregory, J.W. (1921). The Rift Valleys and geology of East Africa. London: Seeley, Service & Co.

Isaac, G.Ll. (1977). *Olorgesailie: archeological studies of a Middle Pleistocene lake basin in Kenya*. Chicago: Chicago University Press.

Kleindienst, M.R. (1961). Variability within the late Acheulean assemblage in eastern Africa. *South African Archaeological Bulletin*, 16,62, 35-52.

Kleindienst, M.R. (1962). Components of the East African Acheulian assemblage: an analytic approach. In Mortelmans, C. & Nenquin, J. (Eds.), *Actes du IVe Congres panafricain de Préhistoire et de l'étude du Quaternaire* (pp. 81-105). Tervuren, Belgium.

Kübler, S., Bailey, G., Rucina, S., Deves, M. & King, G.C.P. (2020). Rift dynamis and archaeological sites: Acheulean land use in geologically unstable settings. In Cole, J., McNabb, J., Grove, M., & Hosfield, R. (Eds.), *Landscapes of human evolution: contributions in honour of John Gowlett* (pp. 142-149). Oxford: Archaeopress.

Leakey, L.S.B. (1931). *The stone age cultures of Kenya Colony*. Cambridge: Cambridge University Press. Reprinted 1971, London: Frank Cass.

Leakey, L.S.B. (1934). *Adam's ancestors*. London: Methuen.

Leakey, L.S.B. (1936). *Stone age races of Kenya*. Oxford: Oxford University Press.

Leakey, L.S.B. & Cole, S. (Eds.) (1952). *Proceedings of the First Pan-African Congress on Prehistory, Nairobi*. Oxford: Blackwell.

McCall, G.J.H. (1966). *Geology of the Nakuru-Thomson's Falls - Lake Hannington area*. Ministry of Natural Resources, Geological Survey of Kenya, Report No.78.

McCall, G.J.H., Baker, B.H. & Walsh, J. (1967). Late Tertiary Quaternary sediments of the Kenya Rift Valley. In Bishop, W.W. & Clark, J.D.(Eds.), *Background to evolution in Africa* (pp. 191-220). Chicago: University of Chicago Press.

Maslin, MA, Brierley, CM, Milner, AM, Shultz, S, Trauth, MH and Wilson, KE (2014). East African climate pulses and early human evolution. *Quaternary Science Reviews* 101, 1-17. (doi 10.1016/jquascirev.2014.06.012)

Merrick, H.V. & Brown, F.H. (1984). Obsidian sources and patterns of source utilization in Kenya and northern Tanzania: some initial findings. *African Archaeological Review*, 2, 129-152.

Merrick, H. V., Brown F.H., and Nash, W.P. (1994). Use and movement of obsidian in the Early and Middle Stone Ages of Kenya and Northern Tanzania. In S. T. Childs (Ed.) *Society, Culture, and Technology in Africa*. MASCA 11 (supplement), 29–44.

Munga, J. U. (2012). Morphological variability in Acheulean handaxes from Kariandusi and Lewa Downs archaeological sites in Kenya. Unpublished MA dissertation, University of Nairobi (Ref. C50/81117/20)

Nyamweru, C. (1980). *Rifts and volcanoes: a study of the East African rift system*. Nairobi: Nelson.

Phillipson, L. (1997). Edge modification as an indicator of function and handedness of Acheulian handaxes from Kariandusi, Kenya. *Lithic Technology* 22, 171-183. https://doi.org/10.1080/01977261.1997.11754541

Potts, R., Behrensmeyer, A.K., Deino, A., Ditchfield, P. & Clark, J. (2004). Small Mid-Pleistocene hominin associated with East African Acheulean technology. *Science* 305, 75–78.

Pulfrey, W. (1944). *Report on the examination of the Kariandusi diatomite deposits, Cole Estates, Gilgil.* Nairobi: Mines and Geological Department (unpublished).

Shackleton, R.M. (1955). Pleistocene movements in the Gregory Rift Valley. Sonderdruck aus der Geologischen Rundschau 43: 257-263.

Shackleton, R.M. (1978). Structural development of the East African Rift system. In: Bishop, W.W.(Ed.), *Geological background to fossil man* (pp. 19-28). Edinburgh: Scottish Academic Press.

Shipton, C. (2011). Taphonomy and behaviour at the Acheulean site of Kariandusi, Kenya. *African Archaeological Review*, *2*8, 141-155. (doi: 10.1007/s10437-011-9089-1)

Shipton, C. (2018). Biface Knapping Skill in the East African Acheulean: Progressive Trends and Random Walks. *African Archaeological Review*, 35,107–131., https://doi.org/10.1007/s10437-018-9287-1

Trauth, M.H., Mastin, M.A., Deino, A. & Strecker, M.R. (2005). Late Cenozoic moisture history of East Africa. *Science*, 309 (5743): 2051-2053.

Washbourn-Kamau, C.K. (1971). Late Quaternary Lakes in the Nakuru-Elmenteita Basin, Kenya. *The Geographical Journal*, 137, 522-535.

Williams, L.A.J. (1978). Character of Quaternary volcanism in the Gregory Rift Valley. In: Bishop, W.W.(Ed.), *Geological background to fossil man* (pp. 55-70). Edinburgh: Scottish Academic Press.

Wynn, T, & Tierson, F (1990). Regional comparison of the shapes of later Acheulean handaxes. *American Anthropologist*, 92, 73-84.

- Journal article
- Harris, M., Karper, E., Stacks, G., Hoffman, D., DeNiro, R., Cruz, P., et al. (2001). Writing labs and the Hollywood connection. *Journal of Film Writing, 44*(3), 213–245.
- Article by DOI

Slifka, M. K., Whitton, J. L. (2000) Clinical implications of dysregulated cytokine production. *Journal of Molecular Medicine,* doi:10.1007/s001090000086

- Book

Calfee, R. C., & Valencia, R. R. (1991). *APA guide to preparing manuscripts for journal publication.* Washington, DC: American Psychological Association.

- Book chapter

O'Neil, J. M., & Egan, J. (1992). Men's and women's gender role journeys: Metaphor for healing, transition, and transformation. In B. R. Wainrib (Ed.), *Gender issues across the life cycle* (pp. 107–123). New York: Springer.

Figures

1. Map: the setting of Kariandusi in the central rift valley, showing other early sites. The outline of the late Pleistocene megalake in the Nakuru-Elmenteita basin is indicated following Washbourn-Kamau (1971).

2. Section across the Kariandusi sites

3. Obsidian and lava handaxes from Kariandusi.

4.