

An Acheulian Site Near Bir Kiseiba in the Darb el Arba'in Desert, Egypt

C. Vance Haynes, Jr.

Departments of Anthropology and Geosciences, University of Arizona, Tucson, Arizona 85721

T.A. Maxwell

Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560

A. El Hawary

Egyptian Geological Survey and Mining Authority, 3 Salah Salem, Abbasiga, Cairo, Egypt

K.A. Nicoll

Department of Geosciences, University of Arizona, Tucson, Arizona 85721

S. Stokes

Research Laboratory for Archaeology and the History of Art, Oxford University, 6 Keble Road, Oxford OX1 3QR, United Kingdom

Corr?

A small concentration of Acheulian cleavers and handaxes within the driest region on Earth adds to the increasing evidence that the eastern Sahara was considerably more verdant during the Middle Pleistocene than it is today. The similarities to stone artifact assemblages of Acheulian sites in sub-Saharan Africa and in the Levant support the evidence for the movement of hominids, utilizing the Kombewa lithic technology, between Africa and the Middle East during the Middle Pleistocene. © 1997 John Wiley & Sons, Inc.

INTRODUCTION

The Darb el Arba'in Desert, very likely the driest region of our planet, occupies the hyperarid (less than 1 mm annual rainfall) core of the eastern Sahara (Haynes, 1982), the area west of the Nile Valley between Dakhla Oasis in Egypt and Wadi Howar in central Sudan (Figure 1). The uninhabited region is traversed by an ancient camel caravan route, the Darb el Arba'in or 40-day road, by which commerce moved between central Africa and the Nile Valley at Asyut from an unknown time in the distant past until the slave trade was brought to an end by the British in 1899 (Shaw, 1929). The few watering places that determined the route are miniature oases or bir where water can be had by excavating wells a meter or so deep into desert sand. These places are marked by sparse vegetation consisting usually of a few date or dom palms, tamarix trees, and clumps of coarse grass.

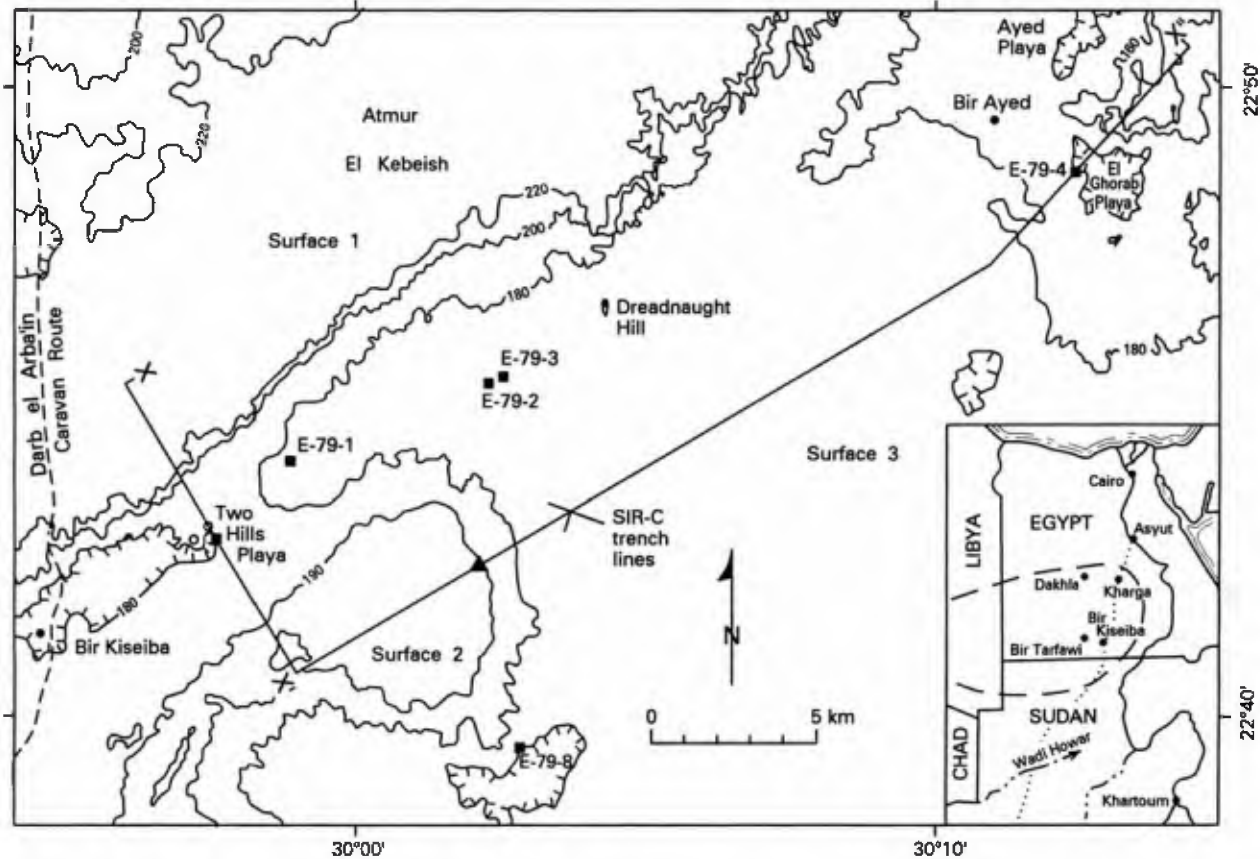


Figure 1. Map of the Bir Kiseiba region of the Darb el Arba'in Desert showing the Kiseiba Acheulian site no. 1 (▲) in relation to geomorphic surfaces 1, 2, and 3 and other archaeological sites (■). The line of cross section of Figure 2 is shown by x-x'-x''. Dashed line of the location map is the 1 m isohyet approximately outlining the Darb el Arba'in Desert, dotted line is the Darb el Arba'in caravan route.

Bir Kiseiba, a typical watering place on the ancient caravan route, lies at the base of a NE–SW trending escarpment about 40 m high (Figure 2) and made up of Cretaceous shale and sandstone of the Nubia Formation (Issawi, 1971) capped by alluvium with a relict calcic horizon of a truncated paleosol (Figure 2). Eastward the desert floor rises gently to a plateau that is about 20 m higher than the surrounding terrain and is topped by a sand sheet covering alluvial gravel containing a red paleosol with a discontinuous calcic horizon. In traversing this small plateau a few scattered clusters of Acheulian artifacts have been observed on the surface of the red alluvium that is partly covered by eolian sand sheet of Holocene age.

In February 1996, while investigating buried river channels revealed by the SIR-C Space Shuttle Imaging Radar (Figure 3) (Maxwell et al., n.d.), a cluster of Acheulian stone tools was discovered essentially in primary context at the north-eastern edge of the plateau (Figures 1 and 3). In preparation for more detailed geoarchaeological investigation, the artifacts were mapped and photographed *in situ*, and the basic stratigraphy was determined by excavating two small test pits, A and B, at the uphill and downhill ends of the cluster and by subsurface sampling of the sediment between the test pits using a 10 cm diameter hand auger (Figure 4). The artifacts are being left in place until an expedition can be organized to focus on the archaeology. What follows is a brief description of the site, the artifacts, and the geology along with a concluding remark on the potential significance of what we shall call the Kiseiba Acheulian site no. 1 (KAS-1).

SITE DESCRIPTION

Thirty exposed or partly exposed artifacts are concentrated in an area measuring 12 × 12 m and forming a very low ridge between two very shallow dry drainages at the edge of the plateau (Figure 5[a]). The artifacts appear to be randomly distributed in a yellow fluvial sand and without any predominant orientation (Figure 4). Most artifacts are lying flat, although two cleavers are tilted and one is standing on edge (Figure 5[b]). The clustered assemblage consists of 12 cleavers, 3 hand-axes, 1 pick, 1 chunk, 1 blade, and 10 flakes, all of orthoquartzite. Three other artifacts lay outside of the cluster. A handaxe of brownish red quartzite 38 m SW of the center of the cluster (control pin of Figure 4) is well sand blasted as are a brown quartzite subspheroid 32 m south and a dark red quartzite chunk 18 m to the west. The exposed surfaces of the artifacts show moderate to weak wind abrasion or sand blasting ranging from slight rounding or dulling of flake scars and edges (Fig. 5[c]) to pitting and undercutting of more resistant portions of the quartzite. Unexposed surfaces show moderate to weak abrasion, but a few undersides are quite fresh (Figure 5[d]). Therefore, the artifacts within the cluster do not appear to have been transported very far, if at all, by fluvial processes, wind abrasion being the main cause of wear. This may be further evaluated with archaeological excavations of the site and the finding of completely buried artifacts.

The undersides of several artifacts have coatings of a white powdery substance, presumably anhydrite derived by dehydration of gypsum. Anhydrite is, to various

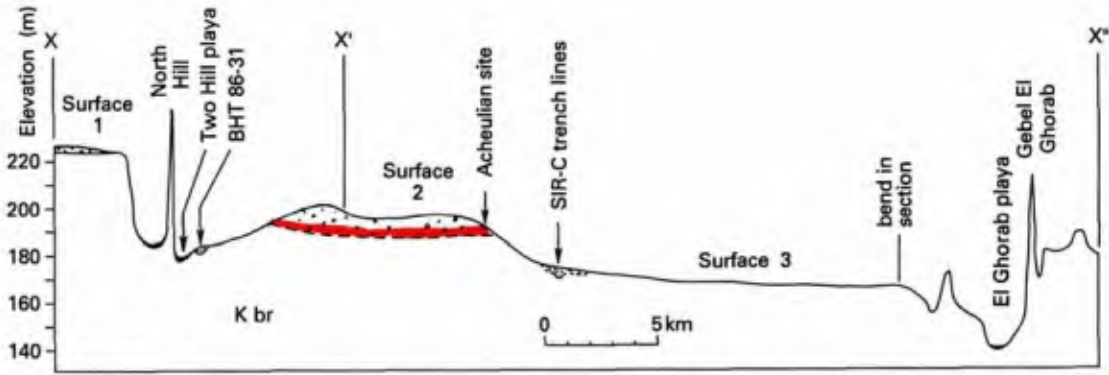


Figure 2. Geologic cross section x-x' of Figure 1 showing the Quaternary deposits of the region in relation to Cretaceous bedrock (Kbr) and geomorphic surfaces 1, 2, and 3. Thickened black lines in depressions are Holocene playa muds.

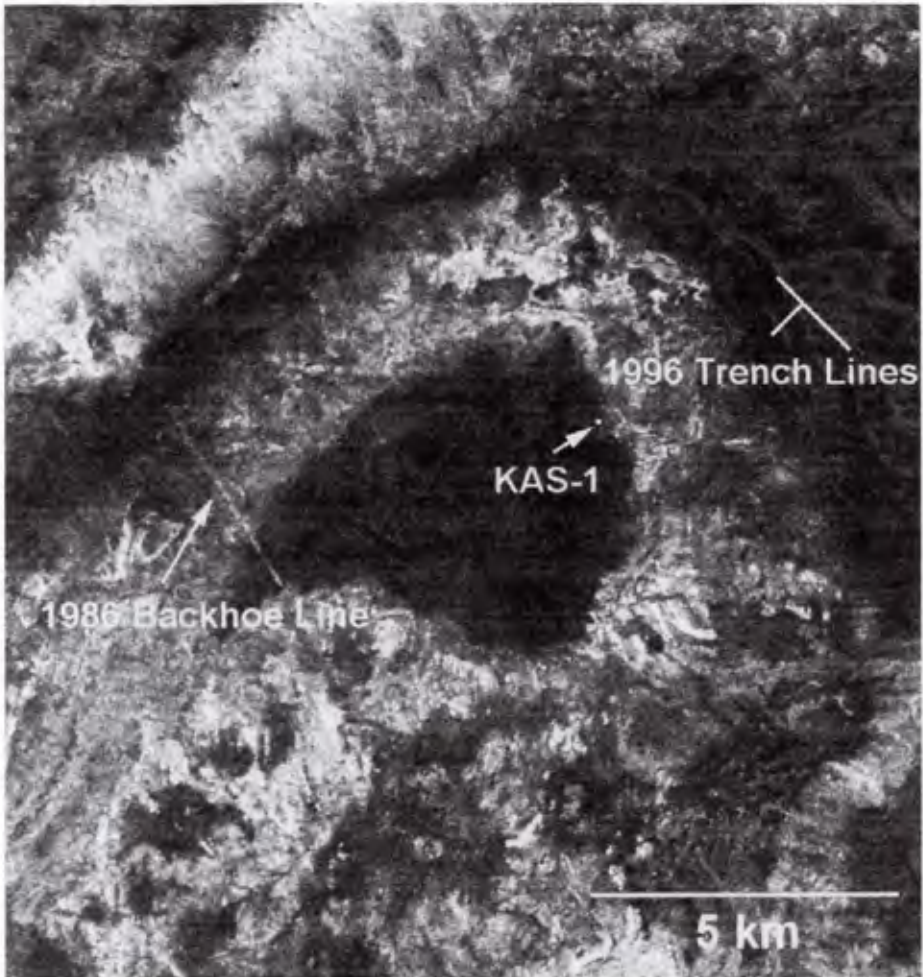


Figure 3. SIR-C Shuttle Imaging Radar, L-band (24 cm) wavelength, image of the Kiseiba Acheulian site no. 1 (KAS-1) region showing the 1986 backhoe trench line and the 1996 trench lines. Surface no. 1 is the mottled gray area in the upper left (NW) corner, surface no. 2 is the mottled dark gray area between the two trench lines, and surface no. 3 is the dark gray area between the bedrock scarps (white to light areas) between surfaces 1 and 2 and wrapping around the north and northeastern sides of surface no. 2. Buried drainages revealed by SIR-C are the gray dendritic patterns of surface no. 3 at and near the 1996 trench lines.

degrees, nearly ubiquitous in paleosols of this region (Prestel et al., 1979; Haynes, 1985). In some cases the coating separates from the artifact upon lifting and remains on the mould left in the sand matrix (Figure 5[d]). The undersides of a few artifacts have a red stain (Figure 5[d]), presumably a hydrated oxide of iron that is typical of some desert rock varnishes. These secondary deposits appear to have

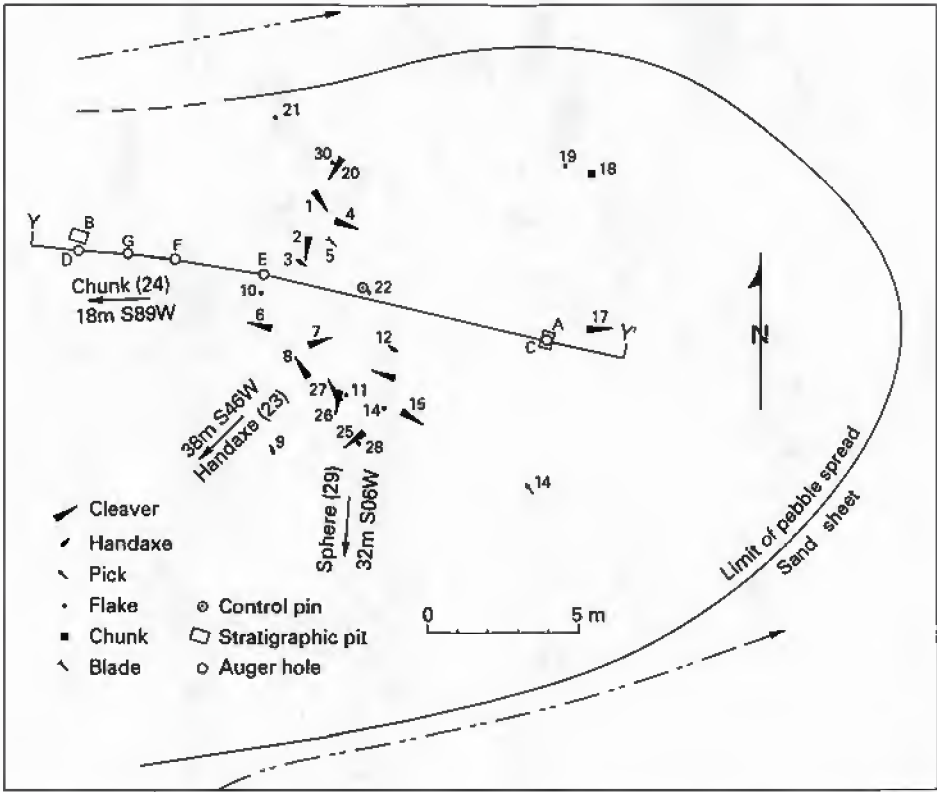


Figure 4. Distribution map of Kiseiba Acheulian site no. 1 showing artifacts exposed on a pebble spread over a very low-profile topographic nose between two inactive drainage swales. Profile of Figure 5 shown by line y-y'.

been a result of the several episodes of pedogenesis that the sedimentary matrix has undergone over several hundred thousand years.

THE ARTIFACTS

Of the 30 artifacts making up the assemblage, cleavers predominate, representing 41% and averaging $17 \times 11 \times 3$ cm in size. Miscellaneous flakes represent 33% and handaxes, averaging $18 \times 11 \times 3$ cm, 13%. Many of the cleavers and handaxes were made by the Kombewa technique on large flakes having two ventral surfaces (Owen, 1938). Bifacial artifacts displaying this technique are characteristic of some Acheulian sites of the East African rift valleys, the horn of Africa, and the Ahmar Mountains of the NW Sahara (Clark, 1975).

The bifaces are in an unrefined state of reduction suggesting that the assemblage is not far from the source of the quartzite from which they are made. The nearest

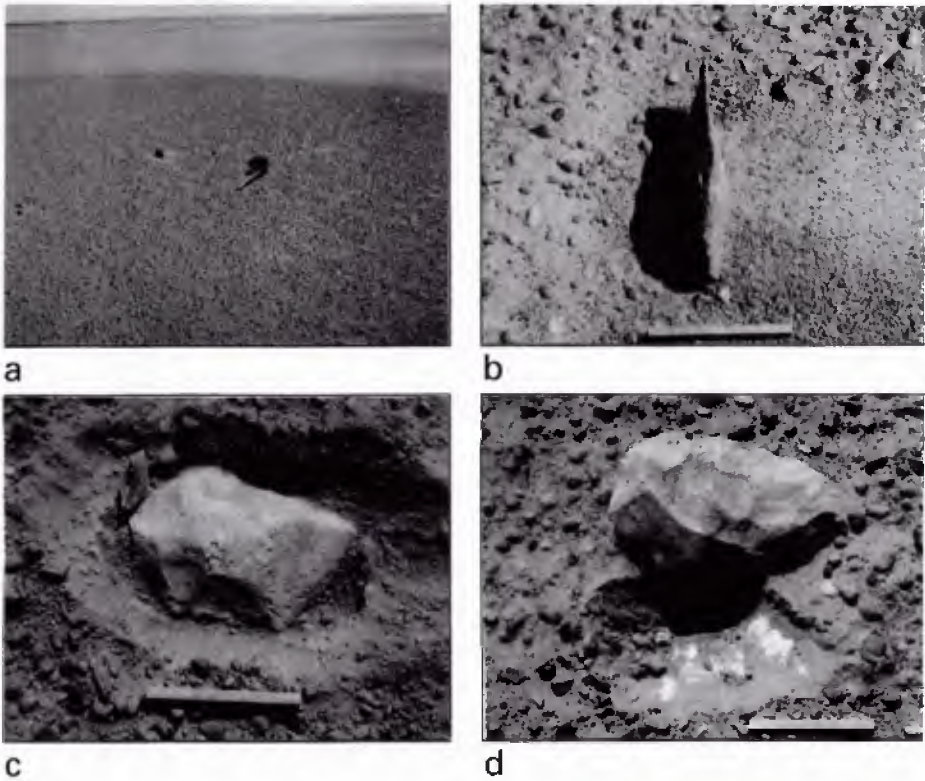


Figure 5. Photographs of Kiseiba Acheulian site no. 1 (a) Eastward view showing quartzite artifacts exposed through a pebble spread over a topographic nose and covering yellow fluvial sands. Cleaver 4 shown standing on edge in center, cleaver 20 and flake 30 in lower left, cleaver 17 top left, cleaver 25 and flake 28 on far right. Vehicle in left background is on surface 3 where trenches expose buried sand-filled channels. (b) Cleaver 4 exposed on edge (10 cm scale). (c) Cleaver 13 exposed in pedogenically reddened fluvial sand covered by pebble spread. The flake appears to refit the adjacent scar. (d) Bottom side of handaxe 12 on a Kombewa flake showing pedogenic reddening. Coating of white anhydrite remains in the impression.

quartzite outcrop to our knowledge is a ridge of dark brown ferruginous, manganiferous quartzite 2.5 km NW of the site, but none of the artifacts appear to be made from this material. Another possible source is in an area of quartzite yardangs approximately 15 km SSE; however, no quarry sites were observed in this area, which may not have been exposed at the time of the Acheulian occupation, that is, the yardangs may be due to post-surface 2–3 deflation. Prominent quartzite ridges occur along the buried drainage of Wadi Arid about 170 km to the WSW (McCauley et al., 1982; McCauley et al., 1986). There is no source of quartzite boulders in the area. A more systematic search will be necessary to better assess the lithic source area.

If the site represents a campsite more waste flakes might be expected. On the

other hand, Kleindienst (1961) has pointed out that debitage is not always found among assemblages of large tools. At Bir Sahara Acheulian sites BS-14, WNW of KAS-1 about 130 km, Hill (1992) attributed the near absence of small debitage in the surface collection of mostly handaxes to deflation because debitage was found below the surface. Another explanation for the near absence of debitage might be that the assemblage represents a cache of forms to be further refined elsewhere. This would also account for the small size of the assemblage. If the cache was originally in a pit or pile, the dispersal could be explained as typical of deflation of sand containing a cluster of much coarser particles. Bagnold (1941:158) observed that the individual particles fall away from a tight cluster as they are undercut. Over time the cluster is broken up and dispersed. The dispersed cluster, as a part of the gravel lag, would inhibit the rate of deflation which may explain the preservation of the site as a rounded topographic nose isolated by two shallow drainages at the edge of the plateau (Figures 4 and 5[a]).

STRATIGRAPHY

Most of the surface 2 plateau is underlain by a red sand and sandy pebble alluvium several meters thick in most places (Figure 2) and informally named the Kiseiba alloformation (af) (North American Commission on Stratigraphic Nomenclature, 1983). This is very likely a remnant of an ancient river bed that has been topographically inverted by erosion of less resistant deposits bordering the ancient river or wadi. Inverted wadis are a common geomorphic feature of the eastern Sahara (Giegengack, 1968; Haynes, 1982, 1985).

A soil test pit placed in the Kiseiba af in 1980 about 5 km to the southwest of the Acheulian site as well as backhoe trenching along a transect extending south-eastward from Two Hills (Figure 3) in 1986 revealed at least 2 m of firm to hard, yellowish red (5YR 5/6) sandy gravel with a discontinuous stage III calcic horizon (Machette, 1985). The lack of sedimentary structure indicates bioturbation during pedogenesis. Bedrock sandstone was reached only at the edges of the plateau. No artifacts have been observed within the Kiseiba af. They only occur on its eroded surface or adjacent to it as at KAS-1.

Here the artifact cluster occurs in a reddish yellow (7.5YR 6/6) fine to medium grained alluvial sand inset against gravel of the Kiseiba af (Figure 6). The sand occupies only a small remnant of what must have been a large stream system before erosional lowering of the landscape to the level of surface 3 (Figure 2). The massive sand is firm to hard and friable due to cementation by calcium carbonate (stage II of Machette, 1985) and a small percentage of clay, both likely the products of pedogenesis. Westward the upper 10 cm is pedogenically reddened. Eastward it is truncated by a 2-cm-thick vesicular horizon under the pebble spread. Sandy irregular nodules of CaCO_3 are dispersed throughout at least the upper meter of sand. Only a small percentage of the sand (<3%) is coarser than 1 mm, and many of these grains are well rounded to subrounded whereas the majority of the sand finer than 1 mm is angular to subangular with a normal size distribution for fluvial sand. The rounded coarser fraction is characteristic of that of eolian sand sheets which typ-

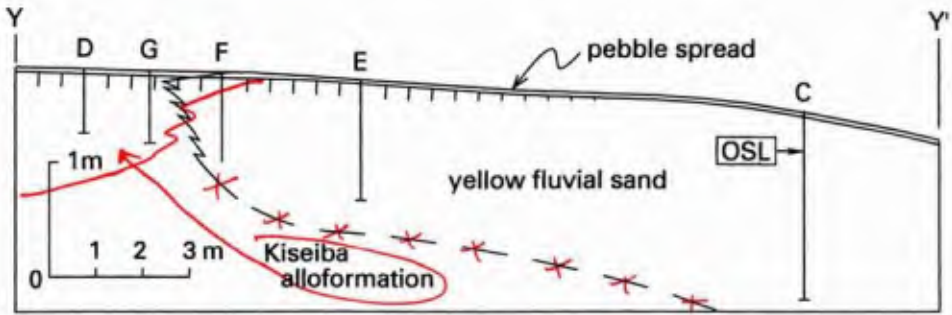


Figure 6. Geologic cross section (y-y' of Figure 4) showing yellow fluvial sand matrix of the artifacts inset against red sandy gravel alluvium of the Kiseiba alloformation. Zone of post yellow sand pedogenic reddening shown by short vertical lines below the pebble spread. Auger holes shown by vertical lines, C,D,E,F, and G with location of optically stimulated luminescence sample shown by OSL.

ically have a bimodal size distribution. These coarser grains are very likely reworked from ancient eolian sand sheets as well as brought down by biturbation from the active sand sheet and pebble spread on the modern surface (Figure 5).

The sand sheet of surface 3, over 20 m below the Acheulian site, is underlain by white fluvial sand with gravel lenses confined to channels (Figure 3) recently revealed by SIR-C (Maxwell et al., n.d.) Sand blasted artifacts on this alluvium are typical of the Middle Paleolithic. We correlate this unit with a similar deposit about 5 km to the northwest where Wendorf and Schild (1984) found rounded Middle Paleolithic artifacts in a white alluvial sand (Figure 1, site E-79-1). The white alluvial sand was also exposed by our backhoe trench 86-31 near Two Hills in 1986 (Figure 2). Two samples from the white sand in this trench have provided preliminary OSL (optically stimulated luminescence) ages of 88 ± 48 kybp and 117 ± 32 kybp in inverted stratigraphic order. Considering the large statistical errors, the inversion may be more apparent than real. The results are in reasonable agreement with the age of other Middle Pleistocene sites in the region (Wendorf et al., 1993).

Holocene playa deposits with Neolithic archaeology occupy depressions inset into the Pleistocene and older deposits. The important Neolithic site at El Ghorab playa (Wendorf and Schild, 1984) lies 21 km WNW of KAS-1 and one at El Adam playa lies 6 km to the SSE (Figure 1 sites E-79-4 and E-79-8, respectively).

The Kiseiba area reveals a geochronological sequence of Pleistocene river deposits in the form of topographically inverted surfaces armored by alluvial gravels. The highest, and therefore oldest, surface (no. 1) is the Atmur El Kebeish (Plain of the Sheep), which the Darb el Arba'in traverses en route to Kharga Oasis over 200 km to the north. Modern caravans bringing 'atrun (trona) from Sudan still follow the route after ascending the escarpment at Bir Kiseiba. Pleistocene alluvium underlying the sand sheet of surface 1 appears to be without any evidence of either hominid remains or artifacts. The next younger surface, no. 2, overlies the Kiseiba af, without artifacts, as far as we can tell. However, the KAS-1 Acheulian site is in

fluvial sediments that may have formed a surface (surface 2-3) intermediate to surfaces 2 and 3 and since removed by erosion. This would account for most of the Acheulian artifacts of the Kiseiba area being found on the surface as part of the lag deposits. Our estimated Middle Pleistocene age for KAS-1, based upon the ages of similar artifacts elsewhere (Bar-Yosef, 1975), may be further refined by OSL age determination currently in process (Figure 6, OSL sample).

Surface 3 contains Middle Paleolithic artifacts as part of a pebble lag but also overlies white fluvial sands that contained Middle Paleolithic artifacts at site E-79-1 (Figure 1). OSL samples from the white sand in buried channels revealed by SIR-C are being analyzed (Maxwell et al., n.d.). Holocene playa deposits occupy several subbasins in the region and are associated with Neolithic archaeology ranging in age from 9800 B.P. to 4600 B.P. (Wendorf and Schild, 1984).

GEOCHRONOLOGY

The prevailing hypothesis is that in the eastern Sahara the climatically wet periods (pluvials) occurred when the climate of Europe was interglacial, whereas the hyperarid periods occurred when glaciation prevailed in Europe (Lézine and Casanova, 1991). The hypothesis is supported by the absence of upper Paleolithic sites in the eastern Sahara during the last glacial of Europe (Wendorf and Schild, 1980; Wendorf et al., 1993). During the hyperarid periods, eolian processes differentially lowered the landscape and inverted the topography. In this way gravel stream beds, representing the lowest parts of the landscape, became elevated features protected from deflation by gravel spreads and sand sheets that armored the surface while adjacent depressions were being lowered (Haynes, 1985). Therefore, in the Bir Kiseiba region the gravel spreads of inverted river beds (surfaces 1, 2, 2-3, and 3) may correlate with interglacial periods of the northern hemisphere while the intervening hyperarid periods of deflation and intense wind erosion that occurred between the fluvial episodes may correlate with glacial periods. Using these premises, very approximate age estimates can be proposed by correlation to the marine oxygen isotope record of glaciation (Shackleton, 1975; Martinson et al., 1987).

The white fluvial sand under surface 3 with Middle Paleolithic archaeology is probably the same approximate age as the lacustrine deposits of the Bir Tarfawi region with Middle Paleolithic archaeology (Wendorf et al., 1993) and units C₄ and C₅ of Wadi Arid (Haynes et al., 1993). The Middle Paleolithic occupation of the Tarfawi region is thought to have occurred during the last two interglacials or isotope stages 5 and 7 (Wendorf et al., 1994). If this estimate is correct, surface 3 would have formed during the subsequent hyperarid phases corresponding to the last two glacial periods in Europe, that is, oxygen isotope stages 4 and 2, and culminating with the deepening, perhaps during the Younger Dryas (Haynes, 1997), of depressions that hold the playa deposits of the Holocene with Neolithic archaeology.

As mentioned earlier, the Acheulian artifacts of the KAS-1 occur in a remnant

fluvial yellow sand that represents a pluvial period after surface 2 was formed but before surface 3 was attained. The much stronger pedogenic development in the Kiseiba af compared to the relatively weak paleosol in the KAS yellow sand indicates that a significant hiatus occurs between them, a hiatus that probably included a period of hyperaridity. If the finer grain size and smaller areal extent of the yellow sand compared to the Kiseiba af is an indication of relative intensity of the respective pluvials, that of the Kiseiba af was considerably more intense than that of the yellow sand. Therefore, correlation of the yellow sand to the interstadial within stage 9 (~300–350 ka) and the Kiseiba af to stage 11 (~370–440 ka) is a possibility. However, the Acheulian artifacts of KAS-1 could be older than Late Acheulian on the basis of the lithic technology represented by the artifact assemblage. In this case correlation of the yellow sand with stage 11 (~370–440 ka) and the Kiseiba af to stage 13 (~470–500 ka) may be a more accurate assessment. On the other hand, as emphasized by Clark (1975), lithic technology within the Lower Paleolithic is an unreliable means of sequentially ordering assemblages. If the apparently unrefined stage of the KAS-1 bifaces truly does not represent the final stage of lithic reduction they could perhaps be of Late Acheulian age.

Uranium-series dating of phreatogenic carbonate deposits in buried river valleys revealed by SIR-A (Szabo et al., 1989) indicated that fluvial episodes occurred in Wadi Arid at or slightly before >300, 212, 141, and 45 ka. Acheulian archaeology is associated with the three oldest episodes (McHugh et al., 1988). Another set of U-series ages was determined for various lacustrine carbonate remnants scattered over the Darb el Arba'in Desert (Szabo et al., 1995). These indicated pluvial periods 320–250, 240–190, 155–120, 90–65, and 10–5 ka. The first three periods are concordant with those of the phreatogenic wadi carbonates. The period from 65 ka to 250 ka probably includes all of the Middle Paleolithic prehistory of the Bir Tarfawi region as well as the Kiseiba white sand and probably includes all of stage 7. If the next order pluvial period is that represented by the KAS-1 yellow sand, an age between 300 ka and 350 ka (stage 9) is a possibility. The Kiseiba af would fall between 370 ka and 440 ka (stage 11) if it represents the next older pluvial episode. This age would still be well within the Lower Paleolithic yet no artifacts have been found in the Kiseiba af nor in similar red alluvial deposits (unit A₂) of Wadi Arid or Wadi Mokhtafi in northern Sudan (Haynes et al., 1993). The Kiseiba af could be considerably older than stage 11 because other paleoclimatic episodes could be missing from the simple sequence presented here.

From these very tenuous age estimates and correlations as well as the abundant but conflicting age dates obtained by different age dating techniques in the Bir Tarfawi area (Wendorf et al., 1994), it is apparent that more precise age dating is needed to resolve the chronology dilemma.

CONCLUSION

The most significant Acheulian sites of the region are the Late Acheulian sites of the Bir Tarfawi area 130 km to the west (Wendorf and Schild, 1980; Wendorf et al.,

1993) and those associated with the buried rivers revealed by Shuttle Imaging Radar (SIR-A&B) (McHugh et al., 1988) 170 km WSW. The Kombewa technology is poorly represented in these assemblages and cleavers are rare, most bifaces being hand-axes. Furthermore, cleavers are rare in the sparse surface scatters of Acheulian artifacts of the region.

Cleavers made by the Kombewa technique are a significant part of assemblages in Middle-Pleistocene-age Bed IV at Olduvai Gorge (Leakey, 1975), 2800 km to the south and at the Middle Pleistocene site of Geshen Benot Ya'aqov in the Dead Sea Rift of the Levant (Goren-Inbar and Saragusti, 1996), 1220 km to the NE. The age dating of KAS-1 is at present too tenuous to define direction of movement. However, keeping in mind the limitations presented by Clark (1975), the Kiseiba Acheulian site no. 1 provides new evidence in support of the movement of one of probably several Early Paleolithic traditions between Africa and the Middle East during the Middle Pleistocene (Bar-Yosef, 1975; Goren-Inbar and Saragusti, 1996) under climatic conditions in the Darb el Arba'in desert at least 2 orders of magnitude wetter than today (Wendorf et al., 1993).

This research is supported by NASA Grant NAGW 30711 to T.A. Maxwell and the Regents Professors fund of the University of Arizona to C.V. Haynes, Jr. Suggestions for improvement of this manuscript were provided by J. Desmond Clark, Christopher L. Hill, Arthur J. Jelinek, Steven Kuhn, John W. Olsen, Mary Stiner, and Fred Wendorf. Expert word processing was performed by Ellen Stamp, Department of Anthropology, University of Arizona.

REFERENCES

- Bagnold, R.A. (1941). *The Physics of Blown Sand and Desert Dunes*. London: Methuen, reprinted 1954.
- Bar-Yosef, O. (1975). Archaeological Occurrences in the Middle Pleistocene of Israel. In K.W. Butzer and G.L. Isaac, Eds., *After the Australopithecines: Stratigraphy, Ecology and Culture Change in the Middle Pleistocene*, pp. 571-604, The Hague: Mouton.
- Clark, J.D. (1975). A Comparison of the Late Acheulian Industries of Africa and the Middle East. In K.W. Butzer and G.L. Isaac, Eds., *After the Australopithecines: Stratigraphy, Ecology and Culture Change in the Middle Pleistocene*, pp. 605-659, The Hague: Mouton.
- Giegengack, R.F. (1968). Pleistocene History of the Nile Valley in Egyptian Nubia. Ph.D. Thesis, Yale University, New Haven.
- Goren-Inbar, N., and Saragusti, I. (1996). An Acheulian Biface Assemblage from Geshen Benot Ya'aqov, Israel: Indications of African Affinities. *Journal of Field Archaeology* **23**, 15-30.
- Haynes, C.V. (1982). The Darb El-Arba'in Desert: A Product of Quaternary Climatic Change. In F. El-Baz and T.A. Maxwell, Eds., *Desert Landforms of Southwest Egypt: A Basis for Comparison with Mars*, pp. 91-117. Contract Report CR-3611. Greenbelt, Maryland: NASA.
- Haynes, C.V., Jr. (1985). Quaternary Studies, Western Desert, Egypt and Sudan—1979-1983 Field Seasons. *National Geographic Research Reports* **19**, 269-341.
- Haynes, C.V., Jr. (1997). Geoarchaeological Manifestations of Younger Dryas and Later Climate Change in the Darb el Arba'in Desert, Eastern Sahara. 11-22 January. Siwa Oasis, Egypt: Paleomonsoons Project Workshop.
- Haynes, C.V., Jr., Maxwell, T.A., and Johnson, D.L. (1993). Stratigraphy, Geochronology, and Origin of

- the Selima Sand Sheet, Eastern Sahara, Egypt and Sudan. In U. Thorweih and H. Schandel Meier, Eds., *Geoscientific Research in Northeast Africa*, pp. 621–626. Rotterdam: Balkema.
- Hill, C.L. (1992). Archaeological and Pleistocene Geology of Acheulian and Middle Paleolithic sites in the Bir Tarfawi Region of the Southern Egyptian Sahara. Ph.D. Thesis, Southern Methodist University, Dallas.
- Isaawi, B. (1971). Geology of Darb el Arba'in, Western Desert, Egypt. *Annals of the Geological Survey of Egypt* **1**, 53–92.
- Kleindienst, M.R. (1961). Variability within the Late Acheulian Assemblage in Eastern Africa. *South African Archaeological Bulletin* **16**, 35–52.
- Leakey, M.D. (1975). Cultural Patterns in the Olduvai Sequence. In K.W. Butzer and G.L. Isaac, Eds., *After the Australopithecines: Stratigraphy, Ecology, and Culture Changes in the Middle Pleistocene*, pp. 477–493, The Hague: Mouton.
- Lézine, A.-M., and Casanova, J. (1991). Correlated Oceanic and Continental Records Demonstrate Past Climate and Hydrology of North Africa (0-140ka). *Geology* **19**, 307–310.
- Machette, M.N. (1985). Calcic Soils of the Southwestern United States. In D.L. Weide, Ed., *Soils and Quaternary Geology of the Southwestern United States*, pp. 1–21. Special Paper 203. Geological Society of America, Boulder, CO.
- Martinson, D.G., Pisias, N.G., Hays, J.D., Imbrie, J., Moore, T.C., and Shackleton, N.J. (1987). Age Dating and the Orbital Theory of the Ice Ages: Development of a High Resolution 0 to 300,000-Year Chronostratigraphy. *Quaternary Research* **27**, 1–29.
- Maxwell, T.A., et al. (n.d.), Manuscript in preparation.
- McCauley, J.F., Schaber, G.G., Breed, C.S., Grolrier, M.J., Haynes, C.V., Issawi, B., Elachi, C., and Blom, R. (1982). Subsurface Valleys and Geoarchaeology of the Eastern Sahara Revealed by Shuttle Radar. *Science* **218**, 1004–1020.
- McCauley, J.F., Breed, C.S., Schaber, G.G., McHugh, W.P., Issawi, B., Haynes, C.V., Grolrier, M.J., and El Kilani, A. (1986). Paleodrainages of the Eastern Sahara—The Radar Rivers Revisited (SIR-A/B Implications for the Mid-Tertiary Trans-African Drainage System). *IEEE Transactions on Geoscience and Remote Sensing* **GE-24**, 624–648.
- McHugh, W.P., McCauley, J.F., Haynes, C.V., Breed, C.S., and Schaber, G.G. (1988). Paleorivers and Geoarchaeology in the Southern Egyptian Sahara. *Geoarchaeology* **3**, 1–40.
- North American Commission on Stratigraphic Nomenclature (1983). North American Stratigraphic Code. *American Association of Petroleum Geologists Bulletin* **6**, 865–867.
- Owen, W.E. (1938). The Kombewa Culture, Kenya Colony. *Man* **38**, 203–205.
- Prestel, D.J., McKay, D.S., and Haynes, C.V., Jr. (1979). Mineralogy of Caliche-Like Salt Crusts from the Western Desert, Egypt: Implications for Martian Duricrust Formation. In *Reports of Planetary Geology Program, 1978–1979*, pp. 200–202. Abstract. Technical Memorandum 80339. Washington, D.C.: NASA.
- Shackleton, N.J. (1975). The Stratigraphic Record of Deep-Sea Cores and Its Implications for the Assessment of Glacials, Interglacials, Stadials, and Interstadials in the Mid-Pleistocene. In K.W. Butzer and G.L. Isaac, Eds., *After the Australopithecines*, pp. 1–24. The Hague and Paris: Mouton.
- Shaw, W.B.K. (1929). Darb el Arba'in: The Forty Days Road. *Sudan Notes and Records* **12**, 63–71.
- Szabo, B.J., McHugh, W.P., Schaber, G.G., Haynes, C.V., and Breed, C.S. (1989). Uranium-Series Dated Authigenic Carbonates and Acheulian Sites in Southern Egypt. *Science* **243**, 1053–1056.
- Szabo, B.J., Haynes, C.V., Jr., and Maxwell, T.A. (1995). Ages of Quaternary Pluvial Episodes Determined by Uranium-Series and Radiocarbon Dating of Lacustrine Deposits of Eastern Sahara. *Palaeogeography, Palaeoclimatology, Palaeoecology* **113**, 227–242.
- Wendorf, F., and Schild R. (1980). *Prehistory of the Eastern Sahara*. New York: Academic Press.
- Wendorf, F., and Schild, R. (1984). Introduction. In A.E. Close, Ed., *Cattle-Keeper's of the Eastern Sahara: The Neolithic of Bir Kiseiba*, pp. 1–8. Dallas, Texas: Southern Methodist University.
- Wendorf, F., Schild, R., Close, A.E., and associates (1993). *Egypt During the Last Interglacial: The Middle Paleolithic of Bir Tarfawi and Bir Sahara East*. New York: Plenum.
- Wendorf, F., Schild, R., Close, A.E., Schwarz, H.P., Miller, G.H., Grün, R., Bluszcz, Stokes, S., Morawsha,

L., Huxtable, J., Lundberg, J., Hill, C.S., and McKinney, C. (1994). A Chronology for the Middle and Late Pleistocene Wet Episodes in the Eastern Sahara. In O. Bar-Yosef and R.S. Kra, Eds., *Late Quaternary Chronology and Paleoclimates of the Eastern Mediterranean*. Tucson: University of Arizona. Published by *Radiocarbon*.

Received April 8, 1997

Accepted for publication April 30, 1997