Abstract

Spring-deposited carbonate rocks, or tufas, exposed along the flanks of the Libyan Plateau near Kharga Oasis, Western Desert, Egypt, can provide a directly datable stratigraphic context for Middle Stone Age/Middle Paleolithic (MSA/MP) archaeological material, if such material can be found in situ within tufa strata. Two such localities (Mata’na Site G and Bulaq Wadi 3 Locus 1) described by Caton-Thompson were revisited and sampled for uranium-series analysis. At Mata’na Site G (KH/MT-02), Middle Stone Age (‘‘Upper Levalloisian’’) material is underlain by tufa with a uranium-series age of $127.9 \pm 1.3$ ka, and overlain by tufa with an age of $103 \pm 14$ ka. At Bulaq Wadi 3 Locus 1, a uranium-series age of $114.4 \pm 4.2$ ka on tufa capping a small collection of Middle Stone Age artifacts also provides a minimum age constraint on that material. Tufa underlying an MSA workshop (KH/MD-10) indicates that this assemblage, characterized by use of several Levallois reduction methods, was deposited after $\sim 124$ ka. Furthermore, uranium-series ages averaging $\sim 133$ ka on a Wadi Midauwara tufa (WME-10) without associated archaeological material suggest that one period of spring flow in the region began during the Marine Isotope Stage 6/e transition, prior to the warmest portion of the last interglacial period. The dated archaeological material suggests that the distinction that has been identified between Nubian and non-Nubian complexes in the Nile Valley may hold for the Western Desert, although local complexity has yet to be fully described.

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Keywords: Uranium-series geochronology; North Africa; Climate change; Marine Isotope Stage 6/e; Middle Stone Age

Introduction

Cultural variability and change in the North African Middle Stone Age/Middle Paleolithic (MSA/MP) have the potential to enhance our understanding of the Pleistocene human dispersal out of Africa and the nature of the emergence of modern human behavior (McBrearty and Brooks, 2000). While the occupation of arid northern Africa during the MSA/MP has long been known (e.g., Clark, 1967), a lack of chronometric determinations associated with archaeological materials, combined with application of different analytical systems, has hindered comparison between localities and regions. Van Peer and Vermeersch (1990; Van Peer 1998) present one of the only general frameworks for classification of the MSA/MP archaeological complexes of the Nile Valley, Eastern Desert, and Eastern Sahara:

In general terms … a distinction can be made between assemblages with bifaces, bifacial foliates, thick “Nubian” scrapers, and the special Levallois point production
methods labeled Nubian 1 and Nubian 2 (Guichard and Guichard 1965, 1968), and assemblages that lack any of these types. The former have been grouped as Nubian Middle Palaeolithic or Nubian Stone Age and the latter as non-Nubian Middle Palaeolithic (Van Peer, 1998: S118).

The first assemblage is also referred to as the “Nubian Complex” (Van Peer, 1998: S120), and the second as the “Lower Nile Valley Complex.” Technologically, the latter group is marked by use of “classical” Levallois reduction and a lack of production of points by any method (Van Peer, 1998).

Van Peer (1998) argued that the Nubian complexes may represent a group of migrant populations from the south, whose adaptation included hunting.

This framework, although it greatly simplifies the complex MSA/MP record of northeastern Africa, also provides a starting point for consideration of new dates for archaeological assemblages from the eastern Sahara. Van Peer (1998) argued, based on evidence from Bir Sahara and Bir Tarfawi, that both complexes are present in the Western Desert. Both the Aterian, which dates to ca. 60 ka and later (Cremaschi et al., 1998), and the earlier MSA with foliates may be considered part of the Nubian Complex (Van Peer, 1998: S118; Wendorf et al., 1993a). Non-Nubian sites include those that apparently lack evidence of Nubian cores, foliates, or other markers of the Nubian Complex [Van Peer, 1998; but a small number of Levallois points are reported for several of these sites (Wendorf et al., 1993a)]. At Bir Sahara and Bir Tarfawi, the Nubian Complex possibly replaced the Nile Valley Complex after a hyperarid period between approximately 155 ka and 135 ka (Van Peer, 1998; for other views of the Nubian Complex, see Garcea, 1998; Schild, 1998; Kleindienst, 2003, 2005).

These assertions by Van Peer lead to several questions. First, does this broad classification of the MSA apply elsewhere in the Western Desert? If so, do the ages of sites containing Nubian and non-Nubian complex artifacts correlate with those from Bir Sahara and Bir Tarfawi? Kleindienst (1999: 104) stated that her “null hypothesis” was that Dakhleh Oasis was habitable for at least the last 300,000 years, and possibly longer. If oases such as Dakhleh and Kharga provided stable sources of water from artesian springs, we might expect that the apparent replacement of one complex by another seen at Bir Tarfawi and Bir Sahara East would not be evident in these locations. Instead, one might hypothesize either a gradual change in the cultural material produced by more stable populations, and/or cultural complexity related to interactions between a migrant group or groups and resident groups.

**Background**

We present here new uranium-series ages, environmental data, and technological descriptions of lithic assemblages from a series of localities on the Kharga Escarpment in the Western Desert. The locations under discussion were investigated in 2001 as part of an ongoing larger investigation by the Kharga Oasis Prehistory Project (Hawkins et al., 2001; Kleindienst et al., in press). Caton-Thompson and Gardner (1932; Gardner, 1932, 1935; Gardner and Caton-Thompson, 1933; Caton-Thompson, 1935, 1952) originally discovered several of these localities in the course of their work in Kharga Oasis in the 1930s. The framework of Stone Age development for Kharga Oasis that Caton-Thompson and Gardner presented is based in large part on the numerous escarpment localities they discovered. We are now able to place some age constraints on the archaeological materials from several of these localities and to offer technological descriptions of material for comparison with archaeological material from the Nile Valley. Furthermore, we present a different view of the depositional events that led to the formation of several of these localities, one that calls into question some, but certainly not all, of the archaeological units proposed by Caton-Thompson.

The habitability of North Africa has varied substantially during the Quaternary as regional climate oscillated between the arid regime that is characteristic of the present and substantially wetter conditions (e.g., Caton-Thompson, 1952; Wendorf and Schild, 1980; Churcher and Mills, 1999). These climatic fluctuations are recorded outside northern Africa by variations in the influxes of terrestrial dust to marine basins (e.g., Moreno et al., 2001; Abrantes, 2003) and freshwater to the Mediterranean Basin (e.g., Rossignol-Strick, 1983; Calvert and Fontugne, 2001), among other paleoclimatic archives. Within the Sahara, lacustrine, paludal, fluvial, and spring-deposited sediments are the primary indicators of increased amounts of surface water relative to the present (e.g., McCauley et al., 1982; Churcher et al., 1999; Hoelzmann et al., 2000; Smith et al., 2004a; Kleindienst et al., 2004; Churcher and Kleindienst, in press). The principal mechanism for the “greening” of the southern Sahara is generally thought to be an insolation-driven, northward movement of the African (Atlantic) monsoon, based on global-circulation models (GCMs), direct dates on sediments indicative of humid climates, and the isotopic composition of Saharan groundwaters (e.g., Sonntag et al., 1979; Claussen and Gayler, 1997; Kröpelin and Petit-Maire, 2000; Larrasoaina et al., 2003; Sturchio et al., 2004). Climate proxies internal and external to the Sahara and GCMs indicate that Marine Isotope Stage (MIS) 5e was a particularly humid time for the region (e.g., Prell and Kutzbach, 1987; Kallel et al., 2000; Mandel and Simmons, 2001), though direct dates on spring and lacustrine sediments (e.g., Szabo et al., 1989; Causse et al., 1989; Schwarcz and Morawska, 1993; Szabo et al., 1995; Zouari et al., 1998) suggest that groundwater discharge may have increased in northern Africa prior to the peak of the last interglacial period due to recharge along the southern margin of the Sahara during early phases of monsoon intensification (Petit-Maire et al., 1991).

In central Egypt, springs along the edge of the Libyan Plateau became active during MIS 6 and 5e, resulting in the deposition of spring carbonate rocks (tufas) at many locations along the escarpment itself, as well as in the adjacent lowlands (Fig. 1; Crombie et al., 1997; Sultan et al., 1997; Hamdan, 2000; Smith et al., 2004a; Kleindienst et al., in press). The sedimentology of the tufas indicates that, during humid phases, waterfalls, marshes, small ponds, and streams were...
common elements in the landscapes surrounding active springs (Crombie et al., 1997; Nicoll et al., 1999; Smith et al., 2004a), though the tufa stable-isotope geochemistry suggests that regional soils were neither particularly thick nor biologically productive (Smith et al., 2004b). Plant casts in tufas from Kharga record the presence of fig trees (*Ficus ingens*, *Ficus salicifolia*, and *Ficus sycomorus*), reeds (*Arundo* sp.), ferns (*Pteris vittata*), African hackberry (*Celtis integrifolia*), and an unidentified palm in areas of spring activity (Caton-Thompson, 1952). In southern Egypt, lacustrine environments prevailed at Bir Tarfawi and Bir Sahara during MIS 5 (Wendorf et al., 1993a). Sedimentological, geochemical, and faunal evidence from these lacustrine deposits suggest rainfall of at least 500 mm/yr and the presence of wooded savanna and lakes that remained fresh for extended periods of time, though evaporative episodes indicative of drier climates did occur during the lifetime of the lakes (Wendorf et al., 1993a).

**Methods**

Archaeological localities described by Caton-Thompson were reached by interpolating coordinates from her maps (Caton-Thompson, 1952) and navigating to these locations using...
a Global Positioning System (GPS). While Caton-Thompson’s (1952) map of Bulaq contained a coordinate grid, her sketched map of the Mata’na tufa deposits and archaeological localities did not. Caton-Thompson’s map was therefore overlain on aerial photographs of the region, and geologic units on her map matched to outcrops visible on the aerial photographs. These photographs were themselves registered to a geographic coordinate system using GPS ground control points. At both Naqb Bulaq and Naqb Mata’na, Caton-Thompson’s or Gardner’s ~70-year-old excavation trenches were visible, thus confirming that we had identified the locations she described. Tufa samples were collected from Wadi Midauwara as part of an ongoing geologic and archaeological survey (Hawkins et al., 2001; Smith et al., 2004a).

Where archaeological material was stratigraphically associated with tufas, we obtained tufa samples from contexts as close to artifactual material as possible. At both of Caton-Thompson’s localities discussed here, however, the artifact-bearing stratigraphic unit was a marl (calcium carbonate silt). As these fine, often unconsolidated silts are particularly susceptible to diagenetic alteration or detrital contamination that may complicate uranium-series dating (e.g., Wendorf et al., 1993b; Szabo et al., 1995), sampling in these locations was confined to the stratigraphically closest framestone or boundstone tufas (nomenclature following Pedley, 1990; approximate equivalent to Caton-Thompson’s “cellular” tufas; Caton-Thompson, 1952). Because we were largely restricted to sampling deposits in stratigraphic proximity to artifactual material, we were unable to choose only the ideal tufa facies (those deposited with a low primary porosity, e.g., laminated tufas) for dating.

Therefore, all samples underwent petrographic analysis prior to selection for dating in order to eliminate obviously highly altered samples from consideration. Unequivocal determination that a particular sample consists of unaltered calcite is difficult, if not impossible. Thus, we sought rather to identify and disqualify from further analyses samples that exhibited significant postdepositional alteration. Kharga tufas have been shown to preserve primary fabrics (e.g., organo-sedimentary lamination, clotted/peloidal textures), as well as secondary features (pore-filling cements, aggrading neomorphism) indicating diagenesis under a variety of conditions (Crombie et al., 1997; Nicoll et al., 1999). Although there has been some suggestion that diagenetic alteration of tufas can be recognized isotopically (e.g., Janssen et al., 1999), distinct populations of “altered” and “unaltered” samples cannot be identified in the Kharga tufas by this method (Smith et al., 2004b). In addition to qualitative identification of tufa fabric, point counts (500 points per sample) were performed in order to estimate porosity and relative proportions of micrite (generally, though not exclusively, primary) and sparite (usually secondary) in each sample (following Crombie et al., 1997).

Detrital material within the tufa (predominantly quartz and iron oxides) was noted where observed. Because the petrographic analysis did not guarantee selection of unaltered samples, additional precautions were taken during uranium-series analysis (see below).

**Uranium-series chronology**

We drilled between 140 and 261 mg of powder from visually clean, nonporous carbonate for $^{234}\text{U}-^{230}\text{Th}$ dating ($^{230}\text{Th}$ ages) at the Radiogenic Isotope Laboratory, University of New Mexico. The samples were dissolved in 15N HNO$_3$, and a $^{233}\text{U}-^{236}\text{U}-^{229}\text{Th}$-mixed spike was added, and U and Th were separated using our standard column chemistry technique, described in Polyak and Asmerom (2001). Our laboratory U and Th procedural blanks range from 10 to 40 pg and 5 to 20 pg, respectively, and although corrected for, these have no significant influence on the ages. The Th and U isotopes were measured on a Micromass Sector 54 thermal-ionization mass spectrometer with an ion-counting Daly. Our $\delta^{234}\text{U}$ value (the % variation in the $^{234}\text{U}/^{238}\text{U}$ ratio of a sample from the secular equilibrium value, which is equal to the ratio of the half-lives of $^{234}\text{U}$ and $^{238}\text{U}$) for NBL-112A is $-37.4 \pm 0.5\%_\text{oo}$ ($n = 82$). The reported uncertainties (Table 1) in the ratios are $2\sigma$ of the mean; $^{230}\text{Th}$-age uncertainties include uncertainties related to the initial $^{238}\text{Th}/^{232}\text{Th}$ correction. Although the samples contain variable amounts of detrital Th, the initial $^{230}\text{Th}/^{228}\text{Th}$ (atomic ratio) correction chosen conservatively as 8.8 ppm is not large relative to the measured $^{230}\text{Th}/^{228}\text{Th}$ ratios used to correct the $^{230}\text{Th}$ ages of these samples. With increasing age, the fraction of $^{230}\text{Th}$ that is unsupported (detrital) diminishes with increasing radiogenic $^{230}\text{Th}$, making the $^{230}\text{Th}$ dating of tufas very robust.

**Results**

**Tufa petrography**

The four samples dated here, though highly porous (28–40% pore space based on point counts), exhibit relatively little textural evidence of secondary cementation or recrystallization. Sparite was only detected in point counts in sample WME10, where it constituted 2% of the sample, though microspar was observed during nonsystematic examination of several samples. The most common texture observed in these samples was the clotted, peloidal, micritic texture that is very common in Kharga tufas, and tufas in general (Pedley, 1990; Nicoll et al., 1999; Smith et al., 2004a). Detrital quartz was a minor component of the Bulaq Wadi 3 sample (small silt-sized grains occurred infrequently), and all but the Mata’na sample contained iron-oxide coatings on the margins of pore spaces. Iron minerals in the tufas may either be authigenic or detrital (Nicoll, 1996; Nicoll et al., 1999). Nothing was observed in these samples that would make them particularly unsuitable for dating.

**Uranium-series geochronology**

Results of uranium-series dating are presented in Table 1. For three of the four samples (01-MT-001-G, WM-037B, and WM-E10), we split processed subsamples and analyzed the individual halves separately, with results reported as a weighted average for the sample. In addition, for the Wadi
Table 1

<table>
<thead>
<tr>
<th>Sample</th>
<th>Subsample</th>
<th>Initial 238U (ppb)</th>
<th>Initial 232Th (ppt)</th>
<th>230Th/232Th activity ratio</th>
<th>Corrected age (yr BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-MAT-001G</td>
<td></td>
<td>1181 ± 5</td>
<td>0.8961 ± 0.0050</td>
<td>0.8979 ± 0.0017</td>
<td>127,892 ± 5.3</td>
</tr>
<tr>
<td>WM-037B</td>
<td></td>
<td>835 ± 5</td>
<td>7.937 ± 0.002</td>
<td>7.937 ± 0.002</td>
<td>125,665 ± 6.5</td>
</tr>
<tr>
<td>WM-037Ba</td>
<td></td>
<td>828 ± 4</td>
<td>80.933 ± 0.36</td>
<td>80.933 ± 0.36</td>
<td>127,892 ± 5.3</td>
</tr>
<tr>
<td>WM-E10</td>
<td></td>
<td>1591 ± 11</td>
<td>77.800 ± 3.18</td>
<td>77.800 ± 3.18</td>
<td>133.3 ± 5.3</td>
</tr>
</tbody>
</table>

Notes: Corrected ages use an initial 230Th/232Th atomic ratio and are based on the assumption that the relatively minor amount of secondary material observed in the point counts of WM-E10 was enough to affect the determined age; as such, the averaged WM-E10 uranium-series age of 133.3 ± 5.3 should be taken as a minimum constraint on the time of tufa deposition.

Mata’na Site G (KH/MT-02)

Site G at Mata’na (Gardner, 1935) is located just below the edge of the Libyan Plateau, in a small section of tufa incised into older, higher tufa sheets draped down the escarpment flanks (Fig. 1). Caton-Thompson (1952: 41) described a “crumbly and silty” upper tufa, overlying a 50-cm-thick silt “containing a Palaeolithic floor,” above a 5 m of a “harder and cleaner” leaf-bearing tufa (Fig. 2). These deposits represent a typical stratigraphic succession for “perched spring-line,” or “fluviatile barrage” tufas (following Pedley, 1990), in which phytitherm or phytoclast tufas (deposited in flowing water) interfinger with intraclast and micritic silts and silty tufas (deposited in small ponds). The artifact-bearing silt layer was deposited in a shallow pond, probably ~100 m² in area (based on outcrop extent and valley width), with occasional patches of aquatic vegetation. The artifacts excavated by Gardner may have been deposited in situ when the pond partially or completely dried out, as Caton-Thompson (1952) suggested based on the volume of material she recovered. However, granule-sized edgewise clasts of the local Tertiary bedrock (a white shale) in a matrix-supported ~8-cm-thick layer towards the base of the silt suggest that some of the material deposited in this pond was washed in during relatively high-energy events, though no clasts, shale or otherwise, hydraulically equivalent to the excavated artifacts were observed within the section. Although we cannot rule out fluvial transport of the artificial material, the location of the pond near the top of the Libyan Plateau escarpment means that there is very little area upslope of the pond from which artifacts may have been washed in. Thus, if the material were moved, it was likely not moved very far. This is supported by the very fresh condition of the material; however, Caton-Thompson’s description of the site as a “Palaeolithic floor” does not seem to be supported, given that artifacts were distributed vertically throughout the exposed section.
We conducted archaeological fieldwork at Mata'na G that included collection of artifacts exposed on the eroding face of the section and from the unconsolidated sediment below, as well as from two discard piles located at either end of the excavated section. Objects collected from the discard piles had tufa adhering to them, and, with the exception of one "side-blow flake" with an orange desert varnish, they were in the same condition as the material collected from the excavation face. In the limited time available for fieldwork, it was not possible to excavate further the face of the section; therefore, our assessment is based on Caton-Thompson’s published descriptions and the material we collected.

Caton-Thompson (1952: 142) described this location as a flaking station and encampment. Her first assessment was based on the high proportion of flakes and cores and the low numbers of tools. She arrived at the second conclusion based on the presence of a “pot boiler” and burnt flakes (Caton-Thompson 1952: 142). We also discovered discolored flakes with potlidding in the section face, lending support to Caton-Thompson’s assertion that some of the material has been altered by fire. However, it is probable, as discussed above, that the artifacts have been redeposited. They are in fresh condition and bear no evidence of desert varnish, suggesting that they did not lie on the surface for a long period and that they were not transported a long distance. However, at this time, we must treat the age determination on the associated tufa as limiting the minimum age of the material.

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Caton-Thompson (1952: 27–28, 142–143) assigned the material from Mata’na G to a unit she termed “Upper Levalloisian.” The hallmarks of this unit are cores that are primarily oval and discoidal—those that would be described as “classical” Levallois in Van Peer’s (1998) framework. We recovered five cores, one of which we collected from the excavation face. Four of these are round or oval and have been prepared by centripetal removals. Two are preparations for a single large flake removal, while two bear evidence of repreparation after striking. An opposed-platform blade core collected from one of the discard piles is of the same condition as the other material but is not described by Caton-Thompson. It may have been collected at another location, or Caton-Thompson may have based her published description only on material that was physically removed from the site. She did note the presence of flake blades. In either case, production of blades elsewhere in Africa and the Levant is well documented at this time (e.g., McBrearty et al., 1996). Caton-Thompson discovered two triangular Levallois cores (for production of pointed flakes using the Nubian II method) and three triangular Levallois flakes. These constitute only a small proportion of the reported cores and flakes (5% and 9%, respectively). In terms of tool types, Caton-Thompson described and illustrated two tools that she described as Tabalbalat points. These tools have been basally thinned on the ventral and probably dorsal face in order to aid in hafting. Although this could be construed as evidence of use of points in hunting, at least one of these objects is more likely to be a scraper than a point (Caton-Thompson 1952: Plate 72).

An age of 127.9 ± 1.3 ka for the lower, leaf-bearing tufa is consistent with the date of 103 ± 14 ka obtained previously on the capping tufa (Smith et al., 2004a), though the difference between the mean ages (~24 kyr) is greater than would be expected given the ~75-cm stratigraphic separation between the two samples and the sedimentation rates common in tufa-depositing environments. Even using relatively low observed values for tufa and calcite-silt accumulation rates [1.5 mm/yr for tufa (Kano et al., 2003) and 0.1 mm/yr for authigenic silts (i.e., minimum average values for carbonate portions of annual varves; Lotter et al., 1997)], the sediments preserved between the two dated tufa samples should represent only ~5.2 kyr. This indicates either that substantial periods of nondeposition occurred, or that a significant portion of this stratigraphic section has been lost. The irregular contact between the artifact-bearing silt and the underlying tufa suggests that some thickness of sediment was lost prior to the establishment of the pond. Thus, the age of the upper tufa stratum may be
more representative of the depositional age of the artifactual material than that of the lower tufa, as there is no obvious unconformity between the two.

In sum, our assessment of the material at Mata’na G suggests redeposition of artifacts that were produced sometime before 103 ± 14 ka. There are traces of the material indicative of the Nubian Complex, but we cannot exclude the possibility of mixing of materials of different ages; the dating allows for a time span of many millennia to be represented.

**Bulaq, Wadi 3 Locus 1 (KH/BQ-04)**

Wadi 3 Locus 1 (defined by Caton-Thompson, 1952) (KH/BQ-04) is very similar to Mata’na G in its geomorphic and stratigraphic setting, with artifact-bearing strata occupying a low terrace incised into older deposits close to the edge of the Libyan Plateau (Caton-Thompson, 1952: Fig. 1). The general stratigraphic sequence for the terrace consists of gravels (minimum thickness ~1.5 m), overlain by silts with tufa lenses (approximately 1 m thick), capped by 2.5 to 3 m of tufa, with artifacts present in all three strata (Caton-Thompson, 1952). Tufa overlying the obvious excavations along Wadi 3 (Fig. 3) was not sampled, in part because of difficulty of access, and also because the tufa immediately above the excavated region appeared particularly porous, friable, and coarsely crystalline, and thus unsuitable for dating. The dated sample was taken ~30 m north of Caton-Thompson’s excavations at Locus 1, approximately 50 cm above the contact between the tufa and the silts. Although the tufa terrace is itself somewhat dissected, making it impossible to directly relate all three of Caton-Thompson’s described loci (Fig. 1) to the dated sample, the proximity of the three loci to each other, the relatively consistent slope of the terrace remnant surface, and the similarity in stratigraphic sequence along the length of the terrace support Caton-Thompson’s (1952) assertion that the materials at all three loci may be considered as being deposited at approximately the same time.

We examined the exposed section at Bulaq Wadi 3 Locus 1 and were unable to locate artifacts near the section or in the exposed profile. Caton-Thompson (1952: 127) classified this material as “Levalloiso-Khargan.” She defined this unit as intermediate between the Levalloisian and the Khargan; the latter unit is now thought to postdate the Aterian (Wiseman, 1999). The defining characteristics of the Levalloiso-Khargan, in Caton-Thompson’s view, are the presence of Levallois cores and flakes in two size categories: large cores comparable to those of the Levalloisian, and smaller ones. Flakes are modified by basal truncation and steep marginal trimming.

Caton-Thompson’s collection of material from Bulaq Wadi 3 Locus 1 was very small—she described twelve objects and illustrated six. It is not possible to determine, based on her 1952 publication, which of the artifacts derive from Wadi 3 Locus 1 and which derive from Wadi 3 Loci 2 and 3. Although

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![Fig. 3. (A) Photograph of Wadi 3 Locus 1 by ALH, 3/2001. (B) Plate 3 (3) from Caton-Thompson (1952), illustrating Wadi 3 Locus 1.](image-url)
Caton-Thompson described the material from Bulaq Wadi 3 as being not “much rolled or battered,” we again must assume that at least some of these materials have been transported, particularly those that were recovered from gravels, and that the age obtained on the tufa represents a minimum age for the artifact assemblage. Furthermore, if, as Caton-Thompson (1952: 125) asserted, “the beds are so clearly homogeneous that it is safe to consider collectively the implements from the three find spots,” then the production of points using Nubian II technology would be placed earlier than 114.4 ± 4.2 ka. However, we urge caution with respect to interpretation of the assemblage beyond this: the steep retouch described by Caton-Thompson may have been produced through battering during redeposition or possibly trampling before redeposition (McBrearty et al., 1998). Furthermore, our examination of the excavations at Bulaq A suggest that the archaeological material at this location is also redeposited, suggesting that the “Levalloiso-Khargan” is not known from any in situ locality and the term is best avoided.

Comparable to the 103 ± 14 ka age on the tufa overlying Mata’na Site G, the 114.4 ± 4.2 ka date for the tufa that caps artifact-bearing silts at Bulaq is among the youngest ages for tufa strata in Kharga Oasis (Sultan et al., 1997; Smith et al., 2004a; Kleindienst et al., in press), although tufa formation is documented at a comparable time in Kurkur Oasis (~100–120 ka; Crombie et al., 1997). Although it would be expected that a southward migration of the Atlantic monsoon during the cooler substages of MIS 5 would result in drier conditions in the eastern Sahara, and thus dates on lacustrine and spring sediments would cluster during substages 5e, 5c, and 5a (e.g., Szabo et al., 1995), the data set on timing of pluvial conditions is not yet sufficiently extensive or precise to allow for identification of any such trends.

Wadi Midauwara, KH/MD-10

Although the majority of the tufa deposits at Wadi Midauwara occupy the gently sloping floor of the fault-controlled embayment in the Libyan Plateau (Smith et al., 2004a), portions of the escarpment slopes are covered with several generations of tufa deposited in environments similar to those discussed above at Bulaq and Mata’na. The archaeological locality MD-10 (see below) occurs on the discontinuous upper reaches of a tufa sheet sloping down to the west (Figs. 1 and 4), and the tufa sample (WM-037B) was taken from the surface of a ~0.5-m-thick outcrop directly beneath one of the archaeological collection locations. It is difficult to determine the precise environments represented by these tufas, as there is so little outcrop; however, a larger tufa sheet, ~400 m north of MD-10, and somewhat older (150 ± 13 ka; Smith et al., 2004a), contains several well-developed barrage dams, which record the presence of small (~1–3 m) waterfalls along this portion of the escarpment. These barrage tufas also contain evidence of local vegetation besides the reed casts that are nearly ubiquitous in Kharga tufas (Smith et al., 2004a): tree-trunk casts (10–20 cm in diameter) and several leaf casts, probably Ficus.

Much of the archaeological record in the eastern Sahara lies on the desert surface; such was the case at MD-10. Gray-brown chert crops out locally, and chert nodules are also present in the colluvium. We collected all archaeological material on the surface of nine 5 × 5 m squares (Fig. 4). The density of material varied considerably, and it appears to increase as one progresses downslope. However, it does not appear that objects have been transported: refits from within the same unit were noted, and the material is in fresh condition. Evidence of post-MSA use comes in the form of one side-blow flake core and one small pressure-flaked foliate. However, everything else we recovered fits easily within what is expected for the MSA: of 46 analyzed cores, 44 are Levallois and two are discoidal. Although it is not possible to determine site-formation processes, we suggest that this workshop and other MSA workshops in the Western Desert were formed by repeated use of the same location for production of blanks and possibly cores for transport. Therefore, the material collected

Fig. 4. Location of collection squares and tufa outcrops at MD10. Map generated using Trimble Pathfinder ProXR DGPS, accuracy ~10 cm horizontal, ~20 cm vertical.
probably represents use over a significant period of time, most likely thousands of years. The locality would have been attractive, given the abundant raw material and the splendid view into the oasis lowland.

A number of modes of Levallois reduction are represented in this assemblage: centripetal preparation for the removal of one flake (preferential), and centripetal preparation for the removal of multiple flakes (recurrent) account for 20% and 13% of the collected cores, respectively. The proportions of cores for point production are interesting in consideration of Van Peer’s hypothesis regarding the production of points. Several methods of point production are represented in this assemblage. Two of the methods appear to correspond with the Nubian I and II methods described by Guichard and Guichard (1965, 1968), and in addition, some triangular cores show evidence of preparation without formation of a steep distal keel. Altogether, cores on which pointed flakes were produced make up 24% (±6%) of the assemblage. The age of 124.8 ± 4.0 ka represents a maximum age for this assemblage.

Wadi Midauwara, WM-E10

Sample WM-E10 was taken from a low tufa terrace sloping to the south along the northern margin of the Wadi Midauwara embayment (Fig. 1). This particular terrace was selected for sampling because it was the topographically lowest of a series of tufas along the escarpment flanks north of Midauwara, occupying a surface only ~3 m above the floor of the modern gully incised into the tufas. This terrace thus could be expected to record the latest spring activity along this local portion of the Wadi Midauwara escarpment flank, where, based on the preservation state of macroscopic depositional features (following Smith et al., 2004a), tufa terraces are most likely younger at lower elevations. The average age of two subsamples of this tufa, 133.3 ± 5.3 ka, is the same (within 2σ error) as the ~124.8 ± 4.0 ka age for tufa at MD-10 and the ages previously obtained on the youngest tufas within the embayment itself (136 ± 3 ka and 126 ± 4 ka; Smith et al., 2004a). These ages suggest that the final phase of tufa deposition in the Midauwara region may have ended earlier at Midauwara than at Bulaq or Mata’na, though additional dates are required to test this hypothesis.

We found no archaeological artifacts in association with this tufa deposit.

Discussion

Caton-Thompson (1952) proposed a sequence of Stone Age units for Kharga Oasis based on three seasons of fieldwork in both the escarpment region and the lowland oasis. Kleindienst et al. (in press) subsequently suggested that at least two of these units, the “Levalloiso-Khargan” and the “Acheulio-Levalloisian,” require reevaluation and should possibly be discarded. Our examination of the Bulaq A and Bulaq Wadi 3 material leads us to the conclusion that the artifacts Caton-Thompson used as the basis for definition of the “Levalloiso-Khargan” are redeposited and could represent material from a number of different depositional episodes. Furthermore, the fact that the artifacts are found in gravels in both cases suggests that some of the reported tools may have been modified by battering during a high-energy fluvial event.

The “floor” that Caton-Thompson (1952) described at Mata’na G was not evident on further examination of the section she reported; instead, artifacts appear throughout the section. This pattern may be due to postdepositional vertical movement of artifacts through saturated plastic sediment or along shrinkage cracks during desiccation of the water bodies in which artifact-bearing silts were deposited. Alternatively, bioturbation of sediments caused by animals walking through the shallow ponds or other processes may have redistributed the artifacts. In either of these cases, variable orientation of artifacts in the section would be predicted; this was observed at Mata’na. However, distribution of artifacts throughout the clastic sediments in these locations could also indicate that the material was washed into the site in a series of depositional episodes.

Conclusions

The results of this investigation may be viewed in two ways: how they contribute to our understanding of changing climate in the Western Desert during the Pleistocene, and how they contribute to understanding human occupation of this region.

The uranium-series dates obtained on four tufas from three regions of tufa deposition near Kharga Oasis all fall within the late MIS 6–MIS 5 humid phase recognized across northern Africa (see above; Fig. 5). A comparison of these new dates with those on Pleistocene sediments indicating humid conditions at Kharga and Dakhleh oases (Sultan et al., 1997; Smith et al., 2004a; Kleindienst et al., in press), at Kurkur Oasis (Crombie et al., 1997), and at several other localities in southern Egypt and northern Sudan, including Bir Sahara/Bir Tarfawi (Szabo et al., 1995), suggests that discrete clusters of ages at certain times are not evident, even within this relatively limited geographic region. The broad distribution of dates may simply be a function of the often large (>10 ka) errors associated with many of the published uranium-series ages, in which case additional work refining the chronology of known pluvial deposits in central and southern Egypt may clarify the timing of distinct humid phases. Alternatively, recharge of aquifers during times of enhanced rainfall may have allowed spring flow to continue well after the cessation of local precipitation. In that case, the availability of surface water would have persisted after times of maximum rainfall over northern Africa, as predicted by GCMs and climate records external to this region. Spring flow supported by extraregional recharge could also potentially occur prior to these times as a response to much earlier rainfall events within the springs’ recharge area. Thus, minor humid phases, in which rainfall never penetrated as far north as Kharga, may nonetheless have had a delayed effect on spring flow in the region. Marine Isotope Stage 5, however, does seem to have been a particularly humid time in
Egypt, based on the numbers of dates from different regions that reflect spring and lake activity during that time.

We may draw several conclusions about human occupation based on the archaeology. First, Van Peer’s division of archaeological complexes into Nubian and non-Nubian appears to be partially supported. At only one locality (MD-10) did we discover a significant number of Levallois point cores produced using Nubian methods. The age of this locality may be younger than other localities, but at this time, we can only state that age determination on MD-10 (124.8 ± 4.0 ka) represents a maximum age, while the other determinations on Mata’na Site G and Bulaq Wadi 3 (127.9 ± 1.3 and 114.4 ± 4.2 ka) represent minimum ages. Van Peer placed the Nubian Complex in the Western Desert at 135 ka and later; thus, MD-10 fits expectations. The co-occurrence of Nubian point production with foliates, tangs, and/or Nazlet Khater points cannot be evaluated at this time because MD-10 represents a former workshop and is essentially devoid of formed tools.

While we note the presence of Nubian materials at WD-10, we must also point out that we find markers of the Nubian Complex in small amounts at Bulaq Wadi 3 and Mata’na G. Van Peer’s classification system is based on presence or absence rather than proportions; thus, following his nomenclature, these two locations should also be classified as Nubian Complex. However, we suggest that the minor proportions of points and point cores could mark an indigenous innovation, variation arising from differences in site function, or the result of contact between populations from different cultural traditions. The record from the Nile Valley shows evidence of complexity; as more chronometrically dated localities from the Western Desert are described, it is likely that we will discover similar complexity.

We note in closing that the framework for the Stone Age of Kharga Oasis proposed by Caton Thompson and Gardner on the basis of only three seasons of fieldwork in the 1930s is remarkably robust. On the basis of our 2001 fieldwork, we propose that the “Levalloiso-Khargan” be discarded, as suggested by Kleindienst (1999: 102). However, the placement of the “Upper Levalloisian” as an MSA unit predating the Aterian appears appropriate. Caton-Thompson and Gardner’s exploration and study of the tufa deposits of Kharga Oasis has provided an extremely valuable foundation for further research in the region.

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