Thermoluminescence Dating of a Middle Palaeolithic Occupation at Sodmein Cave, Red Sea Mountains (Egypt)

N. Mercier, H. Valladas and L. Froget

Laboratoire des Sciences du Climat et de l'Environnement, Unité Mixte de Recherche CNRS–CEA, Avenue de la Terrasse, 91198 Gif-sur-Yvette, France

J.-L. Joron

Groupe des Sciences de la Terre, Laboratoire Pierre Süe, Saclay, 91191, Gif-sur-Yvette, France

P. M. Vermeersch and P. Van Peer

Laboratorium voor Prehistorie, Katholieke Universiteit Leuven, Belgium

J. Moeyersons

Koninklijk Museum voor Midden Afrika, Tervuren, Belgium

(Received 27 March 1998, revised manuscript accepted 27 November 1998)

The Palaeolithic sequence from Sodmein Cave in the Egyptian Eastern Desert, near Quseir, contains seven stratified archaeological levels from the Middle and Upper Palaeolithic. The lowest archaeological level (Middle Palaeolithic level 5) consists of huge fireplaces associated with a lithic assemblage in which Nubian Levallois technology and bifacial tools are present. From this level, six fragments from two large burned flint blocks have been dated by thermoluminescence. A mean age-estimate of 118 ± 8 ka for the six dates, all of which fall between 109 and 127 ka, puts the use of this hearth at the beginning of Oxygen Isotope Stage 5, most likely during episodes e or d. This age is close to that of other Egyptian Middle Palaeolithic sites with very similar lithic assemblages.

Keywords: MIDDLE PALAEOLITHIC, EGYPT, THERMOLUMINESCENCE, QUATERNARY.

Introduction

This contribution presents the first thermoluminescence (TL) age determinations for the Palaeolithic sequence at the Sodmein Cave site, recently excavated by the Belgian Middle Egypt Prehistoric Project of Leuven University (Vermeersch et al., 1994; Moeyersons et al., 1996). Located 35 km to north-west of Quseir (Figure 1), the Sodmein area is the first in the Egyptian Eastern Desert to reveal stratified archaeological levels ranging from the Middle Palaeolithic to the Neolithic.

Stratigraphic Position of the Fireplaces and Nature of the Samples

Seven Palaeolithic (Vermeersch et al., 1994; Van Peer, Vermeesch & Moeyersons, 1996) and several Neolithic occupation levels (Vermeersch et al., 1996) have been identified. They are found mostly in the eastern portion of the cave-fill near the cave entrance and are characterized by low artefact densities. Some show evidence of post-depositional re-working. While the precise formation processes of these levels remain unclear, the techno-typological and physical homogeneity of the assemblages as well as their stratigraphic separation justify the assignment of seven occupation periods.

The stratigraphic sequence of excavation sector B in the northern part of the cave where the dated fireplaces occur is presented in Figure 2 and briefly discussed. Throughout layer C scattered artefacts occur which have been brought together in Upper Palaeolithic level 1 (UP1). However, it is possible that this level constitutes the re-worked upper part of Upper Palaeolithic level 2 (UP2). The latter can be considered a true
occupation level with an important accumulation of lithics around a hearth (feature 29 in Figure 2). The associated charcoal was dated by $^{14}$C to 25,200 ± 500 BP (UtC-3313). Numerous blades are present. Cores generally exhibit a single striking platform. Retouched tools are almost absent.

Middle Palaeolithic level 1 (MP1) contains few artefacts, which show significant vertical dispersion especially in the southern excavation sectors. Among the tools are burins and two points with basal thinning on the ventral face. The latter characteristic qualifies them as Emireh points, a common type in the Levantine Middle Palaeolithic.

Middle Palaeolithic level 2 (MP2) is well-represented throughout the cave. A radiocarbon age-estimate on charcoal from a hearth in sector A yielded $>30,000$ BP (Lv-2084). The presence of tanged Levallois products might support the identification of this level as Aterian.

Middle Palaeolithic level 3 (MP3) is well-defined and is located at the interface between layers F2 and G. Charcoal from a consolidated organic layer overlying this level in sector B was radiocarbon-dated to $>45,000$ BP (UtC-3317). Levallois technology, including the classical and Nubian methods, is well-represented. Among the tools are a few truncated-faceted pieces.

Middle Palaeolithic level 4 (MP4) is best represented in the southern part of the cave. In sector B it is found at the top of layer G close to the inter-fingering contact with layer F2. Its stratigraphic relationship to MP3 will be further explored during future work. Quite possibly, both will prove to represent a single occupation level. The lithic assemblage from MP4 is very similar to the one from MP3. A $^{14}$C-date on charcoal from feature 25 in the western part of layer G indicated an age of $>44,500$ BP (Lv-2087).

A large hearth occurs in the lowest archaeological level (MP5), associated with only a few artefacts. The hearth consists of three distinctive, superimposed ash layers. These successive layers have an inclination parallel to the slope of the stratigraphic units. The ash layers are most clearly discernible in the western extension of the hearth. In the centre and eastern zone they tend to collapse into one thick layer. Within the hearths were burnt bones of large mammals, such as buffalo and elephant, as well as those of some species indicative of the presence of open water (e.g., crocodile). This faunal assemblage is quite similar to that of
the Lake phases 1 and 2 at Bir Tarfawi and Bir Sahara in the western desert, dated to the last interglacial (Wendorf et al., 1993). Among the lithics associated with this feature is a Nubian Levallois core with a transversal pattern of preparation, the so-called Nubian 1 subtype (Guichard & Guichard, 1968). Also present was a fragment of a rather thin, bifacially flaked tool.

Below the lowest level is debris from a major collapse of the cave roof, which currently limits further archaeological exploration of the cave.

**TL-dating of the Lowest Middle Palaeolithic Level**

Dating attempts of the upper Middle Palaeolithic levels using $^{14}$C clearly indicate that their age exceeds the possibilities of this dating method. Because Middle Palaeolithic level 5 (MP5) yielded flints with evidence of burning, it became obvious that thermoluminescence could be used to obtain age-estimates for this layer. The usefulness of this technique for dating burnt flints, particularly from Middle Palaeolithic sites which are beyond the limit of radiocarbon dating, is now well-documented (see Valladas, 1992; Mercier, Valladas & Valladas, 1995).

The six dated fragments came from two large, burnt chert blocks (three fragments each) belonging to different phases of occupation. Sample 93/489 is associated with the upper ash layer (UL) and was found at the eastern edge of the fireplace. Sample 95/56 is from near the western edge and comes from the middle ash layer (ML). Apparently, this chert block was used as a construction element.

**Radiometric parameters and age-estimates**

To measure the palaeodose, i.e., the total radiation dose received by the flints following their last exposure to fire, we used the normalization technique (Mercier, Valladas & Valladas, 1992). Once the central core of each flint was crushed and sieved (Valladas, 1992), powder in the 100–160 μm range was collected and divided into two portions. After the three aliquots of the first portion received incremental doses of $\gamma$-radiation from a $^{137}$Cs source, their TL was measured (Valladas, Mercier & Létuvé, 1994). The natural (NTL) and artificial (ATL) thermoluminescence (Figure 3) each gave a glow curve with a distinct maximum at 380°C, typical of flint. These curves allowed us to plot TL growth as a function of added artificial dose (TL1 in Figure 4). The second portion was heated for 90 min at 350°C, to eliminate all the TL of the powder, and then divided into 4 aliquots which were irradiated with incremental doses of $\gamma$-radiation and their TL measured. Using the second set of measurements we plotted the growth curve of regenerated TL (TL2, figure 4). Through a comparison of TL1 and TL2 growth curves the normalization technique allowed us to determine the palaeodose of each flint as a function of temperature. The insert in Figure 4 also shows that the palaeodose obtained between 300 and 500°C was invariant enough to satisfy the plateau test (Aitken, 1985).

To obtain age-estimates for the flints, i.e., to find out how much time elapsed since their last exposure to heat...
in excess of 500°C, we determined the annual amount of radiation received by each sample. The annual dose has two major components—internal, from the $^{238}$U, $^{232}$Th and $^{40}$K found in each flint, and external, from the cosmic radiation and radioisotopes within the sediment surrounding the flints during burial. The internal dose was calculated from the concentrations of the three relevant radioisotopes measured by neutron quantidade.

Figure 3. TL glow curves for sample SM3 recorded between 200 and 500°C, showing the emission peak centred around 380°C. The successive artificial $\gamma$ doses added to the natural (Nat.) were 154.7, 309.4 and 464.0 Gy. The TL emission was detected with a EMI 9635QB photomultiplier tube equipped with a 3 mm blue filter (maximum transmission: 380 nm).

Figure 4. TL1: first TL growth curve as a function of the added $\gamma$ doses for sample SM3. TL2: second TL growth curve, regenerated after the natural sample had been heated in a furnace at 350°C for 1 h 30 min. Inserted is the palaeodose calculated as a function of the heating temperature for this sample.
Table 1. Radiometric parameters for the six dated burnt flints from Sodmein Cave

<table>
<thead>
<tr>
<th>Sample</th>
<th>Lab. No.</th>
<th>Ref. No.</th>
<th>Layer</th>
<th>Depth (m)</th>
<th>Internal U (ppm)</th>
<th>Internal Th (ppm)</th>
<th>Internal K (%)</th>
<th>S-alpha (µGy/a/cm²)</th>
<th>Internal dose (µGy/a)</th>
<th>External dose (µGy/a)</th>
<th>Annual dose (µGy/a)</th>
<th>Palaeodose (Gy)</th>
<th>Age (ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>UL</td>
<td>93/489</td>
<td>144</td>
<td>1.71</td>
<td>0.11</td>
<td>0.08</td>
<td>20.55±4%</td>
<td>893±72</td>
<td>578±71</td>
<td>1471±101</td>
<td>168±3</td>
<td>114±8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>UL</td>
<td>93/489</td>
<td>144</td>
<td>1.46</td>
<td>0.10</td>
<td>0.06</td>
<td>19.60±8%</td>
<td>723±67</td>
<td>578±71</td>
<td>1301±97</td>
<td>153±6</td>
<td>117±10</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>UL</td>
<td>93/489</td>
<td>144</td>
<td>1.00</td>
<td>0.11</td>
<td>0.08</td>
<td>19.08±5%</td>
<td>672±53</td>
<td>567±71</td>
<td>1239±89</td>
<td>158±7</td>
<td>127±10</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ML</td>
<td>95/56</td>
<td>15.3</td>
<td>1.47</td>
<td>0.12</td>
<td>0.06</td>
<td>15.46±3%</td>
<td>647±47</td>
<td>561±71</td>
<td>1209±85</td>
<td>144±5</td>
<td>119±9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ML</td>
<td>95/56</td>
<td>15.3</td>
<td>2.13</td>
<td>0.10</td>
<td>0.05</td>
<td>17.58±8%</td>
<td>990±87</td>
<td>534±71</td>
<td>1524±112</td>
<td>166±6</td>
<td>109±8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ML</td>
<td>95/56</td>
<td>15.3</td>
<td>2.58</td>
<td>0.13</td>
<td>0.06</td>
<td>23.39±4%</td>
<td>1409±121</td>
<td>572±71</td>
<td>1982±141</td>
<td>228±8</td>
<td>115±9</td>
<td></td>
</tr>
</tbody>
</table>

The U, Th and K contents are given in ppm, ppm and %, respectively, and have a systematic error of 10% each. The Sα value is the alpha sensitivity determined by comparing the TL signal induced by α-rays delivered by a Pu-238 source to the TL signal generated by β-rays coming from a Sr-90 source.

The internal dose was calculated from the U, Th and K contents and the specific dose-rates given by Liritzis & Kokkoris (1992).

The external dose was calculated by averaging the individual values of the six dosimeters: 610, 660, 590, 560, 570 and 590 µGy/a (statistical error: ±3%). This value has been corrected to take into account the attenuation of γ-rays through the samples. The total error includes the dispersion of individual values and a ±7% uncertainty in the water content of the sediment during the long burial.

The palaeodose values were calculated by integrating the TL signals between 350 and 400°C.
Figure 3: Detail of a red ochre stick from Bir Tarfawi. The ochre was found embedded in a hearth. (Photograph courtesy of J. H. V. van Peer.)

Detailed results can be found in: 1Stokes (1993); 2Huxtable (1993); and Bluszcz (1993).

### Evaluation

An age-estimate of 118 ± 8 ka compares well with TL and optical dates for the East and West Lake phases 1 and 2 in the Eastern Sahara (Table 2) (Wendorf et al., 1993; Bluszcz, 1993; Huxtable, 1993; Stokes, 1993). The site of Bir Tarfawi has provided rich lithic assemblages associated with these phases. Bifacial foliates and Nubian Levallois technology, including the Nubian 1 subtype (e.g., Wendorf et al., 1993; figure 22-31, h), are present here. Later assemblages from Lake phases 3 and 4 almost completely lack bifacial tools. They are comparable to MP4 and MP3 at Sodmein Cave.

All these Isotope Stage 5 assemblages from the western and eastern desert have been associated with the Nubian Complex which appeared in the Lower Nile Valley at the end of the Middle Pleistocene (Van Peer, 1998). Here as well, foliated bifacial tools are characteristic of early Nubian Complex occurrences (Vermeersch, in press, a, b). During the favourable climatic conditions of early Stage 5, Nubian Complex groups spread to adjacent regions where they remained present during the subsequent period of degrading climatic conditions. As in the Nile Valley, here too one finds evidence of change: bifacial tools disappear and types such as truncated-faceted pieces emerge. The Nubian 2 Levallois method for the production of pointed blanks, with bipolar preparation, replaces the Nubian 1 method.

### Conclusions

The lower Middle Palaeolithic level of Sodmein Cave (MP5) can be dated to 118 ± 8 ka BP. This date is in good agreement with dates for similar sites in the Eastern Sahara and confirms the idea that early Nubian Complex groups spread to regions adjacent to the Nile Valley during early Isotope Stage 5.

The Sodmein sequence adds valuable information as to the diachronic succession of Palaeolithic industries in Northeast Africa. At present, it is not clear how this general archaeological sequence can be correlated with that of the Maghreb and the Levant. Detailed comparative research is necessary. At least, the more recent levels at Sodmein appear to exhibit similarities with Levantine material.

### Acknowledgements

We wish to thank the Belgian “Fonds voor Kollektief Fundamenteel Onderzoek” and the “Onderzoeksfonds, Katholieke Universiteit te Leuven” for funding.

#### Table 2. TL and optical dates from Eastern Saharan Middle Palaeolithic sites (Wendorf et al., 1993)

<table>
<thead>
<tr>
<th>Lake phase</th>
<th>Site</th>
<th>Material dated</th>
<th>Lab. ref.</th>
<th>Date (ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bir Tarfawi, Lake East</td>
<td>sand</td>
<td>OX10748(T)-6</td>
<td>96.4 ± 7.2/−10.9</td>
</tr>
<tr>
<td>2</td>
<td>Bir Tarfawi, Lake East</td>
<td>sand</td>
<td>OX10748(T)-3</td>
<td>119.3 ± 22.9</td>
</tr>
<tr>
<td>2</td>
<td>Bir Sahara</td>
<td>sand</td>
<td>OX10748(S)-2</td>
<td>103.9 ± 9.5/−13.2</td>
</tr>
<tr>
<td>3</td>
<td>Bir Sahara</td>
<td>burned silt</td>
<td>OXTL506b</td>
<td>108.6 ± 10.6</td>
</tr>
<tr>
<td>4</td>
<td>Bir Sahara</td>
<td>burned silt</td>
<td>OXTL506a</td>
<td>105.4 ± 10.5</td>
</tr>
<tr>
<td>5</td>
<td>Bir Sahara</td>
<td>sand</td>
<td>GdTL-166</td>
<td>105 ± 15.5</td>
</tr>
<tr>
<td>6</td>
<td>Bir Sahara</td>
<td>sand</td>
<td>GdTL-164</td>
<td>84 ± 10.5</td>
</tr>
<tr>
<td>1</td>
<td>Bir Tarfawi, Lake East</td>
<td>burned core</td>
<td>OXTL506x</td>
<td>96 ± 14.5</td>
</tr>
<tr>
<td>2</td>
<td>Bir Tarfawi, Lake East</td>
<td>sand</td>
<td>OX10748(T)-1</td>
<td>129.2 ± 7.7</td>
</tr>
</tbody>
</table>

Activation analysis (NAA) (Joron, 1974) at the Pierre Sée Laboratory (CEN–Saclay). Thorium and potassium concentrations were c. 0.1 ppm and 0.08%, respectively, while uranium levels ranged from 1.3 to 2.7 ppm. Depending on the flint, the internal dose could account for between 52 and 70% of the total annual dose. The average external dose (600 ± 71 μGy/a) was estimated from radiation received by six dosimeters (CaSO4: Dy) buried in the remaining sediments on both sides of the excavated trench at a distance of <1 m from the original flint finds spots.

**Age estimate**

The age was estimated using the formula:

\[
\text{Age (years)} = \frac{\text{Palaeodose (Gy)}}{\text{Annual dose (Gy/a))}}
\]

All the relevant radiometric data as well as the estimated ages of the six flints are included in Table 1. The weighted mean age-estimates for the upper and middle ash layers are 119 ± 8 and 116 ± 8 ka, respectively. These mean ages cannot be considered distinct when one takes into account the uncertainties associated with each of them.

A weighted mean age-estimate of 118 ± 8 ka can be calculated for these two levels which puts the use of the hearth at the beginning of Oxygen Isotope Stage 5, most likely during episodes e or d (Martinson et al., 1987).
the Egyptian Antiquities Department for support, and Shawn Bubel for revising the English version. This work has been performed in the IUAP 28 of the Belgian Federal Government. LSCE contribution no. 143.

References


