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A revised chronology for Pleistocene paleolakes and Middle Stone Age – Middle Paleolithic cultural activity at Bîr Tirfawi – Bîr Sahara in the Egyptian Sahara

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ABSTRACT

At Bîr Tirfawi and Bîr Sahara in the now hyperarid Egyptian Sahara, relict lake deposits located in adjacent deflation basins near 22°54′57.58″N 28°50′19.54″E preserve evidence of different hydroclimate conditions that enabled cultural activities during the Middle Stone Age – Middle Paleolithic (MSA-MP). Single aliquot regeneration optically stimulated luminescence (SAR-OSL) dating techniques were applied to sediment samples with archaeological contexts to generate a more precise geochronology for the groundwater-supported lakes and prehistoric activities in the region. New age determinations on nine samples collected from Bîr Sahara East and Bîr Tirfawi are presented for the five paleolake phases originally described by the excavation team. The new analyses yielded dates that are more precise, and refine the original geochronology for water availability at this location. The determinations suggest that some of the originally defined lake phases are temporally indistinct. SAR-OSL dates of the West 2 and West 3 lake phases defined at Bîr Sahara East overlap in time, and are contemporaneous with the Grey 3 phase at Bîr Tirfawi, at around 102 ka. The refined age for the Grey 1 phase at Bîr Tirfawi dates to 135 ± 21.6 ka, and two dates for the Post-Lake phase at Bîr Sahara center around 41 ka. A probability distribution plot (pdf) of all nine of the analytical results resolves the chronology of groundwater-supported paleolakes and prehistoric activities in the region around 41 ka (MIS 3), 80 ka (MIS 5a), 102 (MIS 5c-d), and 115 ka (MIS 5d-e). Precise dates for the sediments at these archaeological sites are important for several lines of multidisciplinary inquiry, including the role of Middle-Late Pleistocene climate on landscape change and water availability, variations in material culture and the adaptations in populations of anatomically modern humans (AMH) in the Sahara. Research in the Bîr Sahara – Bîr Tirfawi region is particularly interesting because the sites are within the modern hyperarid core of NE Africa, and are not located along the coasts or major waterway corridors "Out of Africa" like the Nile Valley. Semi-permanent paleolakes and long-lived spring-fed oases located in the modern arid belt west of the River Nile between Egypt and Sudan were crucial biomes for sustaining the lifeways and dispersal of *Homo* throughout the Quaternary. However, the importance and the role of such ecosystems dispersed across the North African landscape is somewhat underestimated in existing hypotheses that aim to describe *hominin* adaptation and dispersals.

1. Introduction

Records of the Middle Stone Age – Middle Paleolithic (hereafter, MSA-MP) span the Middle-to-Late Pleistocene time and provide insights on the origins and evolution of anatomically modern humans (AMH) and their material culture in Africa and Eurasia (e.g., White et al., 2003; McDougall et al., 2005). Although understanding early AMH and their dispersals "out of Africa" remains one of the most important topics in paleoanthropology (e.g., Lahr and Foley, 1994, 1998; Van Peer, 1998; McBrearty and Brooks, 2000; Derricourt, 2005; Burroughs, 2007; Vaks et al., 2007; Frumkin et al., 2011), research is hampered by the paucity of sites with well-dated stratigraphic contexts, particularly in regions with geopolitical constraints and in the harsh desert locales of North Africa (Nicoll, 2001, 2004). Resolving precise chronologies remains

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paramount for assessing the dynamics of regional and global climatic and environmental change across landscape gradients, and for reconstructing local adaptations of prehistoric populations (Blome et al., 2012; Clarke et al., 2016).

Sites in the presently hyperarid and inhospitable Bîr Tirfawi – Bîr Sahara preserve MSA-MP artifacts in stratigraphic contexts with ancient lake and aeolian sand deposits. Fig. 1. Extensive field studies, survey, excavation, and specialist investigations by the Combined Prehistoric Expedition (CPE) commenced in the 1970s, and continued over many years to document these important stratified sites (Wendorf and Schild, 1980; Wendorf et al., 1993). In the early 1990s, a central goal was to relate the archaeology and stratigraphic sequences to global patterns of climate change since the last interglacial. Initial geochronologic determinations were obtained using a wide range of techniques on many sediments deposited by these groundwater-fed paleolakes (Wendorf et al., 1993, 1994).

Published dates for the sediments in context with artifact assemblages at Bîr Tirfawi and Bîr Sahara utilized thermoluminescence (TL) and optical dating using multiple aliquot additive dose regeneration (MAAD) methods (Wendorf et al., 1993 and chapters therein). The optical dating conducted in the 1980s and early 1990s obtained the equivalent dose from the measured luminescence signal (Aitken, 1998; Bøtter-Jensen et al., 1999, 2003). This was a common approach utilized prior to the development of the single-aliquot regenerative-dose (SAR) method for optically stimulated luminescence (OSL) dating (Wintle, 1997; Murray and Wintle, 2000; Wintle and Murray, 2006). The SAR protocol is widely regarded as a revolution in the application of optical dating techniques (Malainey, 2010) because the method yields more replicable and precise measurements on sub-samples (aliquots) of only 1–2 mg, or about 100–1000 grains. A dose-value is obtained for each single aliquot and the total equivalent dose is then calculated as the average of all measured aliquots for a given sample; the regeneration curve provides the basis for reconstructing the sediment age (Bøtter-Jensen et al., 2003).

This paper presents the results of SAR-OSL analyses on quartz-rich sediment samples previously collected in 1988 from lake deposits with archaeological contexts in the Bîr Sahara East and Bîr Tirfawi region. These new determinations refine the existing chronology of optical dates based on the determinations originally reported in Wendorf et al. (1993), and discussed in Hill (2009). Precise dates are critical for accurately interpreting when groundwater-supported lakes were present and enabled prehistoric cultural activities in this landscape. Furthermore, accurately dating the timeframes when conditions were hospitable in this part of Saharan North Africa enables robust correlations with Quaternary climate change archives such as the marine oxygen isotope stages (MIS) and the global sea level curve. Stratigraphic records of lakes from the subtropics and low latitudes are particularly valuable proxies of hydroclimatic change, and have been used to reconstruct wet-dry phases affecting the African continental interior over Quaternary timescales (e.g., Haynes, 1982; Kutzbach and Street-Perrott, 1985; Cohen et al., 2007; Scholz et al., 2007; Drake et al., 2011).

2. Study area

The study region is located in the core of the modern hyperarid Sahara, and presently lacks sufficient surface water to sustain nomadic pastoralism (Nicoll, 2008). Bîr Sahara East and Bîr Tirfawi are two adjacent topographic depressions situated at about 22°56′ N 28°56′ E, approximately ~400 km west of the Nile Valley, and ~100 km north of the Egypt–Sudan border in the Selima Sand Sheet (Bagnold, 1935; Haynes, 1982; Haynes et al., 1997). In this region, topographic depressions have been enhanced by recent wind deflation (Embabi, 1999) and expose water-lain Quaternary sediments that include spring carbonates, sandy lacustrine facies, and carbonate marl deposits, as well as fossil fauna and archaeological remains (e.g., Said, 1975, 1983; Issawi, 1978; Klitzsch et al., 1987; Alaily and Pohlmann, 1995). These archives are clearly relict from conditions that are markedly different than today; this location is among the most arid regions on Earth, with <10 mm annual rainfall. Paleoenvironmental evidence suggests that the greater region formerly received around 300–500 mm annual rainfall and supported a savanna woodland at various times during the Quaternary;

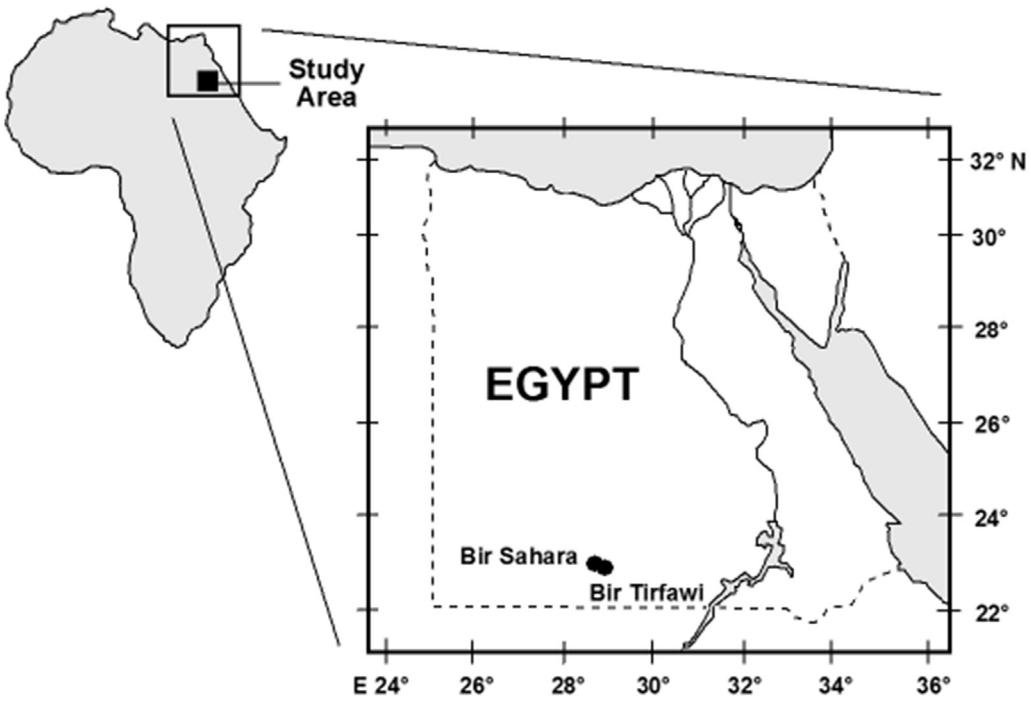

Fig. 1. Geographic location of the study sites.

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