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Evidence for Pleistocene lakes in the Tushka region, south Egypt

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ABSTRACT

Space Shuttle Radar Topography Mission (SRTM) data have revealed new details on the extent and geomorphic relations of paleodrainage in southern Egypt. Following a period of late Tertiary drainage from the Red Sea Hills south through Wadi Qena and west across the Tushka region, the Nile River as we now know it established its connections with Central Africa and the Mediterranean in the middle Pleistocene (oxygen isotope stage, OIS 7 to OIS 5). SRTM topography reveals a lake level at ~247 m that is coincident with the elevation of middle Pleistocene fish fossils 400 km west of the Nile, and with the termination of shallow runoff channels in northern Sudan that were active during the middle Pleistocene and Holocene pluvial periods. An additional lake level at ~190 m is based on the current elevation at Wadi Tushka, and is consistent with Paleolithic sites at Bir Kiseiba followed by Neolithic sites at lower topographic levels. Overflow of the Nile through Wadi Tushka during the wetter north African climate of the middle Pleistocene, coupled with limited local rainfall, was the likely source of water for these lakes.

INTRODUCTION

The area west of the Nile between Aswan and the Sudan border is an important key to the evolution of drainage in the northeast Sahara throughout the Cenozoic. However, this region has been partially inundated by five lakes at elevations of 132–144 m since 1998 (Abdelsalam et al., 2008); the surface has started to host irrigation pivots and associated fields, and 100 km west of the Nile, the few scattered oases have begun to be exploited for their near-surface groundwater. Thus it is important to investigate the undisturbed desert surface before it is completely overtaken. Recent hypotheses for Nile evolution suggest major changes in drainage from a pre-Nile southwest direction in the Oligocene–Miocene to northeastward drainage in the Pleistocene resulting from establishment of the present Nile (Issawi and McCauley, 1992), all of which affected the Kiseiba-Tushka region.

We used Shuttle Radar Topography Mission (SRTM) data at the available 3 arc-second (90 m) spatial resolution (see the GSA Data Repository1) to delineate the topography and surficial deposits of the Kiseiba-Tushka depression, bounded by Kiseiba Oasis on the west, Wadi Tushka on the east, the Egyptian western limestone plateau to the north, and the gradual southward rise of the desert surface into Sudan (Fig. 1). The resulting digital elevation model displays evidence for northeast drainage that explains the locations of several oases along the Darb el-Arba‘in caravans. The surface has started to host irrigation pivots and associated fields, and 100 km west of the Nile, the few scattered oases have begun to be exploited for their near-surface groundwater. Thus it is important to investigate the undisturbed desert surface before it is completely overtaken. Recent hypotheses for Nile evolution suggest major changes in drainage from a pre-Nile southwest direction in the Oligocene–Miocene to northeastward drainage in the Pleistocene resulting from establishment of the present Nile (Issawi and McCauley, 1992), all of which affected the Kiseiba-Tushka region.

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NILE EVOLUTION AND THE WESTERN DESERT

Fluvial activity in the Tushka region was intricately related to the timing and direction of overland drainage across the western limestone plateau before the Oligocene–Miocene rifting of the Red Sea that initiated formation of the Nile valley (Williams and Williams, 1980). Drainage from the Red Sea hills to southwest Egypt (and across Africa) during this period was suggested based on the near east-west orientation and junction angles of the subsurface paleochannels revealed by Space Shuttle Imaging Radar (SIR) (McCauley et al., 1986). Prior to the establishment of the northward-draining Nile, Wadi Qena drained the Red Sea Hills southward through the present Nile valley, and to the west across the Kiseiba-Tushka depression to combine with the northward drainage from the Gilf Kebir plateau, eventually debouching into the Mediterranean (Issawi and Osman, 2008).

Sediments of the Nile valley indicate that the present Nile did not have a connection with Central Africa before the middle Pleistocene, based on the presence of fluvial sand deposits that extend from Wadi...
Qena across the present Nile valley and the lack of Ethiopian minerals in sediments older than the middle Pleistocene Dandara silts (Hassan, 1976; Butzer, 1980). The upper part of the Ethiopian mineral-rich Dandara Formation has been dated at 213 ka (oxygen isotope stage, OIS 7; Issawi and Mc Cauley, 1992), although sediments below that horizon contain a mix of Ethiopian and Nubian lithologies.

Current stratigraphic data thus suggest that establishment of the northward-draining Nile and connection with Blue Nile sediments occurred over a time period spanning OIS 7 to OIS 5 (~240–100 k.y.). Williams and Williams (1980) proposed two models for integrating northward drainage: overflow of a lake in northern Sudan, or headward erosion of the Nile through the uplifted rocks of the Nubian swell. In either case, following establishment of northward drainage in the middle Pleistocene, westward transport of Eastern Desert sand and gravel across the Nile valley would have ceased. Construction of the Tushka overflow canal provided access to topographic and stratigraphic data suggesting that Wadi Tushka was once a tributary to the Nile, draining a large middle Pleistocene or earlier lake in the Kiseiba-Tushka depression (Haynes, 1980). Using SRTM topography, we can now constrain the extent of such lakes, compare the boundaries with other geomorphic features, and speculate on the water source.

**TOPOGRAPHIC REMNANTS OF FLUVIAL AND LACUSTRINE FEATURES**

SRTM topography reveals several previously unmapped drainage channels that originate in the Selima Oasis region and drain to the northeast (Fig. 2). Selima is an uninhabited oasis that was the site of several Holocene lakes at 265–285 m elevation, and 10 m above the highest Holocene tufas are limestone benches with well-weathered Middle Paleolithic artifacts (Haynes et al., 1989). The lacustrine limestone indicates that a small middle Pleistocene lake occupied the Selima depression, and overflow of that lake to the north explains the source of the paleochannels. Two
1985). However, two Acheulean hand axes were found in the upper 7 m of sediment infill of the Tushka excavations; the specimen from the upper 2–3 m was less abraded than the ax at depth (Haynes, 1980). Such evidence suggests that infilling of Wadi Tushka to near the 190 m level occurred prior to the middle Pleistocene Acheulean occupation. This elevation is remarkably consistent with the elevations and ages of archaeological sites north of Bir Kiseiba, 150 km to the west. There, a 5-km-wide plateau at ~200 m elevation has abundant late Acheulean artifacts weathering out of the topmost 1–2 m (Haynes et al., 2001). The sand sheet surrounding the plateau is at 170–180 m, and is characterized by Neolithic sites (Wendorf et al., 1984), scattered Middle Paleolithic artifacts mixed with the lag, and several generations of paleochannels (Grant et al., 2004). A lake at 190 m would completely enclose the plateau surface (Fig. 3), leaving the two sandy alluvial units that contain the artifacts subaerially exposed, consistent with their sand-abraded appearance. This lake would have covered 30,400 km² at an average depth of 47 m, and contained 1450 km³ of water.

The northeast alignment and location of the Dibis West–Dibis–El-Shab–Kurayim–Kiseiba string of oases can now be considered remnants of Pleistocene drainage. Although each of these oases is in a local topographic low, commonly a few meters below the surrounding sand sheet, the concentration of groundwater is likely aided by subsurface permeable fluvial deposits (as shown for Bir Kiseiba by Grant et al., 2004). The northward topographic gradient likely aided water flow toward the channel thalwegs both during the time of the Selima-Tarfawi lake and during the Holocene pluvial, ca. 10–6 ka.

Although the paleochannels north and west of Selima Oasis indicate local runoff from rainfall, the middle Pleistocene timing of Bir Tarfawi fossils and calcareous benches at Selima allow another hypothesis for the origin of the lakes. High discharges in the early Pleistocene coupled with continued sedimentation in the upper Nile valley from the Eastern Desert in the form of the Qena sand and the Kom Ombo gravels virtually ensured continued sedimentation in the upper Nile valley from the Eastern Desert. Observations, such as fossils and calcareous benches at Selima, have allowed the hypothesis that the water flow to the Nile valley was channelized during the middle Pleistocene, the water being deflected from the old Nile channel to northward topographic gradients likely aiding water flow toward the channel thalwegs in the Selima-Tarfawi lake. The water flow being deflected from the old Nile channel to northward topographic gradients likely aiding water flow toward the channel thalwegs both during the time of the Selima-Tarfawi lake and during the Holocene pluvial, ca. 10–6 ka.

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**DISCUSSION**

This hypothesis of middle Pleistocene lakes is subject to the assumption that the topography derived from SRTM represents that of the middle Pleistocene. The gross topographic elements of the sand sheet are likely to be retained in this area, as shown by the stability of the sand sheet (Maxwell and Haynes, 2001) and the correlation of SRTM- and SIR-derived drainage >500 k.y. apart in age (Ghoneim and El-Baz, 2007). Additional sources of uncertainty are the absolute ages and longevity of the proposed lakes, and the amount of local precipitation during the middle Pleistocene. The absolute ages of archaeological assemblages are poorly constrained in southwest Egypt (Schild, 1987), and only scattered uranium-series and optically stimulated luminescence dates in local areas are available to determine the timing of carbonate deposition and associated occupations that are beyond the range of ¹⁴C dating (Wendorf et al., 1993; Szabo et al., 1995). Given these caveats, it may still be possible to use the location and elevation of archaeological sites to test these ideas. A brief review of those sites known to us suggests that several Acheulean and Middle Paleolithic artifact locations are found at elevations that straddle the 247 m datum. While such equivocal results do not support a long-standing, monotonically subsiding series of lakes, they are not inconsistent with lakes formed from sporadic flooding.

Past attempts to reconcile a Nile connection for middle Pleistocene fish (Van Neer, 1993) and lacustrine deposits at both Bir Tarfawi (Hill, 2009) and Dakhla Oases (Kieniewicz and Smith, 2009) have relied on a combination of precipitation and groundwater to maintain stable lakes, since estimates of 500 mm/yr precipitation (Wendorf et al., 1993) are insufficient to support a standing body of water. Seasonal (or more frequent) flooding of the Nile, particularly during pluvial conditions, may well have provided the water necessary for the megalakes proposed here.

**CONCLUSIONS**

Comparison of a SRTM-derived digital elevation model with geomorphic features and scattered archaeological sites and associated sediments suggests the presence of at least two levels of middle Pleistocene paleolakes in the Western Desert. These lakes could have originated from overflow of the Nile through Wadi Tushka, the low point on the west bank of the Nile. An overflow origin is consistent with recent hypotheses on the origin of the Nile and its integration with drainage from Central Africa.

The sedimentary evidence for these old Egyptian lakes is less compelling than that of the newly defined mega–Lake Chad (Leblanc et al., 2006), the Northern Darfur Megalake in northwestern Sudan (Hoelzmann et al., 2001), the White Nile lake in central Sudan (Williams et al., 2010), or Lake Megafazzan in Libya (Drake et al., 2008). Nonetheless, the topographic data add to the growing evidence for numerous early and middle Pleistocene lakes across North Africa that could have supported human migration patterns.

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**REFERENCES CITED**


