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Holocene freshwater carbonate structures in the hyper-arid Gebel Uweinat region of the Sahara Desert (Southwestern Egypt) ☆

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ABSTRACT

The eastern part of the Sahara is at present the driest region of the desert. Yet the extensive animal rock art in the area, presumed to depict real activities in the lives of the painters, suggests that environmental conditions were significantly different when the rock art was produced. Here we report on exploration of the area, which led to the discovery of morphologically-distinct carbonate structures that line the walls of two valleys in Gebel Uweinat, and were likely formed in standing water. The carbonate structures comprise what appear to be shoreline carbonate formations, and date back to 8100 and 9400 years BP. The chemical and morphological similarity of these formations to carbonate structures from modern lakes suggests that these lakes contained fresh, standing water suitable for human and animal use. However, the significant quartz content suggests that windblown sand was pervasive, and thus the vegetation cover may have been sparse. This discovery supports the possibility of grasslands in the area, which may have been able to support human habitation, and adds to the evidence for a wetter climate in the area in the early Holocene.

1. Introduction

The mountainous Gebel Uweinat region of the Sahara Desert, near the triple border of Egypt, Sudan, and Libya (N22°, E25°), receives negligible rain at the present time (Fig. 1; Haynes, 2001). Yet, extensive rock art in the area depicts scenes of abundant animals, and in 1933 the Hungarian explorer László Almásy discovered rock art depicting swimmers (Almásy, 1934). Studies of the rock art have assumed that the animals and scenes depicted on the walls represent real activities in the lives of the painters (Haynes, 1980). Thus the images indicate that there were very different environmental conditions in this region during the time the rock art was produced, though precipitation rates and the extent of vegetation cover are uncertain. Previous exploration of the Egyptian desert has found supporting evidence of a wetter climate 10,500–5000 years ago, concurrent with the expected timeframe for the creation of the rock art (Haynes, 2001; Hoelzmann et al., 1998, 2004; Kuper and Kröpelin, 2006; Navarro-González et al., 2007; Nicoll, 2001). Here we report on morphologically-distinct carbonate structures in two narrow valleys in the Gebel Uweinat area within this currently hyper-arid zone which have similar morphology and composition (Fig. 1) to carbonate shore deposits seen, *inter alia*, in Pavilion Lake, Canada (Laval et al., 2000) and Lake Alchichica, Mexico (Kaźmierczak et al., 2011).

While there is general agreement that during the early Holocene conditions in the Gebel Uweinat area were more clement than at present, the details of the climatic history are uncertain. Dateable artifacts of past humid periods there are limited to an ostrich egg-shell, with a radiocarbon age of 7280 ± 90 years BP (~9200 calibrated years BP; Wendorf and expedition, 1977). While some parts of southwest Egypt have been extensively explored – such as Gilf Kebir (200 km NE from the study sites) (Haynes, 2001; and references therein), the Selima Sand Sheet (300 km to the east, including Gebel Kamil) (Haynes, 1982), and other more distant sites (shown in Fig. 1) – these sites generally suggest intermittent rainfall that produced ephemeral watering holes and ponds and questions remain about the extent of vegetation cover (Kröpelin, 1987; Lindstädter and Kröpelin, 2004). Gebel Uweinat is of particular interest because its location in what is now the driest core of the Western Desert of Egypt provides an important constraint on the magnitude and geographic extent of wetter conditions during the early Holocene.

In this paper we report on the composition and morphology of the discovered carbonate structures and suggest their likely mode

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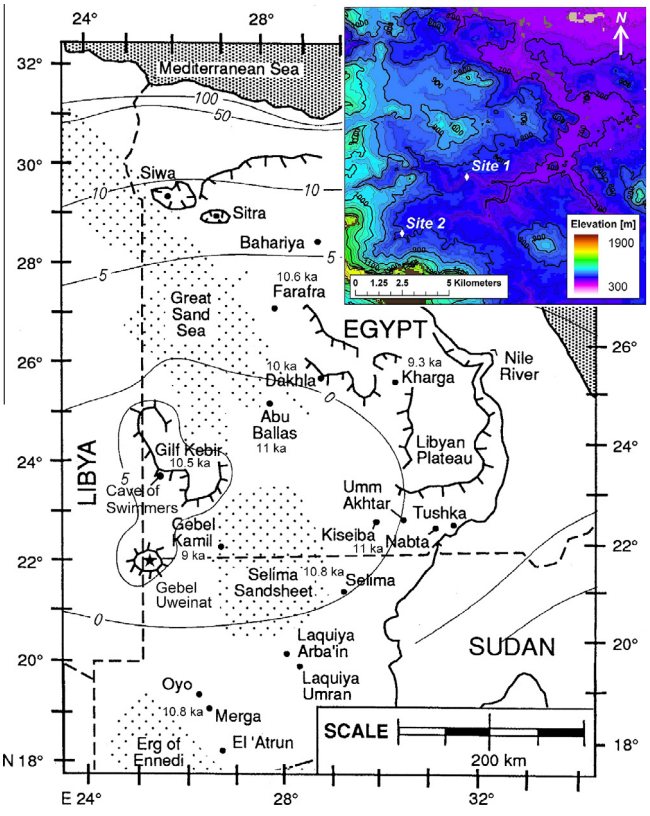

Fig. 1. Contextual map of the eastern part of the Sahara and the studied sites. Map is modified from Nicoll (2001). The study area, Gebel Uweinat, is indicated (star; N22°, E25°). The Cave of the Swimmers (north of the study sites) and the timing of onset of the most recent wet period for select sites in the eastern Sahara are labeled (Kuper and Kröpelin, 2006; Nicoll, 2001). Ages are reported in calibrated years BP. The modern annual precipitation amounts in millimeters (isohyet contours) are overlaid (Haynes, 2001). The inset shows the topography of the northeast part of Gebel Uweinat (Shuttle Radar Topography Mission), where the study sites are found: Site 1 (N21°58′, E25°06′) and Site 2 (N21°56′, E25°04′).

and timing of formation. These results provide constraints on the environmental conditions in the Eastern Sahara during the carbonates' formation period.

1.1. Site description

Gebel Uweinat is a mountainous range in the southwest of Egypt, with a maximum elevation of 1934 m. The basement rock is Precambrian granites, granite gneisses, and diorites, which are exposed at elevations above ~1000 m (Issawi, 1980). The last significant deformation and plutonism occurred during the Precambrian, Kröner et al. (1994) gives ages for the emplacement of the basement rock of 700–800 Myr. At lower elevations and at the study sites, the Precambrian basement is overlaid by a Cambro-Ordovician unit of quartzitic sandstone beds interbedded with highly consolidated conglomerate and syenite porphyry sheets (Burollet, 1963; Issawi, 1980).

During our preliminary exploration of the Gebel Uweinat region, two valleys were discovered that contain morphologically-distinct carbonate structures and at one of the sites form a bench along the valley wall. Both of these valleys are located in likely ancient valley network channels, as apparent from aerial photographs, and from the area's topography (Fig. 1b). At Site 1, the carbonate structures form a distinct bench along the sandstone valley wall; the bench is continuous for over 50 m and is about 1 m thick vertically (Site 1, N21°58′, E25°06′, elevation 715 m; Figs. 1 and 2a and b). The carbonate bench is "pasted" onto the valley wall and is not part of, or aligned with, the stratigraphic sequence. At this location the valley is about 20 m deep. No apparent shorelines were observed. Site 2 is located about 5 km away in a neighboring valley, and at a slightly higher elevation than the first site (Site 2, N21°56′, E25°04′, elevation 775 m; Figs. 1 and 2c). The height of the surrounding, broader valley is about 10 m. The carbonates structures had a similar, distinct morphology, but did not form a bench along the valley walls: they were distributed both along the valley walls and along the valley floor. Their macro-morphology and distribution may be the result of

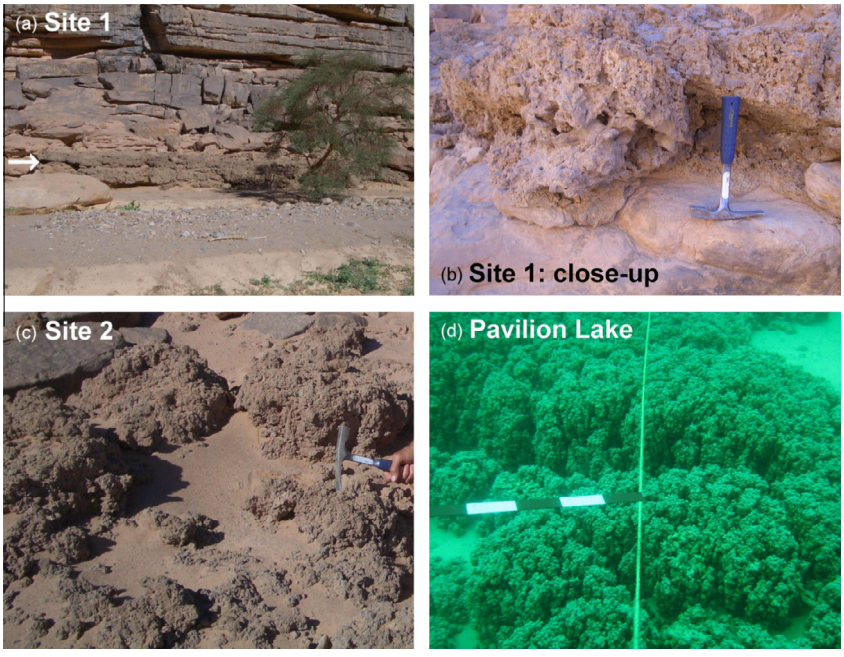

Fig. 2. Carbonate structures at the study sites: (a) carbonate bench (arrow) lining the side of the valley at Site 1, (b) close-up of carbonates at Site 1, and (c) the structures at Site 2. Calcite structures that are morphologically and chemically similar to those at Gebel Uweinat are found in Pavilion Lake, British Columbia, Canada (d) at a depth of 10–15 m (Laval et al., 2000; Lim et al., 2009); each segment on the scalebar is 10 cm.