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GEOCHRONOLOGY OF PHREATOPHYTIC MOUNDS ON THE ATMUR EL KIBIESH, EGYPT: WITH DESCRIPTIONS OF PLANTS COLLECTED DURING THE EXPEDITION TO THE EASTERN SAHARA, EGYPT, AND SUDAN (APPENDIX I)

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ABSTRACT. In the hyperarid eastern Sahara, west of the Nile River in Egypt, areas with vegetated eolian mounds have attracted people and animals because of shallow groundwater that at times of high water tables may be reached by hand digging shallow wells. An eolian phreatophytic mound with a living arak bush (*Silvadora persica* L.) on top, one of three known from this region of SW Egypt, provided a stratigraphic record of its growth. The geochronology of the mounds aggradation and that of a nearby tarfa mound (*Tamarix nilatica* Bunge) was determined by radiocarbon dating plant macrofossils within the stratigraphic succession. Eolian aggradation of the mound postdates deflation that eroded playa sediments of the Neolithic pluvial that ended ca. 5000 BP and appears to be due to a resurgence of the shallow aquifer. Subsequent deflation of the mounds is apparently due to post-1500 BP aridity. Regional vegetation is described in the Appendix I.

KEYWORDS: Egypt, geochronology, hyperarid Sahara, phreatophytic mounds.

INTRODUCTION

This report is about an ancillary part of our 1982 expedition in the eastern Sahara. The first part of our expedition was a reconnaissance of the depressions of Merga, Wadi Hussein, and Oyo in northwestern Sudan where Holocene lake deposits of Neolithic age occur (Haynes 1985) in preparation for more detailed investigations later. The second part was a return to Selima Oasis in northern Sudan where the detailed investigations of similar age lacustrine deposits were begun two years earlier (Haynes 1985). On our return to Kharga Oasis in Egypt, via the Atmur el Kibiesh, we found the third known occurrence of arak in the Western Desert of Egypt on the top of a vegetated mound of eolian sand. Here we report on preliminary results of our study to better understand the origin of these mounds in relation to climate change and archaeology in this hyperarid region of the Eastern Sahara where rainfall is less than 10 mm per year, and that only once in every 20 years or so.

The Atmur el Kibiesh, or plain of the sheep, is a relatively flat expanse of eolian sand sheet that extends in a north-northeasterly direction from the border with Sudan at 22°N to about 23° 30′N (Figure 1). With a width of about 50 km, it stands about 50 to 80 m above the Kiseiba depression forming its eastern border (Haynes 1997 Figures 1 and 2). Clusters of steep-sided vegetated mounds, in the past referred to as *terabil* (Comyn 1911), occur sporadically over the plain and are composed of mounds of eolian sand topped by phreatophytes (Figure 2). These plants are usually either tarfa (*Tamarix nilotica* Bunge) or selim (*Acacia ehrenbergiana* Hayne) (Figure 2a) and rarely arak (*Salvadora persica* L.) (Figure 2b), known in parts of Africa as the toothbrush tree because a small branch or twig can be frayed by chewing to form a reasonably effective brush for the teeth (Täckholm 1974). The Bir Sahara 1:500,000 scale map (sheet 568-B) of Egypt, done by British and Egyptian surveyors before World War II and updated by the War Office, London, in 1960, shows a single arak tree as a dot at 23°10′N, 29°41′E (No. 1). We

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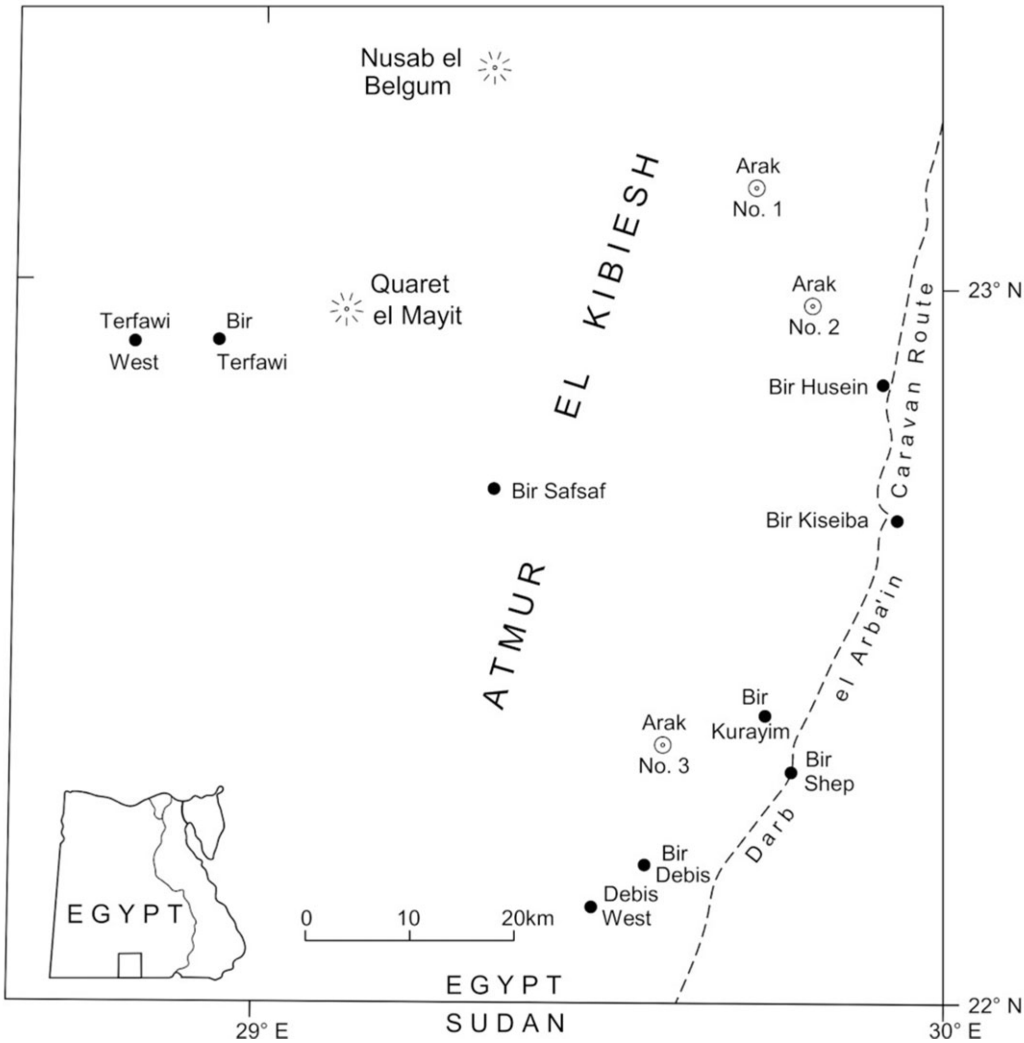

Figure 1 Map of the Atmur el Kibiesh region, Egypt, showing locations of arak mounds (ʘ) and caravan watering places (bir •) where water may be encountered less than 2 m below the desert surface by hand excavation. The Kiseiba depression is the area east of the Darb el Arba'in caravan route. The region is shown on the index map as the box on the border of Egypt with Sudan.

found another one in 1980 at 22°58.7′N, 29°46.0′E (No. 2) and a third one in 1982 at 22° 21.5′N, 29°33.7′E (No. 3) (Figure 3).

Origin of the Mounds

Bagnold (1941:5–6) has pointed out that most wind-driven sand moves within a meter or less above the desert floor and is most concentrated in the lower 10 cm. Particle sizes decrease upward from small pebbles or grit creeping along the desert floor to fine sand. Finer particles are carried along in suspension. Many grains in transit along the desert floor are due to saltation whereby a grain of sand impinging on the sandy surface may bounce back into the air

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Figure 2 Phreatophytic—phytogenic mounds: (a) Selim (*Acacia ehrenbergiana* Hayne) supports two mounds east southeast of Bir Safsaf. Northwesterly view by T. A. Maxwell, 1985. (b) Arak (*Salvadora persica* L.) mound No. 3, (foreground), is being examined by geologist Ahmed Swedan while botanist Loutfy Boulos makes notes. Tarfa mounds may be seen in the middle background. Northeasterly view by C. V. Haynes 1982. (c) Dead tarfa (*Tamarix nilotica* Bunge) mound south of Bir Terfawi West provides firewood for a field party of the Egyptian Geological Survey. Northeasterly view by C. V. Haynes, 1982.

Figure 3 The top of arak mound No. 3 (right foreground) provides a clear view of the dead tarfa mound included in this study (Figure 4). The small mound on the left by the blue vehicle bears remnants of a dying tamarix bush. The healthy vegetation on the right between the arak mound and the large tarfa mound is a dense growth of living tamarix that supports a low incipient tarfa mound. East northeasterly view by C. V. Haynes, February 1982.

or knock a grain formerly at rest to one in motion (Bagnold 1941:19). Some of these saltating grains may rise 2 m or more above the ground-hugging concentration of wind-blown sand. This accounts for the stinging impact of coarse grains against the face of one standing on the desert floor in a sand storm. Many grains, a bit too large to saltate, move along the desert surface in short jerks forming a zone of creeping grains (creep zone).

When wind-driven sand encounter shrubs some is deposited as a result of velocity reduction and turbulence. Mounds so formed of dune sand are called phytogenic dunes or coppice dunes. If the plants roots are taking water from the water table they are phreatophytes, and the resulting mound can be called a phreatophytic mound, as are the subjects of this paper. The water table is usually no more than about 3 m below the desert floor where mounds with living plants occur.

These mounds can grow higher as long as they are supplied with eolian sand and as long as the roots can reach the zone of saturation. The mounds stop growing whenever the sand supply fails to reach the entrapping vegetation or if the water table falls below the reach of the roots. Their maximum height is limited by the fact that the amount of sand in suspension decreases with elevation above the desert floor.

Throughout the region most of the mounds are vegetated by either tarfa or acacia with a few mounds bearing both species. Mounds may be found with vegetation in all states of decay from healthy living trees (Figure 2a) to mounds topped only with dead trees (Figure 2c). And some mounds have been wind eroded down to only a few remnants of fallen trunks and branches forming a lag of dead branches and sticks. For centuries the dead branches have been a major source of firewood (Figure 2c) for the few people who venture into this hyperarid part of the eastern Sahara. It has been called the Darb el Arbain desert (Issawi 1971; Haynes 1982) because of the ancient caravan route that extends from near El Fasher in Sudan to Kharga Oasis in Egypt. The route name has been translated as the Forty Days Road because of the approximate time it takes for camel caravans to travel the distance (Shaw 1929).

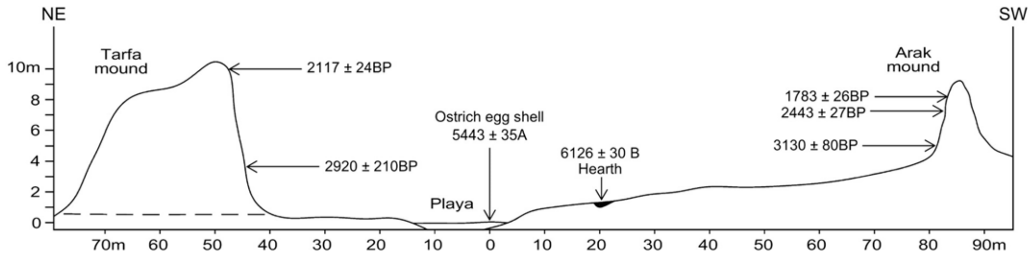

Figure 4 Northeast–southwest profile of arak mound No., 3 and the large dead tarfa mound shown in Figure 3. The deflated playa (projected to the line of section) has a lagged concentration of scattered and broken sandblasted ostrich eggshell with a ^{14}C age of 5443 ± 35 BP. Charcoal from a hearth exposed in the sand sheet nearby provided an age of 6126 ± 30 BP. Both date Neolithic occupations of the desert floor in this area. The ^{14}C dates of the arak mound are shown on the opposite side from where the samples were collected. This is to avoid having to extend the figure accordingly.

Today Egyptian camel caravans still traverse the "Darb" to mine trona (hydrated sodium carbonate) in northern Sudan and take it to markets in Kharga Oasis, or near Isna in the Nile valley. The dead wood of the declining mounds is their only fuel, and acacia wood is preferred to that of tarfa because it is denser and makes long lasting red hot coals, whereas tarfa wood is less dense, burns away faster, and produces smoke with an unpleasant odor. Also, modern expeditions in the region, usually either scientific or military, make use of these sources of firewood (Figure 2c).

Mounds of the Study Area

The goal of our 1982 expedition was to look for and study geologic evidence of climate change provided by sediments of former ground water-supported lakes in northern Sudan and playa lake deposits of southern Egypt (Haynes 1985), frequently in conjunction with the Combined Prehistoric Expeditions of Wendorf and Schild (1980). In addition, living vegetation that we encountered from 1978 to 1982 was recorded by the second author (see Appendix I). On our return from Selima Oasis in Sudan in 1982, and while heading for Kharga Oasis in Egypt we, traversed the Atmur el Kibiesh where there are several clusters of phreatophytic mounds.

Historic to late prehistoric archaeological remains are often associated with them (McHugh et al. 1983). Among a cluster of mostly dead tarfa mounds we found one with a living arak bush at the top (No. 3). Most of the mounds were dead and being deflated by wind in spite of their surface being partially armored with a lag of dead branches. Only the arak mound and a tarfa mound nearby had living vegetation at their tops (Figures 2b and 3). A Brunton-pace and hand-level profile was made between the arak mound and the largest tarfa mound (Figure 4).

While the second author collected and recorded the vegetation (see Appendix I) the rest of us investigated the stratigraphy of arak mound No. 3 by excavating short trenches on the leeward side. This exposed micro strata of dry and decayed vegetation alternating with layers of sand typically weakly cemented with salts (Figure 5 and Tables 1 and 2).

The abundance of dry plant matter in the form of leaf mats, twigs, and wood fragments provides ample material for radiocarbon dating the strata (Table 2). A sample of compressed leaf litter from about a meter above the base of the arak mound provided an age

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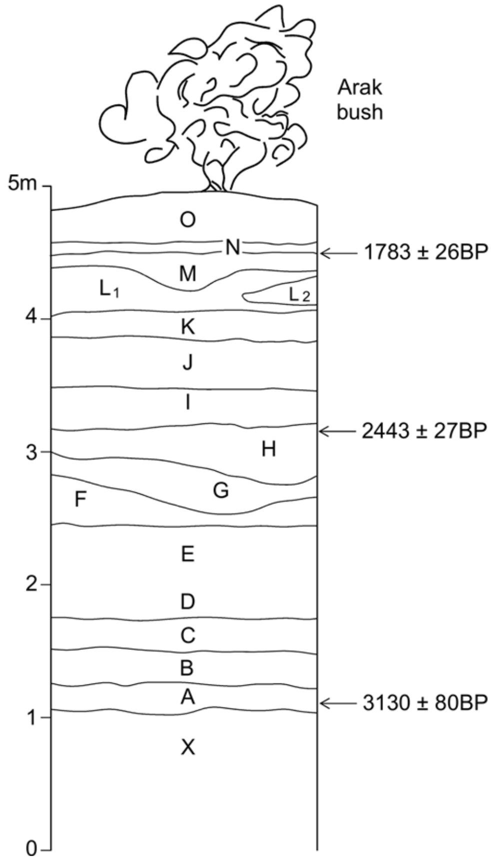

Figure 5 Stratigraphic column of arak mound No. 3 with ^{14}C ages (Table 2) indicated.

of 3130 ± 80 BP (years before present = 1950). Another sample 2 m higher dated 2443 ± 27 BP and a layer of comminuted vegetal matter near the top dated 1783 ± 26 BP (Figure 5). The lower segment aggraded at a rate of ~3.3 mm/yr and the upper at a lower rate of ~1.7 mm/yr indicating, as expected, that the rate of aggradation decreased with height.

The top of the arak mound has a living arak bush with green leaves that were collected by the botanist but have not been radiocarbon dated. However, a similar arak mound (Figure 1, No. 2) that we discovered in 1980 had living green leaves on a bush at the top with a radiocarbon content of 128.77 + 0.46% Modern (M) radiocarbon (^{14}C) (Table 2) indicating growth in 1980, the year we collected it during the nuclear (bomb) era (Hua and Barbetti 2004). A segment of a large branch collected for study was cut and polished at the Tree Ring Laboratory, University of Arizona (Figure 6). The outermost ring provided a ^{14}C value of 130.26 ± 0.50% M (Table 2) which indicates growth during 1979–1980 of the nuclear era, and consistent with the year of collection. The hearth wood (Figure 6) contains 98.29 ± 0.40% M (Table 2) ^{14}C indicating initiation of new growth sometime around 1952 or 1953, i.e. just two or three years before the steep rise of the “bomb” curve initiated by atmospheric testing of thermonuclear weapons (Hua and Barbetti 2004).

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Table 1 Sedimentary descriptions of arak mound strata.

Stratum	Description	Thickness*
O	Plant roots and leaves in tan granular aggregates of very fine eolian sand. Weakly calcareous.	24
N	Compacted leaf litter and light tan, calcareous, very fine sand on old surface. ^{14}C date = 1783 ± 26 BP (AA-105981).	2
M	Very light tan (white) moderately calcareous laminated fine sand with some medium grains and salts, insoluble in 3NHCl: anhydrite?	23
L	Tan silty fine sand with lenses of brown plant fragments.	34
K	Brown wood and plant fragments in silty fine sand.	22
J	Brown twigs in tan silty fine sand.	39
I	Brown leaf and twig litter in tan silty fine sand.	33
H	Brown compact leaf litter in tan silty fine sand. ^{14}C date = 2443 ± 27 BP (AA-105767).	44
G	Brown interbedded leaf litter and tan silty fine sand.	33
F	Brown sandy compressed leaves and twigs.	35
E	Tan silty fine sand with dispersed brown plant particles.	46
D	Reddish brown 2–3 mm granular aggregates of fine to medium sand with dispersed brown plant fragments and weak carbonate reaction. Dispersed coarse sand grains are well rounded and frosted.	27
C	Brown granular aggregates of fine to medium sand with numerous dispersed dark brown plant particles. Weakly calcareous.	25
B	Reddish brown 1–2 mm aggregates of medium sand and organic matter weakly cemented by salts (anhydrite?) with weak carbonate reaction.	29
A	Brown decayed leaves in tan fine to medium well-rounded sand with dispersed coarse frosted grains. ^{14}C date = 3130 ± 80 BP (AA-868).	24

*Maximum observed thickness in centimeters.

Stratigraphy of the Arak Mound

Arak mound No. 3 is composed of more or less horizontal strata of sand containing varying amounts of organic matter and cementation (Figure 5 and Table 1). The organic debris is derived from the accumulation of dead plant remains that became integrated with eolian sand as the mound aggraded. The plant matter ranges from leaves and twigs to wood fragments ranging from small chunks of about 1 cm maximum dimension to larger sticks, all showing varying degrees of decay ranging from clearly recognizable leaves and twigs to organic masses of no recognizable form. In disaggregating samples in the laboratory a few were found to contain fecal pellets of a small gazelle (*Gazella dorcas* L.) that today are occasionally seen on the Atmur el Kibiesh at mounds with living vegetation. A larger pellet may be that of an addax (*Addax nasomaculatus*), the most desert adapted of the African antelopes (Osborn and Hilmy 1980:482–484). Osborn and Hilmy point out that these have not been seen in Egypt's western desert since 1931. However, in 1980 we found two desiccated addax carcasses at the remote rock outcrop of Burg el Tuyur at the southern part of the Selima sand sheet in northern Sudan that ^{14}C analysis revealed had died there in 1955 when an unusually high annual rainfall caused grassland at the northern fringe of the Sahel to extend so far north (Haynes 1997).

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Table 2 Associated radiocarbon dates.

^{14}C lab. number	Sample material	Provenance	^{14}C age BP or % Modern
AA-91494	Arak tree trunk outer ring	Arak Mound No. 2	130.26 ± 0.50 (1979–1980)
AA-108550	Live Arak leaf	Arak Mound No. 2	128.77 ± 0.46 (1980)
AA-91493	Arak tree trunk heart wood	Arak Mound No. 2	98.29 ± 0.40 (1952–1953)
AA-105981	Leaf litter	Arak Mound No. 3 N/M contact	1783 ± 26
AA-108393	Dead tarfa leaves	Top of dead tarfa mound	2117 ± 24
AA-105767	Compressed leaf litter	Arak Mound N0. 3 top of Stratum H	2443 ± 27
A-3245	Dead tarfa leaves	Lower part of dead tarfa mound	2920 ± 210
AA-868	Compressed leaf litter	Arak Mound No. 3 near bae of Stratum A	3130 ± 80
AA-108593	Ostrich eggshell carbonate	Deflated surface of playa	5443 ± 35
AA-108394	Neolithic hearth charcoal	Exposed by deflation near playa	6126 ± 30
SMU-207	Carbonate of active dune sand	Near Nabta Playa ~200 km to east	21,590 ± 180

All layers contain eolian sand, but the layering is due to strata composed mostly of eolian sand alternating with layers dominated by plant detritus. This stratification appears to represent periods dominated by increased wind activity and sand deposition alternating with periods of less wind activity and more plant litter accumulation.

The sands are weakly cemented by $CaCO_3$ and anhydrite (?) (anhydrous gypsum or $CaSO_4$). The former is probably derived via eolian abrasion of Eocene limestone of the Egyptian Plateau to the north and from Quaternary carbonates in the region (Szabo et al. 1995). Carbonate leached from dune sand at Nabta Playa about 200 km to the east (Wendorf and Schild 1980) produced a ^{14}C value of 21,590 ± 180 BP (SMU-207) (Table 2) suggesting a probable mixture of the two sources.

Sand-size grains of an opaque white mineral occur among the quartz grains making up the sand fraction of Stratum B and Stratum M. During decalcification in the laboratory with 6N HCl these grains remained intact. They are probably anhydrite and derived from the deflation of playa deposits up wind of this area. Gypsum is a common evaporate mineral of playa deposits that with time converts to anhydrite under the high temperature and dry conditions of this hyperarid area of the eastern Sahara. Whereas chemical charts list gypsum as soluble in mineral acids, it is in fact very difficult to dissolve this way (Fitzpatrick and Bischoff 1994).

Figure 6 Cut and polished section of arak No. 2 showing location of heart wood with 98.29 ± 0.40% M ^{14}C (Table 2) and outer ring with 103.26 ± 0.50% M, consistent with 1982, the year of collection.

The Tarfa Mound

The large tarfa mound near the arak mound (Figures 3 and 4) appears to be the largest of over twenty dead mounds in this cluster. Dead leaves from a stratum about 3m above the base dated 2920 ± 210 BP (Table 2) and those from near the top, about 6 m higher, date 2117 ± 24 BP for a deposition rate of about 7.5 mm/yr, over twice that of the arak mound.

INTERPRETATION OF THE DATA

Whereas the tarfa mound aggraded much faster than the arak mound, it stopped aggrading about 700 years earlier. The faster rate of aggradation may be due to the tarfa foliage being a denser thicket than that of the arak and, therefore, more effectively reducing wind velocity resulting in more rapid accumulation of eolian sand. The tarfa mounds death before that of the arak mound may be due to its root system being less effective in keeping up with a falling water table. This explanation is supported by the fact that all of the tarfa mounds in the cluster, except two, are dead, and the two living tarfa shrubs are on lower surfaces and appear to have germinated in more recent time. One of these is almost dead (Figure 3, left) and the other (Figure 3, right) is alive and well on the desert floor.

The arak mound essentially stopped growing soon after the ^{14}C date of 1783 ± 26 BP at the base of the compact vegetal layer of stratum N near the top of the mound (Figure 5). There are another 20 cm or so of loose silty fine sand being held by the living arak bush, but this sediment appears to be of recent age based on its looseness and lack of cementation.

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Figure 7 Two historic period graves near Arak mound 3 are probably those of caravaners and were left undisturbed by us. Trench shovel blade in foreground is 6 inches (~15.2 cm) wide. The dead and deflated acacia mounds in the distance are northeast of the arak mound. Northeasterly view by C.V.H. 1982.

The fact that the strata are essentially horizontal suggests that the mound was significantly larger in horizontal dimensions when it was aggrading. Otherwise we would expect the strata to be convexly curved to more or less conform to the present configuration of the mound. Instead they appear to be truncated by erosion of the sides of the mound. This raised the possibility that a broader area of the desert floor was aggrading as the mounds of this cluster aggraded. Subsequent deflation as the vegetation died, presumably due to a fallen water table, eventually led to the present desert floor and configuration of the mounds.

The deflation exhumed playa muds with a lag of scattered eolized ostrich eggshell. Ostrich eggshell throughout this region is commonly associated with deflated Neolithic sites and range from ~5000 BP to 8000 BP in radiocarbon years (Haynes 2001). Our sample provides a date of 5443 ± 35 BP (Table 2). A charcoal hearth exposed on the sand sheet near the arak mound produced a ^{14}C age of 6126 ± 30 BP. Both values are terminal Neolithic ages and indicate that deflation of the land surface on which the mounds grew, occurred sometime before 3130 BP and after about 5400 BP, presumably accompanied by a lowering of the water table. Two graves side by side and outlined by stones occur on the sand sheet (Figure 7). They were not disturbed by us and are probably those of caravaners or smugglers.

These data suggest that after the end of aggradation of the arak mound, not long after perhaps 1500 years ago, and before the end of the Neolithic about 4000 BP, over 5 m of deflation occurred in this cluster of vegetated mounds. The end of mound aggradation was probably due to a drop in the water table after the end of the Neolithic pluvial (Haynes 2001). If this is the case, the active tarfa on the low mound mentioned previously (Figure 3, right) may be due to a resurgence of the water table in response to increased rainfall indicated by records from southern Egypt (Haynes and Haas 1980) and northern Sudan (Haynes 1997). Unfortunately,

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we did not, via radiocarbon analysis, evaluate the initiation date of the healthy living tarfa vegetation.

What needs to be done in the future is to make a stratigraphic examination of the tarfa mound of Figure 4, as well as others in the cluster to see if there are correlations of microstrata between mounds. The low mound with fresh tarfa vegetation also needs to be evaluated by trenching and ^{14}C dating and comparing ^{14}C ages to the "bomb" curve (Hua and Barbetti 2004).

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Suggestions for improvement were provided by T. A. Maxwell, Air and Space Museum, Smithsonian Institution; Robert F. Giegengack, University of Pennsylvania; Carol Breed McCauly, USGS Flagstaff, Arizona; Meg Kennedy Shaw, Washington D.C.; A. J. T. Jull, editor, and anonymous reviewers of the manuscript.

This paper is dedicated to the memory of our late friend and colleague Dr. Loutfy Boulos, one of the world's premier botanists, and to the late Dr. Anthony Muller, a renowned geohydrologist, and is in honor of Dr. Bahay Issawi, former Director of the Egyptian Geological Survey, who made our desert research possible via his administrative assistance and occasionally by participation with us in the field. Dr. Boulos was an internationally known botanist and student of the world-famous Swedish-Egyptian botanist Vivi Täckholm, author of *Students' Flora of Egypt* (Täckholm 1974). Dr. Boulos was a classmate of Dr. Bahay Issawi for whom the volume in which this paper was originally written was intended to be published. Dr. Muller was a geochemist and hydrologist who studied under Paul Damon and me at the University of Arizona. On this expedition, he collected water from several watering places including wells of the General Patroleum Company of Egypt. At the arak mounds he excavated and cleaned up the stratigraphic sections and helped with the description. I am grateful for the contributions of Dr. Ahmed Swedan, who was a young geologist at the Geological Survey of Egypt where all foreign expeditions were required to have an Egyptian representative involved in any research. He was a very helpful and intelligent geologist who had been with me on two other expeditions to the Eastern Sahara, Egypt, and Sudan, including when we found the World War II 1939 Chevrolet of the Long Range Desert Group. He the guided the British

LRDG members to it for recovery. It now resides as a significant exhibit in the Imperial War Museum, London. On the expedition of this paper he provided help passing through Egyptian Army security checkpoints in addition to helping with the stratigraphic descriptions of the phytogenic mounds. I am grateful to all the people who helped make this article possible.

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APPENDIX I

Plants collected during an Expedition to the Eastern Sahara, Egypt and Sudan in the winter of 1982, as well as earlier, by Loutfy Boulos, National Research Center, Dokki, Cairo, Egypt.

Egypt

Tarfawi West, 22°55'N, 28°46'E

January 31, 1982

Tamarix nilotica (Ehrenb.) Bunge (14777) Local name: tarfa
Only species growing in the area, forming dense conspicuous thickets.

Sudan

Burg El Tuyur, 20°59'30"N, 27°41"30"E

February 3, 1982

Stipagrostis plumosa (L.) Munro ex T. Anders. (14778) Formerly called *Aristida*
Dry plants left from previous rains are locally common north and west of this locality.

Ca. 185 km SE of Gebel Uweinat, near Shaw's 1935 Camp 18, 20°57'N, 26°16'E

February 4, 1982

Capparis decidua (Forssk.) Edgew. (14779) Local name: Tondub

One old flowering tree, in a catchment area. The dry old branches constitute a good firewood; however, its smoke possesses a characteristic smell which remains in the clothes for quite a long time.

100 km NNW of Merga Oasis, 19°55'N, 26°17'E

February 5, 1982

Salsola baryosma (Schult.) Dandy (14780) Local name: kharit
Several flowering shrubs in luxuriant growth. Dry old plants are used as a firewood.

Fagonia bruguieri DC. (14781)
Few green shrublets, some bearing flowers and fruits, but mostly dry plants scattered in the area.

Bir Oyo, ca. 40 km NW of Merga Oasis, 19°18'30"N, 26°10'E

February 5, 1982

Desmostachya bipinnata (L.) Stapf (14782) Local name: halfa grass
High hummocks of dead remains of the plant topped by green plants, often in flower; some hummocks are only formed of dry old plants. Trunks of date palm *Phoenix dactylifera* are cut and lying on the ground near the well, some are burnt.

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Wadi Hussein (Maaten), ca. 30 km north of Merga Oasis, 19°22’N, 26°28’E
February 5, 1982

Cornulaca monacantha Del. (14783) Green and dry shrubs.

Merga Oasis, around the Lake, 19°02; 35”N, 26°19”05”E
February 9, 1982

Phragmites australis (Cav.) Trin. ex Steud. (14784) Local name: safsaf (in Egypt), hagna or bous
Thick luxurious growth of tall reeds along the NE side of the lake, close to its banks.

Panicum turgidum Forssk. (14785)
On the sandstone ridges around the lake. *Phoenix dactylifera* L. (14786)

The date palms form the most spectacular growth form around the lake which could be seen from a distance. The trees form a fringe around the lake, next to Phragmites which occupies the area along the banks. Farther away from the lake, some palm trees suffer from the moving sand and often the whole trunk is covered with sand leaving the crowns only exposed.
Sporobolus spicatus (Vahl) Kunth (14787) In most salty sand soil.

Juncus rigidus Desf. (14788)
In a moist interdunal depression on the northeastern edge of the lake, salty sand soil.

Cyperus laevigatus L. (14789)
In a moist interdunal depression on the northeastern edge of the lake, growing in association with *Juncus rigidus*.

Desmostachya bipinnata (L.) Stapf (14790)
Frequent on sand dunes around the lake, usually growing away from the banks.

It is remarkable that the entire vegetation from the whole area around the lake (seven species) is related to monocots.

Merga Oasis, Wa’arat El-‘Abid, 19°01’N, 26°17’E
February 10, 1982

Acacia raddiana Savi (14791) Local name: sunt or sayaal
Large trees, frequently grow among date palms. The wood yields a good firewood. Fruits constitute one of the most favorite foods for Gazelles, several animals seen in the area.

Acacia ehrenbergiana Hayne (14792) Local name: Selim
Shrubs on low sandy hills

15 km NNE of Merga Oasis, 19°08’N, 26°24’E
February 11, 1982

Fagonia arabica L. (14793) Common shrublet in sandy soil.

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Egypt

28 km west of Bir Shab, 22°21’30”N, 29°47’E

February 14, 1982

Salvadora persica L. (14794) Local name: arak
Several hummocks in the area, only one large and high hummock with a living green part of a plant growing toward the top, otherwise all others with dead dry remains; the hummocks are eventually built up of the accumulating debris of the old dry plants, a process which must have occurred during a few hundred years.

Tamarix nilotica (Ehrenb.) Bunge (14795) Local name: tarfa
Several hummocks with living plants, few with dry debris and no green plants. These are close to *Salvadora* hummocks. It seems that *Tamarix* is more tolerant to drought than *Salvadora*.

5 km west of Bir Shab, elevation 218 m, 22°20’30”N, 29°43’E

February 14, 1982

Tamarix nilotica (Ehrenb.) Bunge (14796)
Few shrubs associated with *Stipagrostis vulnerans*.

Stipagrostis vulnerans (Trin. & Rupr.) de Winter (14797)
Almost a pure stand of many hump-like clusters, on low sand dunes; the humps are partly formed due to the small sand dunes on which the grass grows, and partly due to the growth form of the plant.

3 km NE Bir Shab, near the blockhouse, 22°21’30”N, 29°47’E

February 14, 1982

Ziziphus spina-christi (L.) Willd. (14798)
Few fruiting small trees, growing close to each other and forming a thicket.

Ca. 14 km ENE Bir Shab, elevation 223 m, 22°22’N, 29°54’E

February 14, 1982

Cornulaca monacantha Del. (14799) Few shrublets.

Capparis decidua (Forssk.) Edgew. (14800)
A single large shrub, in flower, is growing in the area.

14 km ESE Gebel Nabta, elevation ca. 172 m, 22°30’N, 30°47’

February 15, 1982

Fagonia arabica L. (14801) Few small shrublets.

Zygophyllum coccineum L. (14802)
Few large shrubs, up to 1 m high, of luxuriant growth. The occurrence of these specimens in this locality is a most unusual finding. According to Täckholm (1974), this species has

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never been recorded from the Western Desert of Egypt, being restricted to the Eastern Desert and Sinai.

Salsola baryosma (Schult.) Dandy (14803) few shrublets.

The dry remains of a *Tribulus* species has been observed in the area.

36 km WSW Abu Simbel, 22°12'N, 31°16'E

February 16, 1982

Salsola baryosma (Schult.) Dandy (14804) Few shrublets in flower and fruit.

Fagonia arabica L. (14805) Few shrublets in flower and fruit.

Crotalaria thebaica (Del.) DC. (14806) Several shrubs in flower and fruit.

Schouwia thebaica Webb (14807) Annual, only dry plants occur in the area.

Sudan

100 km SW of Laqiya, 19°52'N, 27°32'E

February 22, 1982

Maerua crassifolia Forssk. (14808) Few small trees and shrubs.

Laqiya depression, 20°06'N, 27°32'E

February 23, 1982

Acacia ehrenbergiana Hayne (14809)
Rich vegetation in several spots of the western part of the depression. Gazelles were seen feeding on *Acacia* green leaves.

Tamarix aphylla (L.) Karst. (14810)
Many large trees, some with old trunks almost lying on the ground. The present location was not known to Baum (1978) in his monographic study on the genus Tamarix, as he gives Khartoum as the only locality for this species from Sudan. This finding fills the gap for Northern Sudan where the plant was not previously recorded and contributes to a better understanding why it reappeared in Ethiopia and Somalia.

Wadi Sahl, NW of Laqiya scarp, 20°30'N, 27°30'E

February 23, 1982

Salsola baryosma (Schult.) Dandy (14811)
Few shrublets, also some *Capparis decidua* shrubs were seen but not collected.

Selima Oasis, 21°22'12"N, 29°18'24" E

February 25, 1982

Demostachya bipinnata (L.) Stapf (14812) Dense growth around the well.

Imperata cylindrica (L.) P. Beauv. (14813)
Common around the well, also of a wider distribution than *Desmostachya bipinnata* throughout the oasis.

Juncus rigidus Desf. (14814) Common in the vicinity of the well.

Phoenix dactylifera L. (14815)
The most conspicuous element of the vegetation in the oasis, growing in dense groves or isolated spaced trees. The dates of some trees are of a high quality.

Hyphaene thebaica (L.) Mart. (14816) Local name: dom palm
Much less abundant than the date palms in the oasis.

Sporobolus spicatus (Vahl) Kunth (14817)
Large hummocks in salty ground, mainly sand, around the oasis. Some old hummocks are left with dry plants only.

Cynodon dactylon (L.) Pers. (14818)
Restricted to a small area, ca. 30 m from the well, where travelers and their camels usually have their rest.

Phragmites australis (Cav.) Trin. ex Steud. (14819)
Few plants around the well, but on the eastern side of the oasis a large area has a luxuriant dense growth of this reed.

Tamarix nilotica (Ehrenb.) Bunge (14820)
Large shrubs on the sand dunes of the eastern side of the oasis. The vegetation in this oasis is rather similar to that of Merga Oasis. This particular type of vegetation is also comparable to that of Bir Tarfawi and similar spots in the Southwestern Desert of Egypt, even within Gebel Uweinat at Ain Brins (cf. Boulos 1982).